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Enhancing Disaster Prevention and Mitigation

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Table of Contents

Infrastructures

Policies and management

Social aspects and education

Preface

The earthquake on May 27th, 2006 has devastated Jogjakarta Special Province and surrounding parts of Central Java Province, Indonesia. The earthquake measuring 6.3 on the Richter scale occurred for 52 seconds at 06.55 AM. Due to the shallow epicenter, the earthquake has caused tremendous destructions, especially in Bantul and Klaten Regencies. Approximately 6000 people died and thousands of houses/buildings and infrastructures were damaged. Most of totally damaged houses were non-engineered suburban structures that were not constructed precisely following the concept of earthquake resistant design. The earthquake also caused such subsequent disasters such as landslides and the lack of clean-water resources.

This unforgettable tragic moment has been followed by other similar disasters in different places in Indonesia as well as overseas. Earthquake, tsunami, flood, drought, landslide, hurricane, environmental degradation, clean-water crisis, waste problem, urban heat island and global warming along with other disasters will threaten the creatures in this planet, particularly those people who live in disaster-prone areas such as Indonesia and some other countries in the world.

Discussions on constructions, buildings, regions, environments, and disasters are urgently required in order to achieve the life of a peaceful and prosperous society in spite of threatening disasters. Therefore, the Faculty of Civil Engineering and Planning of Islamic University of Indonesia (UII) which consists of Departments of Civil Engineering, Architecture, Environmental Engineering, and Master Program of Civil Engineering concentrating on Earthquake Engineering Management, Construction Management, Structural Engineering, and Transportation Engineering in cooperation with Conference's Partners: KIT-Germany, Hokkaido University-Japan, TZW-Germany, EMU-Turkey, IAS-Austria, UKM-Malaysia, COMSAT-CIIT Pakistan has successfully conducted the First International Conference on Sustainable Built Environment (1-ICSBE): *Enhancing Disaster Prevention and Mitigation* on 27th - 29th of May 2010 in Jogjakarta, Indonesia. This conference event is aimed to share the scientific information and findings of the researches conducted by experts and stakeholders in an international forum. In addition, the 1-ICSBE is expected to be a medium for networking amongst experts and other parties to accomplish the same vision, which is developing sustainable built environment.

During the preparation for this conference, the organizing committee received approximately 154 abstracts; and after being reviewed by the Paper Reviewer Panel, 74 papers were presented at the conference. Those papers are published at this proceeding. These papers come from different countries in the world, such as Australia, Japan, Canada, Malaysia, Bangladesh, the Philippines, Turkey, and Indonesia.

M. Teguh, S. Tanaka, & H. Gökçekuş et al.
27/5/2010

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It is truly grateful to: Ministry of Public Works and Ministry of Environment of the Republic of Indonesia; Conference's partners (Hokkaido University-Japan, TZW-Germany, EMU-Turkey, IAS-Austria, UKM-Malaysia); the invited speakers; the Governments of Jogjakarta Special Province, Bantul Regency, and Jogyakarta City; the Rector of Islamic University of Indonesia, the Dean of the Faculty of Civil Engineering and Planning and all faculty members; the international and local scientific reviewers; the Sponsors: PT. Citra Gading, PT. Poladata Consultant, P2SDM Sensa, PT. Puser Bumi Consultant, PT. Prima Andalan Group, Bank Mandiri, and Kelapa Gading Resto; the writers and presenters of papers; the conference participants, the exhibition participants; and our fellow journalists; all of our distinguished guests and respected participants. Our special thanks go to the members of the steering and organizing committee.

In this occasion also, we would like to apologize to all parties for the oversights and misunderstandings since the preparation until the closing of this conference. We all have a great hope that this proceeding will be beneficial for us, our society, and our environment in general.

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Keynote papers

AN APPLICATION OF MULTI-AGENT SIMULATION FOR EVACUATION IN EARTHQUAKE DISASTER

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ABSTRACT

After Hanshin-Awaji huge earthquake disaster in 1994, it has been important for urban disaster prevention to build a comprehensive evacuation program of a large earthquake occurrence. In this program, it is substantial to observe human behavior for the evacuation time. Thus, we should introduce a new methodology based on behavior-oriented agent system, that is, a multi-agent model. In this study, first of all, the production rules of the attributive groups were constructed on basis of the questionnaire survey for the inhabitants. Next, using the set of production rules, we developed a multi-agent system model for evacuation. An agent in this study is a person that can perceive its environment through sensors and decide the activity through effectors. We simulate multi-agent system in a district in Kushiro City of Hokkaido, Japan. Finally, we concluded to build the reproduction of the human traffic behaviors and their interactions during earthquake impact and to be simulated multi-agent model including seven agent groups obtained the results of questionnaire survey.

Keywords: *traffic behavior, earthquake evacuation, multi-agent system*

INTRODUCTION

When not only earthquake disasters but also the other natural disasters such as flooding, landslides occur, it is necessary to decide the evacuation of the people who are living in damaged areas. The emergent evacuation is important to secure the human life. Thus, we should examine the characteristics of human behavior during the evacuation time (Kagaya, et al., 2009). In Japan, after Hanshin-Awaji huge earthquake disaster, it has been an important role of the society to build a comprehensive measure against natural disaster. In particular, in the case of earthquake disaster, it is substantial to establish the evacuation system including both public organization and communities synthetically. Considering the emergent evacuation system, it is difficult to have the characteristics of human behavior towards the disaster (Batty, 2001). It is because human behavior is various in terms of unusual state of psychology (Kagaya, 2009). In other words, when many people refuge simultaneously due to the large earthquake occurrence in a city, they may think and judge how to act independently, and then behave by themselves differently. Moreover, they also give influences to each other. Therefore, it is difficult to know the whole evacuation behavior stochastically due to a simple individual activity (Ulieru, et al., 2000).

In this study we discuss the method of multi-agent simulation as a new technology examining such an emergence. We construct multi-agent system to apply the evacuation behaviors with an occurrence of earthquake (Negishi, et al., 2004), (Kagaya, et al., 2005). In such a previous research, we evaluated several alternative scenarios using the multi-agent simulation model in terms of two conditional parameters on “following” and “knowing the location of evacuation shelter (place)”. As the result, it was obtained that the evacuation of the inhabitants was delayed due to the dependency of other people and the unknown evacuation shelters synergistically. However, we have left the questions if the rules of behaviors are appropriate or not and if the other characteristics affecting on the evacuation behaviors exist or not. Moreover, the existing studies also have the problem on applying the virtual model to the realistic world and reflecting the experimental results on the simulation model.

In view of this background, the objectives of this study is to build the evacuation simulation model based on the rules of human behavior and to execute some alternatives by use of the model. Using the evacuation simulation model, it is also to grasp the characteristics of human traffic behavior during the evacuation.

EVACUATION BEHAVIOR SIMULATION

Human Behavior and Intelligent Agents

An agent is anything that can be viewed as perceiving its environment through sensors and acting on that environment through effectors. A human has five senses for sensors, and hands, legs, mouth and other body parts for effectors (Horvitz, et al., 1988). Thus, the acts of an agent substitute for human behavior including both sensors and effectors. Basically, a rational agent is one that does the right thing using his intelligence. Rational activity depends on the performance measure, the percept sequence, the knowledge of the environment and the performance of action. In other words, a definition of an ideal rational agent is for each possible percept sequence, an agent should do whatever action is expected to maximize its performance measure based on the evidence provided by the percept sequence and whatever built-in knowledge the agent has (Wilson, 1991).

Figure 1 shows a structure of agent system with internal state. This model also shows how the current perception is combined with the old internal state to generate the updated description of the current state. The some options for perception are added (Russell, et al., 1995).

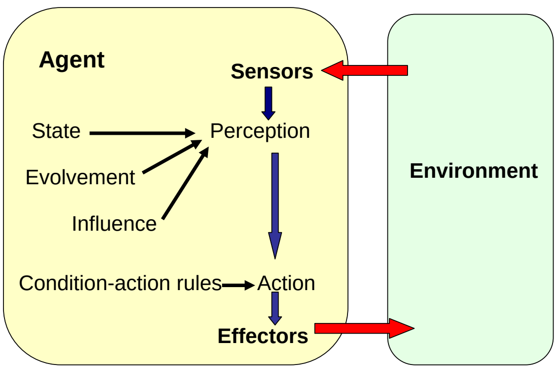

Figure 1. Diagram of a reflex agent with internal state

In the goal-based agent model, we discuss goals in the stage of action. On the other hand, the utility-based agent model adds an evaluation stage due to utility after the percept stage. This study adopts a reflex type or a reflex type with internal state.

Here, the production system, that is, the rule-based system is defined as the combination between perceptions and action in terms of data base, production rule bases and an interpreter, the inference engine. It is generally given in the following form:

If "list of conditions" then "list of actions", where "list of conditions" corresponds to elements in the data base and "list of actions" consists of primary actions such as changing data base elements.

Multi-agent Simulation

An agent is a physical or virtual entity. A physical entity is something that acts in the real world. On the other hand, a software component is virtual entity, since they have no physical existence. Agents are capable of acting, which is fundamental for multi-agent systems. The concept of action is based on the fact that the agents carry out actions which are going to modify the agents' environment and their future decision making. Agents are endowed with autonomy. They are directed by a set of tendencies. Agents have only a partial representation of their environment. The agent is thus a kind of living organism which is aimed at satisfying its needs and attaining its objectives on the basis of all the other elements (Ferber, 1999).

The multi-agent system is applied to a system comprising the following elements, that is, an environment, a set of objects, an assembly of agents, an assembly of relations, an assembly of operations and operators. The technology of multi-agent simulation contributes to the construction of evacuation behavior model and its simulation. Multi-agent is generally composed of a set of agents that act for themselves beneficially in terms of their strategies. It has also some two-way relationships among them. Multi-agent simulation is to simulate the system which is established in terms of computer program.

Models are generally created as an aid to predicting and understanding phenomena. In the case of modeling the multi-agent system, several techniques should be used as shown in Figure 2. First of all we observe phenomenon which is translated into the form of an abstraction. This can be manipulated to obtain results which can help us to improve our understanding or to predict future situations. As the phenomenon based on human behavior is usually complicated, we often use questionnaire in order to understand it more and to anticipate the future. In the modeling of multi-agent system, we should utilize this process effectively. We build an abstract model, and then, promote deduction, reasoning and calculations. As the result, we can forecast and comprehend human behaviors. It is necessary to introduce the anticipated results of phenomena into the model as the information on operations of the behavior (Batty, 2003).

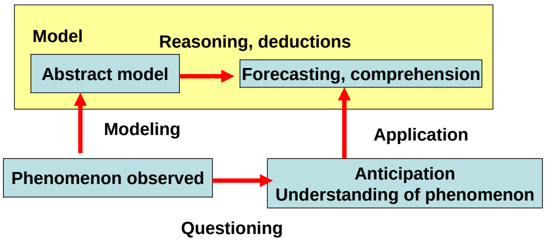

Figure 2. Model building for multi-agent system

Concept of Simulation and Procedure

The multi-agent system in this study is applied to the human traffic behavior with evacuation during the earthquake hazard. When the large-scaled earthquake like Hanshin-Awaji Earthquake occurs, many fires will break out in concurrence with it. First of all, we suppose such a condition and evoke the evacuation behavior in terms of creating each agent. Each agent is included in a family and a community simultaneously. The agents usually act on the multi-agent system interacting with the other agents. The interactions here are characterized by three conditions of mobility such as i) the following the other agents, ii) the lead to the other agents and iii) the inhibition of travel with congestion. Considering such a social environment and interactions, the rule bases of the agent actions are constructed (Kagaya, 2002).

Figure 3 illustrates the procedure of multi-agent simulation analysis which we constructed. Here, first of all, we prepare the space, the agents and the environment in a study area. Next, we establish a digital map of space in terms of GIS. Then, we survey on the questionnaire to make the reasoning system and classify several types of agents using the results due to cluster analysis. We compose of production rules to simulate multi-agent system. After that, we construct multi-agent model and simulation by Monte Carlo method. Finally, we analyze some alternative scenario.

SURVEY ON EVACUATION BEHAVIOR

Objective of Survey

The action rule bases depend on the standard of judgment due to individual characteristics such as the age, the experiences on earthquake disaster etc. So it is necessary to execute a questionnaire in order to construct the human evacuation behavioral rules. Actually, the survey was executed for the citizens in Kushiro City, in Hokkaido. They have experienced comparatively several earthquake disasters. The feature of evacuation behavior can be grasped in terms of the data obtained by the questionnaire. The objective of this analysis is to clarify the relationship between the evacuation behavior and the personal attributes and experiences in the earthquake disaster.

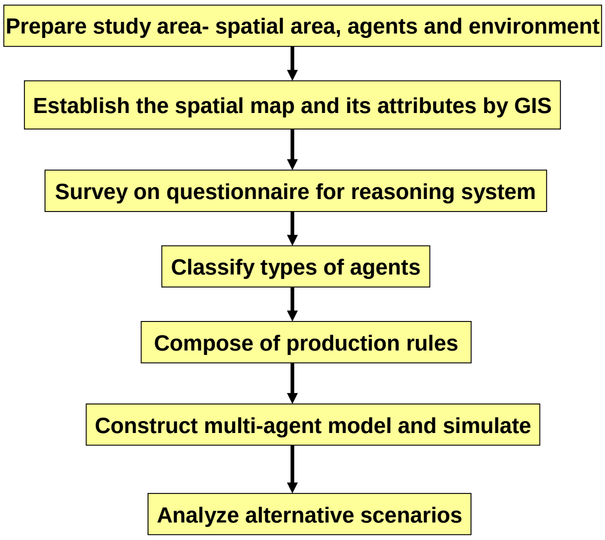

Figure 3. Procedure of multi-agent simulation analysis

Outline of Survey

The questionnaire for evacuation behavior was examined at several districts of Kushiro City. The main question is how to do if the evacuation is required due to a large-scaled earthquake. The outline of survey is shown in Table 1.

Next, the relationship between the age and the evacuation behavior was examined. Table 2 shows experiences of earthquakes of respondents in the study area. We can understand most of people have some experiences. Table 3 illustrates the relationship between the generation and the behavioral characteristics. It was almost same between dependency and independency among neighbor people.

CLASSIFICATION OF HUMAN EVACUATION BEHAVIOR PATTERN

As mentioned above, the relationship between the age and the evacuation behavior was found. Then, the cluster analysis was carried out using data of the question for evacuation behavior such as “Do you know the evacuation place?”, “What kind of action do you choose when the earthquake occur?" and the respondent's attributes as well. As a result of the analysis, it was possible to classify into seven clusters. Table 4 shows the characteristics of the evacuation behavior with each cluster.

Table 1. General outline of survey

Distribution & Collection Method	Home Distribution and Mail Collection
Survey Site	A District in Kushiro City
Number of Samples (Distribution)	600
Number of Samples (Collection)	220 (Rate of Collection36.7%)
Main Components of Question	-Attitude and Activity on the Earthquake in 2003 -Behavioral Evacuation on the Earthquake -Personal Characteristics, etc.

Table 2. Experiences of earthquakes more than the intensity of 3

Experiences / Generatio		Number of earthquakes experienced in Kushiro			Total
		0 - 2	3 - 4	More than 5	
Age	10-19	8	3	0	11
	20-29	8	9	0	17
	30-39	15	14	0	29
	40-49	13	28	2	43
	50-59	14	19	2	35
	60-69	21	37	3	61
	>69	3	10	4	17
Total		82	120	11	213

Table 4. Clusters obtained by characteristics of the evacuation behavior

Cluster	Age group	Evacuation place	Activity with others		Rate (%)
			Family	Neighborhood	
C-1	-19	unknown	following	following	10.2
C-2	20-39	known	taking	independent	12.4
C-3	20-39	unknown	taking	independent	9.1
C-4	40-59	known	taking	taking	21.5
C-5	40-59	known	taking	independent	18.8
C-6	60-	known	following	following	12.4
C-7	60-	known	taking	following	15.6

In order to build the multi-agent model, it is very important to grasp the appropriate behavior of each agent. Using the result of cluster analysis, we can make up the whole characteristics of human behaviors in case of the evacuation system. Each agent has each pattern of behavior. Therefore, an ideal model of multi-agent is to include the characteristics of each agent directly.

However, it is not practical to examine such a simulation. So we use the above-mentioned results and simulate multi-agent due to the patterns of behavior. The cluster analysis is available for adjusting the comprehensive behaviors. The obtained clusters should be considered to reflect the total activity. We define these clusters as agent types C1 to C7.

CONSTRUCTION OF SIMULATION MODEL OF EVACUATION BEHAVIOR

Establishment of the Simulation Space

Figure 4 represents a map used for simulation. This map is also made of the actual map of Mihara district in the Kushiro City which is one of the districts where the questionnaire was surveyed. The evacuation place is displayed by the deep color part in the center of the map.

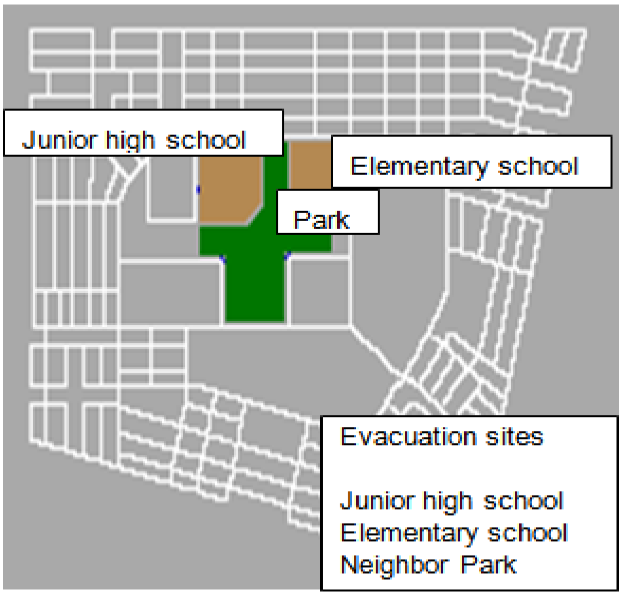

Figure 4. Map of study area

These are wide-area evacuation shelters existing in the district as an elementary school, a junior high school and parks. It is approximately within 1km from every house to the nearest evacuation place. The model of this district was constructed as the two-dimensional model including 7m× 7m grid structure. The people accomplish the evacuation behavior when they access along the road and reaches to the entrance of the evacuation shelter.

Action Rule Bases of the Agent as an Evacuator

The action rule bases of agents with evacuation were represented as seven patterns based on the results of cluster analysis as shown in the previous chapter. In this simulation the amount of the agents is 1000 persons. Each number of the agent group from type C-1 to type C-7 was divided by the proportion shown in Table 5 so that the random behavior was simulated in terms of Monte Carlo Method. Three parameters introduced by questions of "Does the agent know the evacuation place?", "how does the agent act with a family?" and "how does the agent also act in the neighbor people?" were applied to the multi-agent system simulation.

The item of initial setting for the other agents is shown in the following as

1. Initial coordinates: It is randomly placed on the roads in map every trial.
2. Moving speed: the speed of the agent type C-6 and C-7 is 0.8m/sec, and the speed of the other group is 1.4m/sec [2].
3. Family: A set of the family agent was composed of maximum three persons together as a single-family.

Simulation was progressed by repeating the step in every five seconds. In this simulation, they began to evacuate after they had decided what to do, so all agents did not evacuate simultaneously.

Next, we explain how each agent will evacuate after it determines the evacuation. To begin with, evacuators look for the evacuation lots within their range of vision. If they find an evacuation place, they move to that direction. If not, each agent has different activity with each group. Figure 6 shows action rules of the agent type C-1. The agent type of C-1 searches for the family or the neighborhood that helps to evacuate for it in its range of vision. And then, the agent moves to the objective point where such helpers (someone in the family or neighborhood) exist. If the agents cannot find their family or their neighborhood, they oblige to move for themselves selecting the random routes.

Figure 6 shows the action rules from agent type of C-2 to type C-5. In case of agent type of C-2 and type of C-3, they meet their speed with their families, when the other families follow them. The agent with type of C-2 moves along the routes to be approached to the evacuation place. The agent with type of C-3 moves along the random routes. In case of agent type of C-4, when the family or neighborhood follows the agents, they correspond to their moving speed with some persons with the family or neighborhood. In case of the agent type of C-5, their speeds correspond to the moving speed with their family. The agent type of C-4 and the type of C-5 move for selecting the route to approach an evacuation shelter.

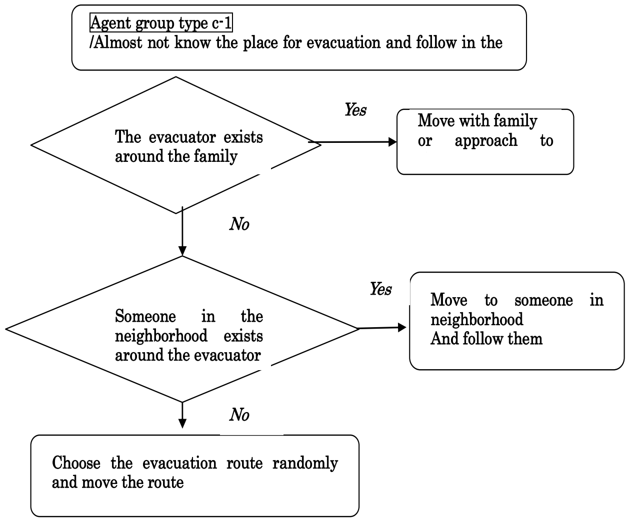

Figure 5. Production rules in the system of agent type of C-1

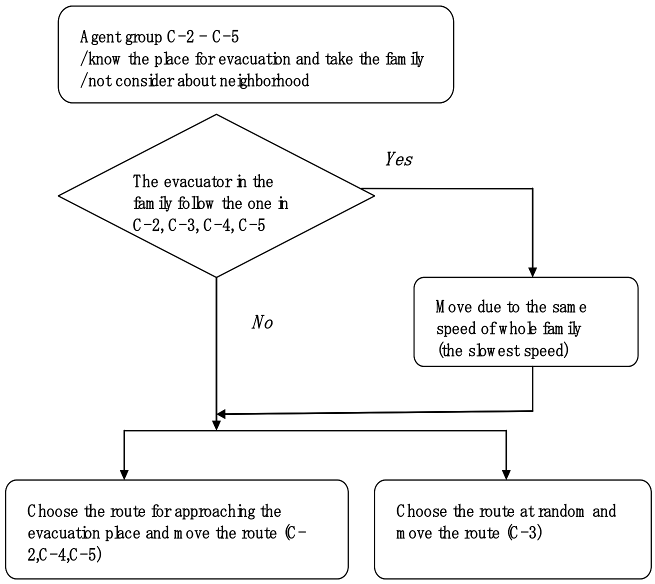

Figure 6. Production rules in the system of agent group type C-2, C-3, C-4, C-5

Figure 8 illustrates the behavior rules of the agent type of C-6 and the agent type of C-7. The agent type of C-6 looks for the family and neighborhood inhabitants who take them to evacuate. When the agents can find the person who is followed by them, they move to the place where the leader is. On the other hand, when the agents cannot find the person who leads them, they remove the route to approach the evacuate place.

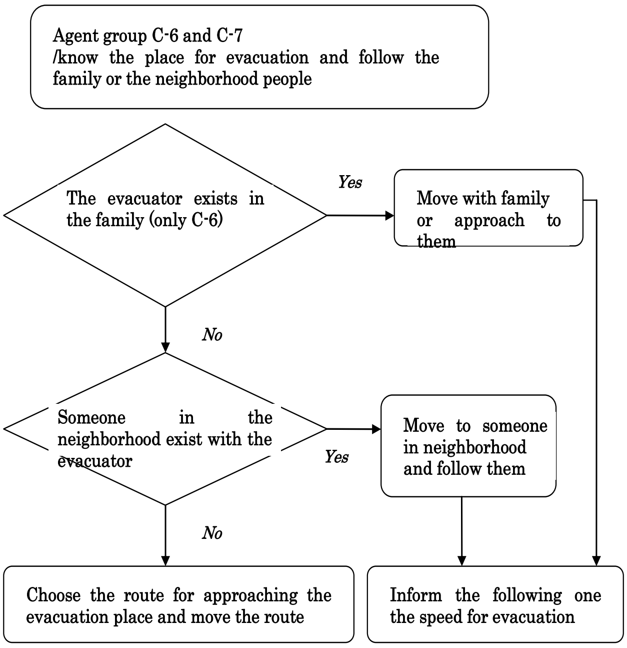

Figure 7. Production rules in the system of agent group type C-6, C-7

The computer simulation was computed by MAS (Multi-agent simulation language) (Yamakage, 2002).

RESULTS AND CONSIDERATION

Results of Simulation

Using the above-mentioned method, the simulation was examined. Figure 9 illustrates an example of the evacuation state on the map. Figure 10 indicate the results in 20 minutes after evacuation started. And Figure 11 indicates the proportions of agents who finished the evacuation as the simulation was executed.

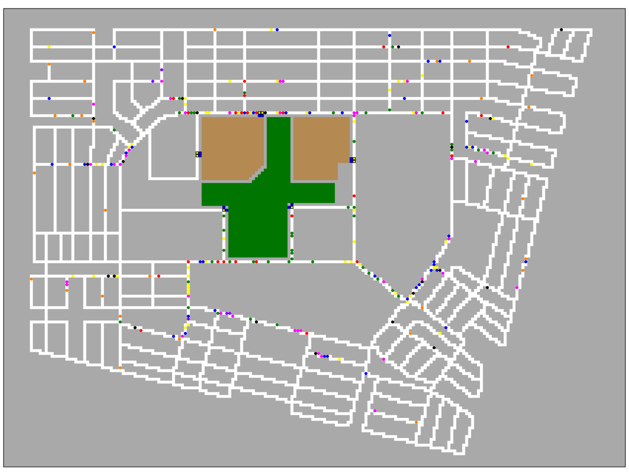

Figure 8. Example of evacuation state due to multi-agent simulation

The simulation are executed by using the random numbers and the different results are obtained by every trial, so that the average value due to twenty simulation trials is adopted as the evacuation results.

The results are condensed from simulation in the following as

1. The start of evacuation was executed step by step, so the congestion of roads for evacuation gradually increased with time. We can observe traffic congestions in some parts of the roads as shown in Figure 8.
2. The activities of the evacuation are different among the generations remarkably as represented in Figure 9.
3. As shown in Figure 10, nevertheless the agents in type of C-1 do not know the evacuation place, their evacuations are progressing. This is because they followed their family entirely.
4. In the case of type of C-3, they do not know the evacuation site, but they took others in their family. They were confused and delayed in evacuation.
5. Moreover, in type of C-6 and type of C-7 in which the aging agents are included, the agents type of C-6 has better results of evacuation than the agents type of C-7. As the result, we can understand the persons following the family or neighborhood people evacuate more efficiently than the persons following only neighborhood.

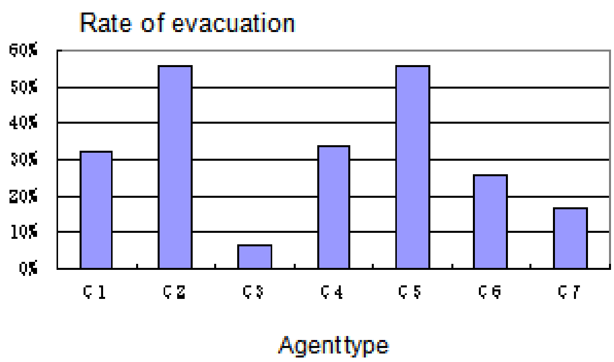

Figure 9. Achievement rate of evacuation for every agent type after 20 minutes

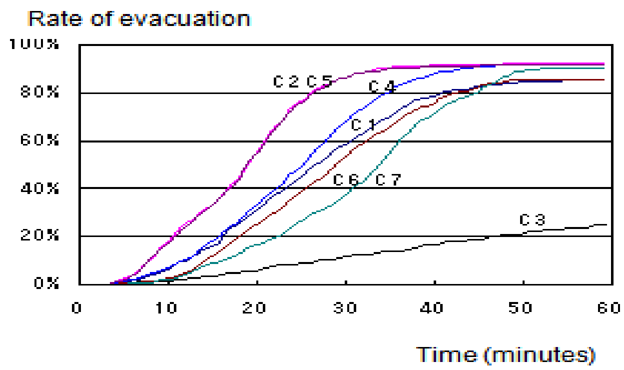

Figure 11 Achievement process of evacuation in every agent type

Consideration of Simulation

This simulation was mainly executed in view of the activities of classified agent types. This is based on the tendency of perceptibility in the occurrence of an earthquake disaster. When we cannot realize such phenomena again, we should think it is one of the most appropriate methods.

When we compare with the agent type of C-1 and agent type of C-3, agent type of C-1 can evacuate more smoothly than agent type of C-3, because they follow to the other agents.

On the other hand, the agent type of C-3 could not evacuate smoothly, because the agent in type of C-3 did not know the evacuation site and did not follow anyone. This case (type of C-3) is not efficient.

The agents in type of C-4 evacuated more slowly compared with agent type of C-2 and C-5, because the agent of C-4 took the followers in the agent type of C-6 and C-7 in which the walking speed of agent is slow.

The agents in type of C-6 and type of C-7 evacuated slowly, because the walking speed so slowly. In particular, the agents in type of C-6 evacuated most slowly. It can be understood that the evacuation efficiency is further better in the case of the subordination to the family, that is, a small group than in the case of the subordination to the neighborhood inhabitants.

CONCLUSIONS

In this study we classified people evacuation behaviors into seven patterns. Using such patterns, we built the rule bases of evacuation behaviors and executed several simulations based on the scenarios.

Here, it is highly reliable to make the simulation model including the behavior rules on basis of the real data from the actual questionnaire survey. We are sure that the inhabitants will act as they perceive the condition in an earthquake disaster. So it is important to examine the survey on awareness and compose of the results.

As the problems to be solved in the future, it is necessary to consider that the more detailed awareness towards earthquake disaster and the thinking with an earthquake occurrence should be included in the whole agents rule bases. Moreover, we think also it is necessary to promote a social experiment supposed to be a large-scaled earthquake disaster.

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SEISMIC RISK ASSESSMENT OF EXISTING BUILDING IN NORTHERN CYPRUS (CASE STUDY OF FAMAGUSTA)

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ABSTRACT

In the past, several earthquakes in the world have caused extensive losses of life and property. Determination of the vulnerable buildings within the existing building stock is therefore a high priority task in the seismic risk reduction of the urban environment. This paper focused on the seismic risk assessment of existing building stoke in Famagusta city (northern Cyprus), by applying a simple survey procedure that has been developed by Sucuoglu and Yazgan in 2003. To achieve this, classification of buildings has been done according to its structural systems, number of stories and the year of construction. Each category was further subdivided into groups yield different building classes. Concentrating on the ordinary reinforced concrete building the risk assessment of Famagusta was done. On the basis of this analysis the percentages of buildings that will be able to stand against the expected earthquake is found, and the percentages of buildings that will be in need of more in depth evaluation.

Keywords*: Buildings, Vulnerability, risk assessment, northern Cyprus.*

INTRODUCTION

Now a day's northern Cyprus concerning many types of buildings that belongs to different period of civilization such as Byzantine, Roman, Luzignan, Venetian, Ottoman, British, Recent time types, it can be seen that many buildings that belongs to those ages still in use, but others fail down (unusable). The certainty of earthquake in northern Cyprus means it is essential to put in place preparedness and emergency procedures. Much effort has been devoted in recent years to the problem of how to devise reliable estimates, given the large uncertainties that exist, many research has been conducted for the evaluation of the existing buildings such as (Sozen and Hassan, 1997; Gulkan and Sozen, 1999; and Yucemen et al., 2004).

SEISMIC RISK ASSESSMENT

Seismic risk is the prospective or probability of loss due to the incidence of an Earthquake. This risk can be thought out of three main elements – the earthquake hazard, the property at risk (i.e., the value that is in danger by the earthquake), and the vulnerability of the property to the effects of the earthquake. The compensation of those three elements can be shown in Figure 1 Earthquake hazard is simply the physical effects of natural environment (what 'nature does', including faulting, shaking, liquefaction, landsliding, tsunami etc.), that can be defined deterministically or probabilistically. Property at risk includes both physical and non-physical items that have financial value (e.g., business interruption, reputation). Vulnerability generically refers to the probability of damage given the occurrence of a hazard.

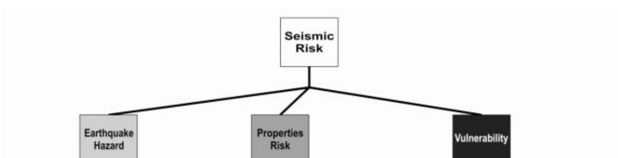

Figure 1. Risk assessment elements

Vulnerability Methods

Vulnerability can be done by using one or both of empirical, and analytical approaches: Empirical, in which mainly can be divided into three important sub-classes: field survey data, experimental and laboratory data, and expert opinion-derived, which is the estimate by knowledgeable persons with first-hand experience observing earthquake performance of structures. Analytical, means the properties of the Buildings are analyzed using a theoretical model based on a mechanics of materials or other theoretical framework.

Current approaches in seismic vulnerability evaluation methods can be classified in three main groups depending on their level of complexity. The first, most simple level is known as “Walkdown Evaluation.” Evaluation in this first level does not require any analysis and its goal is to determine the priority levels of buildings that require immediate intervention. The procedures in FEMA 154 (1988), FEMA 310 (1998) Tier 1 and the procedure developed by Sucuoglu and Yazgan (2003) are examples of walkdown survey procedures. Preliminary assessment methodologies (PAM) are applied when more in-depth evaluation of building stocks is required. In this stage, simplified analysis of the building under investigation is performed based on a variety of methods. These analyses require data on the dimensions of the structural and nonstructural elements in the most critical story. The procedures by FEMA 310 (1998) Tier 2 and Ozcebe et al. (2003), later complemented by Yakut et al. (2003) can be listed as the examples of preliminary survey procedures. It is possible to survey large building stocks by employing the preliminary evaluation methodologies within a reasonable time span.

The procedures in third tier employ linear or nonlinear analyses of the building under consideration and require the as-built dimensions and the reinforcement details of all structural elements. The procedures proposed in FEMA 356 (2000), ATC 40 (1996), EUROCODE 8 (2004) and those by Sucuoglu et al. (2004) and Park and Ang (1985) are examples of third level assessment procedures.

In this paper the procedure that has been introduced in (Sucuoglu and Yazgan, 2003) will be used, and for the sake of completeness and the integrity of the work presented here, the proposed methodology will be given in the following paragraphs.

Structural parameters that have to be observed during the field surveys and the value given to each parameter by the observer are briefly given below.

Survey Parameters

1. Number of Stories: This will indicate the total number of floors above the ground level.
2. Presence of a soft Story: A soft story usually exists in a building when one particular story, usually employed as a commercial space (such as Car Parking), has less stiffness and strength compared to the other stories.
3. Existence of heavy Overhangs: such as balconies and overhanging floors in multistory-reinforced concrete buildings.
4. Apparent Building Quality: A close relationship has been observed between apparent quality [good, moderate, poor] and experienced damage during an earthquake.
5. Presence of short Columns: Frames with partial infill lead to the formation of short columns which sustain heavy damage since they are not designed for the high shear forces due to shortened heights that will result from a strong earthquake.
6. Pounding Effect: When there is no sufficient clearance between adjacent buildings, they pound each other during an earthquake as a result of different vibration periods. Uneven floor levels aggravate the effect of pounding.
7. Topographic Effects: Buildings on slopes steeper than 30 degrees have stepped foundations, which cannot distribute ground distortions evenly to structural members above.
8. Local Soil Conditions: The intensity of ground motion at a particular site predominantly depends on the distance the causative fault and local soil conditions. since there exist a strong correlation between PGV and the shear wave velocities of local soils (Wald, 1999).In this study the PGV is selected as to represent the ground motion intensity. The PGV map in the JICA (2002) report has contour increments of 20 cm/s2. The intensity zones in Cyprus are expressed accordingly, in terms of the associated PGV ranges.

Zone I : 60<PGV<80 cm/s2
Zone II : 40<PGV<60 cm/s2
Zone III : 20<PGV<40 cm/s2

Based on their number of stories and the seismic hazard level at the site buildings are assigned different base scores as shown in Table 1.

Table 1. Base Scores and Vulnerability Scores for Concrete Buildings

Number of Stories	Base Scores (BS)			Vulnerability Scores (VS)					
	Zone I	Zone II	Zone III	Soft Story	Heavy Overhang	Apparent quality	Short Column	Pounding	Topog Effects
1or2	100	130	150	0	-5	-5	-5	0	0
3	90	120	140	-15	-10	-10	-5	-2	0
4	75	100	120	-20	-10	-10	-5	-3	-2
5	65	85	100	-25	-15	-15	-5	-3	-2
6or7	60	80	90	-30	-15	-15	-5	-3	-2

Building Seismic Performance

Once the vulnerability parameters of a building are obtained from walkdown surveys and its location is determined, the seismic performance score PS can be calculated by using Eq.1. The base scores, BS, the vulnerability scores, VS, and the vulnerability score multiplies, VSM, to be used in Eq. 1 are defined in Tables 1 and 2, respectively

$$PS=(BS)-\Sigma(VSM)\times(VS) \qquad (1)$$

The results are then smoothed, and the weights of the parameters for which there was no available data (soft story, pounding, topography) are assigned by using engineering judgment.

Table 2. Vulnerability Parameters, (VSM)

Soft story	Does not exist = 0; Exists = 1
Heavy overhangs	Does not exist = 0; Exists = 1
Apparent quality	Good = 0; Moderate = 1; Poor =2
Short columns	Does not exist = 0; Exists = 1
Pounding effect	Does not exist = 0; Exists = 1
Topograpic effects	Does not exist = 0; Exists = 1

SEISMIC ASSESSMENT FOR FANMAGUSTA

Being located on the boundary between Eurasian and African plates, Cyprus was affected by many destructive earthquakes throughout its history. The largest earthquakes mostly occurred at the southern part of the island, causing damage in Paphos, Limassol, and Famagusta (e.g., the earthquakes of 342 with magnitude Mw 7.4, 1222 with Mw 6.8, 1577 with Mw 6.7, 1785 with Mw 7.1, 1940 with Mw 6.7, and 1996 with Mw 6.7 (Galanopoulos and Delibasis, 1965; Ambraseys, 1992; Kalogeras et al., 1999).

In the recent years the seismic codes that has been used in Cyprus includes (Turkish Earthquake Code in the northern part, and the Eurocode 8 in the southren part), and the classical engineering approach for providing seismic safety in building structures was to ensure their conformance to the current seismic design codes that has been used. This is a valid approach for new buildings. However majority of the existing buildings in Famagusta environment do not satisfy modern code requirements, and a probabilistic seismic hazard assessment that was conducted for Cyprus by (Cagnan and Tanircan, 2009) strongly indicate the inadequacy of both codes that has been used (the Turkish Earthquake Code that is being used in the northern part of the island and the Eurocode 8 that is in effect in the southern part) in the island.

Based on those facts seismic vulnerability assessment for the existing building in Famagusata is necessary. The first, most simple level which is known as “Walkdown Evaluation.” to determine the priority levels of buildings that require immediate intervention will be completed in this paper.

STATISTICAL DATA

General Building Inventory

The following tables includes the Statistical Data for northern Cyprus, showing number of housing units according to structural material, type of building

Table 3. Number of housing units according to structural Material ((TRNC State Planning Organization)

	Total	Reinforced concrete	Masonry	Mud Brick	Prefabricated	Other	Not Indicated
Total	72624	55556	7193	9107	357	316	95
Lefkosa	22996	18206	1666	2830	136	131	27
Gazimagusa	18541	14540	1204	2651	58	71	17
Girne	16583	13905	2162	337	99	55	25
Guzelyurt	8608	4932	1085	2471	48	50	22
Iskele	5896	3973	1076	818	16	9	4

Table 4. Number of housing units according to Type of Building (TRNC State Planning Organition)

District	Total	Detached House	Semi-Detached House	Row House	Subsidiary House	Apartment	Other	Unknown
Total	72624	37508	13255	3995	1338	16244	210	74
Lefkosa	22996	8112	4139	2172	382	8109	61	21
Gazimagusa	18541	9538	3786	677	443	4046	36	15
Girne	16583	8980	2974	514	237	3819	43	16
Guzelyurt	8608	5778	1706	577	210	254	64	19
Iskele	5896	5100	650	55	66	16	6	3

Building Type Classification

Building type will be divided into four main categories as follow:

1. Type 1: Skeleton type reinforced concrete building (slab, continuous beams columns system).

In this type of buildings, the beams are continuous and supported by columns, usually the analysis for moment and shear for the beams is conducted using continuous beam analysis. This type is the mostly common in residential buildings.

2. Type 2: Reinforced concrete shear wall buildings and reinforced concrete moment frame buildings.
   In this type of buildings, the beams are continuous and supported by shear walls, this type of buildings is the mostly common in High rise buildings.
3. Type 3: Masonry, and plain concrete buildings.
   This class includes buildings which was very dominant before 1980. This type of building consist of walls made of plain concrete and/or stone, with wall thickness varying between 20 and 40 cm, no columns provided and the slab are concrete with minimum reinforcement of smooth bars of 12mm in each direction at 30 cm spacing, the slab thickness is 15 cm.
4. Type 4: Mud Stone, Building
   This type of building consists of walls made of Mud Brick, with wall thickness varying between 40 and 50 cm, no columns provided and the slabs are Timber Slabs.

In terms of number of stories in Famagusta, the residential buildings are either up to two stories or apartments with 2 to 4 stories and this is the majority of number of buildings, a small percent (20%) of buildings has number of stories greater than 4.

Turkish seismic design codes is recently developed in the year 2005 and enforced to buildings design starting June 2006 in Northern Cyprus. But the enforcement of engineering supervision for the buildings in Northern Cyprus evolved particularly in the year 1985, hence it has been decided that it would be appropriate to classify buildings as pre-1985 (included) and post-1985 reflecting the state of engineering design applications (Structures are designed by professional engineers), but the quality control due to engineering supervision during construction, and the soil testing reports evaluation by Engineering supervision is not yet applied, hence the projects is not completed professionally; (to complete a project professionally Soil testing should be performed for structures with plan area greater than 150 m2, the design and soil testing reports are reviewed by the Engineering Association before construction, site engineer is appointed -by the Engineering Association- to control the quality of construction in the field).

The building inventory classification used in this Paper is categorized according to building type, number of stories and construction date. Thus a classification of the buildings inventory was obtained according to building type, number of stories and date of construction:

Taking the construction type into consideration: ("i" dimension of the matrix)

1. Skeleton type reinforced concrete building (slab, continuous beams columns system).
2. Reinforced concrete shear wall buildings and reinforced concrete moment frame buildings.
3. Masonry and plain concrete buildings

Taking the number of stories into consideration; ('j" dimension of the matrix)

1. Low rise (1-2 stories)
2. Mid rise (3-4 stories)
3. High-rise (more than 4 stories)

Taking construction date into consideration: ("k" dimension of the matrix).

1. Construction year: Pre-1985 (included).
2. Construction year: Post-1985.

Table 5 shows the building inventory considering Famagusta Area, considering to the mentioned classification, and statistical data. The final numbers of classes that are used in the study are actually only 9 classes (Figure 2).

Table 5. Type of building in the building stock indexed with B_{IJK} identifier.

Class	Building Type (I)	Number of Stories (J)	Age (K)	Number of buildings
B111	1	1-2 floors	Pre-1985	4521
B112	1	1-2 floors	Post-1985	**6781**
B121	1	3-4 floors	Pre-1985	**395**
B122	1	3-4 floors	Post-1985	1180
B131	1	More than 4 floors	Pre-1985	0
B132	1	More than 4 floors	Post-1985	780
B211	2	More than 4 floors	Pre-1985	0
B212	2	More than 4 floors	Post-1985	630
B311	3,4	All floors	Pre-1985	253
Total number of buildings				**14287**

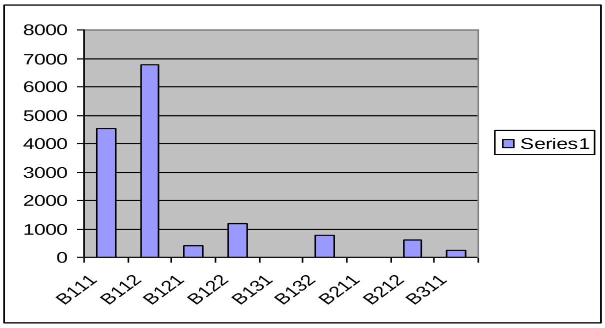

Figure 2. A column diagram shows the distribution of buildings into their relevant class.

First Stage Evaluation (Walkdown Evaluation)

The walkdown survey yielded the complete inventory of the building stock in the Famagusta district. At the end of this survey the buildings were identified in terms of their structural systems, their number of stories and their type of use. Walkdown survey results showed that there are currently 18,541 buildings in Famagusta14,540 comprise RC buildings, 1,204 comprise masonry buildings, 2651 were mud brick, 58 prefabricated and 88 were not identified. Table 6 catalogues the RC buildings with number of stories.

Table 6. Tabulation of RC Buildings According to the Number of Stories

# of Stories	1 or 2	3	4	5	5+
# of Bldgs	11303	1575	780	630	315

The walkdown survey yielded a preliminary seismic performance grading of the existing RC buildings in Famagusta relative to each other. The calculated performance scores of the RC buildings with 7 stories or less are given in Table 7. This table shows that the performance scores of the buildings are inversely proportional with the number of stories. This was calculated from the spatial distribution of existing RC buildings in Famagusta with respect to the calculated performance scores.

SUMMARY AND CONCLUSIONS

This paper presents a seismic vulnerability assessment application on a local scale. In the introductory parts of the manuscript a multi tier assessment methodology was summarized and in the second part the details of the field applications were introduced and the findings were presented.

The walkdown survey was made in the Famagusta area in northern Cyprus. 14603 buildings surveyed. Some buildings, which were assigned very high performance scores at the end of first tier, those buildings with lower performance scores should be given priority and a second tries should be performed as indicated in (Sucuoglu and Yazgan, 2003) , in the long run, the entire building stock in the region should be screened by the use of 1015 buildings should be selected for further investigation in the second tier.

Table 7. Calculated performance scores of RC buildings having 6 stories or less

Number of Stories	Performance Scores				Total
	PS ≤ 30	30< PS ≤ 60	60< PS ≤ 100	100< PS	
1-2	0	0	2150	9153	11303
3	0	15	1105	455	1575
4	6	234	498	42	780
5	60	410	145	15	630
6	225	65	20	5	315
Total	291	742	3918	9670	14603

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THE INDONESIAN NATIONAL PLAN OF DISASTER MANAGEMENT, 2010 – 2014

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ABSTRACT

Many kinds of hazards are found around Indonesia in high intensity and frequency. Those hazards may lead to catastrophes. Therefore, Indonesia is one of high disaster risk countries in the world. In order to systematically reduce the risk of the disasters, Indonesia has promulgated a national disaster management law in 2007 as the law base in dealing with disaster management in Indonesia, namely Indonesian Law No 24/2007. In the law states that the National Government and Regional Governments have been mandated to create the plan of disaster management that are coordinated by the National Agency for Disaster Management (BNPB) and Regional Agencies for Disaster Management (BPBD), respectively. In national level, BNPB coordinated ministries and other national government institutions that are related to disaster management created the National Plan of Disaster Management (Rencana Nasional Penanggulangan Bencana), abrevated by Renas PB, for the first time in 2009 for the period of 2010 to 2014. Renas PB is aimed to guide all efforts in every step in the disaster management by the government institutions. The Renas PB covers efforts in the prevention, mitigation, preparedness, emergency, and recovery of disasters. The Renas has strategic position and it is very crucial since in the implementation the programs in the Renas PB are included in the strategic plans (Rencana Strategis, RENSTRA) of national government institutions. The Renas PB also guides to a more operational and broaden national plan that is the National Action Plan of Disaster Risk Reduction (Rencana Aksi Nasional Pengurangan Risiko Bencana), abbreviated by RAN PRB, for the period of 2010 to 2012 for guiding disaster management actors, including non-government entity. This paper briefly describes the Renas PB that is intended to boost up the implementation of disaster management actions that are planned, guided, and integrated as it was mentioned in the disaster management mission in Indonesia.

Keywords:

BACKGROUND

Many kinds of hazard sources are found in Indonesia in high intensity and frequency. Therefore, the country is included in the countries that have high risk in disaster. There were huge disasters as well as a series of small scale disasters occurred in Indonesia. In the 19th and 20th centuries, there were gigantic and deadly volcano explosions, for example, Tambora Volcano, Krakatau Volcano, and Kelud Volcano.

The most deadly disaster in the 21st century started from Indonesia, which were the 2004 Aceh earthquake and tsunami. The disaster killed more that 200 thousand people and destroyed shores in 11 countries. Many kinds of natural disasters, such as earthquake and flood, as well as non-natural and social disasters hit Indonesia almost every year that kill many people and create tremendous loss.

To reduce the risk of disasters, Indonesia needs a series of integrated, coordinated, and comprehensive plans. In response to the need, the government created a national disaster management plan in 2009. The plan, that was coordinated by BNPB (*Badan Nasional Penanggulangan Bencana* / National Agency for Disaster Management / National Disaster Management Agency) in the process of its formulation, is the National Plan of Disaster Management (*Rencana Nasional Penanggulangan Bencana*), abbreviated by Renas PB, for the period of 2010 to 2014 (BNPB, 2009). The plan portrays the projected condition for 5 years concerning disaster management started from disaster hazard identification, disaster risk analysis and ended with action programs and chosen priority focus along with the participation of ministries/agencies (*kementerian/lembaga* / K/L) and the budget. The Renas PB is the manifestation of government efforts related to the formulation of activities and priority focus of disaster management. Creating the Renas PB is a part of the implementation of the Indonesian Law No 24/2007 concerning Disaster Management in Indonesia.

The Renas PB is an official document that contains data and information about disaster risks in Indonesia in the period of 2010 to 2014 and the government plan in reducing those risks through activity programs. The activity programs are based on the vision and mission of disaster management and action plan that is based on the risk management principles. The implementation of Renas PB is required to be integrated in the development plan as it is mentioned in the Article 35 of Law No 24/2007. Later, the Renas PB leads to a more operational and broaden national plan that is the National Action Plan of Disaster Risk Reduction (*Rencana Aksi Nasional Pengurangan Risiko Bencana*), abbreviated by RAN PRB, for the period of 2010 to 2012 to direct disaster management actors, including non-government entity.

This paper is intended to briefly illustrate the Renas PB (BNPB, 2009). The sequence of this narration is the purpose of the Renas PB, the document position and the law base of the Renas PB, the development process of the Renas PB, the action principles of the Renas PB, and the content of the Renas PB. The content of the Renas PB is general description of disaster; problems, challenges and opportunities; the policies of disaster management; programs; budget and funding; and monitoring, evaluation, and report.

THE PURPOSE OF THE RENAS PB

The purposes in creating the Renas PB are:

1. to identify high risk region from possible kinds of disasters and to formulate the specific actions that need attention along with action programs, priority focus, and indicative budget and
2. to provide a reference for ministries and government agencies and disaster management stakeholders in Indonesia in order to accomplish planed, integrated, coordinated, and comprehensive disaster management.

THE DEVELOPMENT PROCESS OF THE RENAS PB

The Renas PB is executed for five years for inter-sector government plan. The essence of the Renas PB is integrated to the document of National Middle Period Development Plan (*Rencana Pembangunan Jangka Menengah Nasional* / RPJMN) that contain policies, development programs and action plans of the government along with the frame of regulations, the frame of budget, and the detail of programs. Every year, the government refers RPJMN in making the Government Action Plan (*Rencana Kerja Pemerintah* / RKP). The ministries and national agencies (K/L) refers the Renas PB in making their Action Plans. Regional governments refer the Renas PB in formulating their Regional Disaster Management Plan (*Rencana Penanggulangan Bencana Daerah*/RPBD) and Regional Middle Period Development Plan (*Rencana Pembangunan Jangka Menengah Daerah* / RPJMD). The Renas PB becomes a guideline in conducting the mainstreams of policies and programs of disaster management in Indonesia. Therefore, the position of the Renas PB is very strategic.

The law base of the Renas PB is Indonesian Law No 24/2007 regarding disaster management in Indonesia. In article 4 states that the purpose of disaster management efforts is to assure the implementation of planed, integrated, coordinated, and comprehensive disaster management. In article 6 mentions the responsibility of the government in the accomplishment of disaster management. In article 35 states that Government is obliged to prepare disaster management plan during absence of disaster occurrence. In article 36 mention that BNPB/BPBD coordinates the plan. The Renas PB refer to a series of related laws that were previously stipulated.

THE ACTION PRINCIPLES OF THE RENAS PB

The Renas PB is the realization of the government commitment in the issues of disaster management that has been legalized by the Head of BNPB in the form of the Head Regulation (*Peraturan Kepala*, Perka). The Renas PB is a guideline for ministries and agencies (K/L) in the establishment their Strategic Plan (*Ren-*

cana Strategis, Renstra) and National Action Plan of Disaster Risk Reduction (RAN PRB). The Renas PB is also a guideline for the formulation of Regional Disaster Management Plan (*Rencana Penanggulangan Bencana Daerah* / RPBD) and Regional Middle Period Development Plan (*Rencana Pembangunan Jangka Menengah Daerah* / RPJMD).

The principles in conduction the Renas PB follow:

1. Ministries, government agencies, regional governments, and community including business actors refer to the Renas PB in the disaster management related actions.
2. Ministries and government agencies are responsible to create their action plans (Renstra) that incorporate disaster risk reduction referring to the Renas PB, and they are also responsible to ensure the consistency between their Renstra and the Renas PB in the disaster management related issues.
3. Regional governments are responsible to create their regional disaster management plans (RPBD), that become a guideline in formulating the strategic plans of regional working units (*Rencana Strategis Satuan Kerja Pemerintah Daerah*, Renstra SKPD), to incorporate disaster risk reduction referring to the Renas PB, and to ensure the consistency between their RPBD as well as RPJMD and the Renas PB in the disaster related issues.

BNPB and the Ministry of National Development Plan / National Development Plan Agency (*Kementerian/Badan Perencanaan Pembangunan Nasional*, Bappenas) are obligated to monitor the breakdown of the Renas PB to the action plans of K/L and the RAN PRB as well as RPBD and RPJMD in order to increase the effectiveness of the realization of the Renas PB.

THE CONTENTS OF THE RENAS PB

The content of the Renas PB is general description of disaster; problems, challenges and opportunities; the policies of disaster management; programs; budget and funding; and monitoring, evaluation, and report. The following brief explanation is the general content of the Renas PB.

THE GENERAL DESCRIPTION OF DISASTER

There are three components to be considered in the efforts of disaster risk reduction. The components are hazard, vulnerability, and capacity, as the following explanation.

Hazard

Hazard is occurrence or event that may lead to disaster. Hazard could be in the form of natural phenomenon, non-natural phenomenon, or social interaction. In Indonesia natural hazards are, for example, earthquake, tsunami, volcano eruption, landslide, flood, drought, forest / land fire because of natural factors, building and settlement fires, erosion, extreme waves and abrasion, extreme climate, plant pest and disease, epidemic, outbreak, extraordinary event, and outer space event / outer space object. Non-natural hazards could be in the forms of forest/ land fire caused by human, transport accident, constructional / technological failure, industrial impact, nuclear explosion, environmental pollution, and outer space activity. Social hazards are, for instance, social unrest and social conflict.

Vulnerability and Capacity

Vulnerability is a system attribute existing prior to the disturbance/change/hazard, although it is often related to the history of disturbances to which the system was exposed in the past (hence the importance of the system's history) (ECLAC, 2003). The vulnerability could be physical, social, economical, and environmental forms.

An aspect to determine vulnerability is the position of a community toward the center of hazard. For illustration, a community that lives closest to a volcano crater is the most vulnerable, and a community lives in a shore that is close to subduction zones is vulnerable to tsunami. Other aspect of vulnerability is the level of density population. Indonesia has uneven distribution of population. The capital city of Jakarta and several other cities are extremely dense having more than 10 thousand residents per square kilometer comparing to 7 residents per square kilometer in the Province of Papua. Therefore, the cities become very vulnerable places to live. Other aspects of vulnerability are poverty and insufficient educated people. Poor community having inadequate education is very vulnerable to face disaster.

The response capacity is the system ability to adjust or to resist the disturbance, moderate potential damage and take advantage of opportunities. Various factors play a part in determining response capacity, including resilience, the availability of reserves and information, internal regulation mechanisms and the existence of cooperative links with other systems (ECLAC, 2003).

Capacity to respond to disaster could be from the side of institution or community. In the side of institutional capacity, Indonesia has leaped since the enactment Law No 24/2007 concerning disaster management followed the implementation of Indonesian President Regulation No 08/2008 by establishing BNPB and provincial, district, and municipal BPBD. Therefore, the efforts in disaster management turn out to be more directed, integrated, and comprehensive. To increase the institutional capacity could be accomplished in making the institutions to be improved in authority, facility, and resources. Capacity of community could be strengthened by escalating disaster awareness, disaster simulation and training, and knowledge in reducing disaster risk of the people. Growing number and quality of the centers of disaster study in universities and the community organizations dealing with disaster management actions are able to support the capacity strengthening of institution and community, respectively.

Disaster Risk

Applying risk management approach, the efforts in reducing disaster risk means the efforts in reducing hazard, reducing vulnerability, and/or increasing capacity. The Renas PB has zoned hazards and disaster risk in Indonesia in the forms of both maps and tables.

PROBLEMS, CHALLENGE, AND OPPORTUNITY

The Renas PB (*Rencana Nasional Penanggulangan Bencana* / National Plan of Disaster Management for the period of 2010 to 2014) mentions problems, challenges, and opportunities in handling disaster management in Indonesia as follows.

Problem

Among problems in managing recent disasters are mentioned in the following examples.

1. The performance in dealing with disaster management has not been optimal. In general, government, community, and disaster management related stakeholders have not been ready to face disasters.
2. The institutional orientation of disaster management still focuses on emergency stage rather than on entire disaster management stages. It means that the disaster management orientation is still responsive rather than preventive.
3. The roles of government and organization beyond victim communities are still dominant. It means that the aids for the victims and the rescue operations can not be performed satisfactorily, especially to remote areas.
4. The innovation and application of engineering approach and technology to reduce disaster risk have not been optimal yet. Coordination among universities and research institutions has not been adequately intensified.

Challenge

Among challenges in managing near future disasters are revealed in the following example.

1. The institutions of BNPB and BPBD are still young. Several regional governments have not established BPBD. It means that they have to intentionally enhance their performance and to rapidly establish more BPBD.
2. New orientation in disaster management has not been adequately socialized to become policies, regulations, and permanent procedures to reach the lowest level of government.
3. As a big and relatively young country, huge need in strengthening capacity is obvious. So many people live in the hazardous areas are urgent to create activities to increase their capacity faster. This urgency also applies to officials having disaster management related duties.
4. The organizations during the emergency stage of disasters are considered to be sluggish. The organizations during the rehabilitation and reconstruction stages of disasters have not included local wisdom and the mindset of “build back better”.
5. The budget is very limited to handle big efforts in reducing disaster risk. The biggest portion of the budget is still focused on the stages of emergency and post disasters rather than on the stage of pre disaster during the absence of disasters.

Opportunity

Among opportunities in handling near future management of disasters are stated in the following cases.

1. After the stipulation of Law No 24/2007 and consecutively the establishment of BNPB, conducive environments in supporting the efforts of disaster risk reduction as well as in accelerating differential regulations has emerged.
2. The establishment of BNPB, following by BPBD around the country, causes the implementation of disaster management to become more directive, integrated, comprehensive, and effective-efficient.
3. Increasing attention of the world and Indonesian communities in the issues of disaster risk reduction grows more party and people to form organizations to participate in the disaster management affairs. This leads in better dealing with disasters, since the responsibility is not merely by government anymore.

The advance of information and communication technology creates easier collaborations in dealing with disaster management among actors, either domestically or internationally.

DISASTER MANAGEMENT POLICY, PROGRAMS, BUDGET AND FUNDING, MONITORING, EVALUATION, AND REPORT

The Renas PB contains disaster management policy (vision-mission, institution arrangement, and strategy), program, budget and funding, monitoring, evaluation, and report as follows.

Vision and Mission

The vision of disaster management in Indonesia is to establish: "A Resilience Nation in Facing Disasters". The mission of disaster management in Indonesia is to: (1) to protect the nation from disaster threats trough risk reduction, (2) develop an advanced disaster management system, and (3) organize a planed, integrated, coordinated, and comprehensive disaster management.

Institution Arrangement

Referring to Indonesian Law No 24/27, primary institution to organize the disaster management is BNPB (*Badan Nasional Penanggulangan Bencana* / National Agency for Disaster Management). The implementation of disaster management, BNPB coordinates and collaborates with K/L (*kementerian/lembaga*, ministries/government institution) and other related institutions. BPBD (*Badan Penanggulangan Bencana Daerah*, Regional Disaster Management Agency) handles disaster management in the level of province, district, or city. Besides government disaster management agency, there is a National Platform of Disaster Risk Reduction (*Planas* PRB) to accommodate the participation of all disaster management actors. The organization supports in the alignment of national policies, programs, and actions of disaster risk reduction. Other such platforms are established in sectoral or regional levels. The Renas PB also states the roles of ministries and national institutions in dealing with disaster management.

Strategy

Strategy to realize the vision and mission of disaster management in Indonesia follows: (1) strengthening regulation frames of disaster management, integrating risk reduction programs into development plan, empowering universities, developing community based disaster management, establishing Quick Response Unit of Disaster Management (SRC – PB), creating risk disaster programs for specific need groups, escalating the role of non-government organizations and government partner organizations, and increasing the role of business actors.

Program

The Renas PB (*Rencana Nasional Penanggulangan Bencana* / National Plan of Disaster Management for the period of 2010 to 2014) contains programs and priority focus as basic components in making disaster management activities. Programs are the breakdown of vision and mission as well as action options based on risk management analysis. Indonesia is developing disaster management system that has five pillars in the forms of legislation, planning, institution, funding, and capacity amplification subsystems. The Renas has nine programs that are (1) strengthening regulations of law and institutional capacity, (2) integrated plan of disaster management, (3) research, education, and training, (4) increasing capacity and participation of the community and other actors in disaster risk reduction, (5) disaster prevention and mitigation, (6) disaster early warning, (7) disaster preparedness, (8) disaster emergency, and (9) disaster rehabilitation and reconstruction. The Renas PB has detailed the programs and priority focus.

Budget and Funding

In the Renas PB, the needed budget in handling disaster management has been compromised in the total Rp. 64.475.060.000.000,00 (around US$ 7 billion) for five years, averaging Rp. 12.895.012.000.000,00 each year. The indicative budget breakdown for each program and each specific disaster are shown in Table 1 and Table 2, correspondingly.

Table 1. Indicative budget for each program

No	Program	Indicative Budget (billion rupiah)
1.	Strengthening regulations of law and institutional capacity	30.638,00
2.	Integrated plan of disaster management	24,16
3.	Research, education, and training	368,50
4.	Increasing capacity and participation of the community and other actors in disaster risk reduction	2.855,60
5.	Disaster prevention and mitigation	6.665,50
6.	Disaster early warning	822,00
7.	Disaster preparedness	7.415,80
8.	Disaster emergency	1.008,50
9.	Disaster rehabilitation and reconstruction	14.677,00
	Total	**64.475,06**

Table 2. Indicative budget for each disaster type

No	Disaster Type	Indicative Budget (billion rupiah)
1.	Earthquake	12.489,00
2.	Tsunami	4.007,50
3.	Volcano	931,00
4.	Landslide	1.111,60
5.	Flood	2.150,00
6.	Other disaster types	2.774,70
	Total	23.463,80

The sources of funding in handling the disaster management could come from National Budget (*Anggaran Pendapatan dan Belanja Negara* / APBN), Regional Budget (*Anggaran Pendapatan dan Belanja Daerah* / APBD), business actors, and funding institutions. The Renas PB explains those funding in detail.

Monitoring, Evaluation, and Report

Monitoring and evaluation (monev) are needed to control the realization of development programs and activities in order to congruent with the plan. The monev of programs and activities written in the Renas PB refers to appropriate regulations of law. The monitoring of the Renas PB implementation is the obligatory of the heads of K/L. Entities beyond government can be involved in the monitoring activities in the forms of working groups with the coordination of government. Evaluation of the implementation can be conducted both routinely and suddenly after disaster occurrences. Implementation of programs and activities in disaster risk reduction is mandatory to be informed in the form of middle written reports and final written reports. The reports include the analysis of success or failure in the implementation and contain recommendations.

Closure

Indonesia has many sources of hazard. A hazard may lead to a disaster. If there is no adequate efforts in disaster risk reduction, disasters in Indonesia is going to escalate year by year. Many previous efforts in disaster risk reduction yield success, for example, the construction of houses using concept of BARRATAGA (a type of earthquake resistant houses using masonry walls) in Bantul and vicinity areas in Yogyakarta, Indonesia prior to the 2006 Yogyakarta earthquake that obviously could save lives and property during the strong quake (EERI, 2006; EHC, 2006; 2004; NHK, 2006; Sarwidi and Associates, 2004). That activity was the results of lesson learned from previous disasters (Sarwidi, 2001), which needs improvement every time (Sarwidi and Associates, 2008).

Although getting success in disaster risk reduction, such partial activity was considered to give small scale impacts. The born of Renas PB leads efforts in reducing disaster risk to become more planed, guided, comprehensive, and integrated. There are many problems and challenges in the organizing disaster management in Indonesia. However, there are also found abundant of opportunities. Therefore, the disaster risk in Indonesia, and consequently the world, is going to be decreased significantly time by time if the efforts are conducted by more people using systematically manners, such as what are contained in Renas PB.

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POLLUTION OF THE SONGHUA RIVER WITH NITROBENZENE BY ACCIDENT AND THE COUNTERMEASURES

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ABSTRACT

The pollution of the Songhua River in China with nitrobenzene was investigated by analysizing the concentration of nitrobenzene in water, ice and fish samples collected from the Songhua River after the explosion of a petrochemical plant.Nitorbenzen was detected in most of samples but the concentration in all samples was sufficiently lower than the permissible level for drinking water in China. At the same time, the removal of nitrobenzene in water was investigated by using carbon materials released from combustion of woody biomass as adsorbents. The carbon material showed the similar ability of adsorption for nitrobenzene to that of commercially available activated carbon. Moreover, the removal of nitrobenzene and some benzene relatives was demonstrated by magnetic separation with hydrophobized magnetite.

INTRODUCTION

An explosion of chemical plants occurred at the petrochemical plant owned by Petro China Jilin Petrochemical Company in Jilin, Jilin Province, China, on 13 November 2005. The information from various media indicated that the explosion had resulted in the spill of approximate 100 tons of chemicals, including benzene, aniline and nitrobenzene (NB), into the Songhua River. Consequently, the main supply of drinking water of Harbin city, on the banks of the Songhua River, was cut off for several days to avoid the contamination of water distribution systems in Harbin. The Songhua River (1,927 km), which flows through Jilin and Heilongjiang provinces, merges with the Amur River in Russia, eventually flows into the Sea of Okhotsk as shown in Figure 1.

The pollutants spilled from the explosion were reported to be benzene, aniline and NB. However, the concentration of benzene was immediately reduced to the permissible level (0.01 mg L^{-1}) in surface water in China and aniline was not detected. NB was a main pollutant to spread to the wide area in the Songhua River. NB is widely used in the field of chemical industry for the production of raw materials, such as aniline, quinoline, azobenzene and trinitrotoluene, which are used to make explosives, rubbers, pesticides, agricultural chemicals and so on.

The exposure to NB via inhalation or absorption through the skin causes methemoglobinemia, which results in fatigue, dizziness, headache and nausea. NB is one of the aromatic compounds that remain in the environment for a relatively long period. The specific gravity of NB is greater (1.2 g cm^{-3} at 4 °C) than that of water. Therefore, when it is released into an aqueous environment, NB tends to sink to the bottom of water, where it remains for a long time. On the other hand, the solubility of NB in water is relatively high (1900 mg L^{-1} at 20 °C). When it is released into rivers, it is gradually hydrated and partially dissolved in water. Few investigations of NB in water, ice and fish samples collected from the Songhua River after the explosion of petrochemical plant had been reported.

The concentration of NB in river water has now decreased to the safe level, however, we still have to pay much attention to the case of the Songhua River, because pollution by accidents such as the explosion might give in the future severe damage to human health and aquatic ecosystem in not only China but also all other countries. At the same time, we have to develop new technologies and materials to remove harmful materials from a contaminated environment as the countermeasures for the accidents which might occur in future.

In this study, we determined the concentration of NB in water, ice and fish samples which were collected in the Songhua river after passing of pollutants through Harbin city. We also examined the adsorption capacity of the carbon materials that are released during the combustion of woody biomass for the development of an inexpensive and environmentally friendly adsorbent for NB.

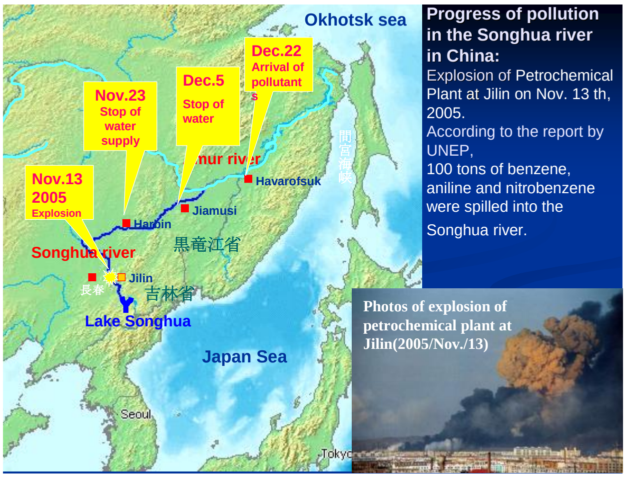

Figure1. Progress of pollution of the Songhua River

Moreover, in order to facilitate the recovering method of adsorbents in water after adsorption of pollutants, we demonstrated the magnetic separation of nitrobenzene and some benzene derivatives with magnetite having hydrophobic surface.

RESULTS AND DISCUSSION

Concentration of NB in Water, Ice and Fish Samples from the Songhua River

The date when the explosion occurred in Jilin was 13 November 2005 and the date when the pollution plume arrived at Harbin city was 25 November 2005. It was said that because it was the beginning of winter season, the surface of the Songhua River had begun to freeze, and some amount of the NB might be captured in the ice. According to the UNEP's report, the concentration of NB in a ice sample was one fourth of that in water. It was in the middle of March of 2006 that we at first took the ice and water samples from the Songhua River in the city of Harbin. This was four months later after the spill of NB to the river. In the case of the Songhua River having the massive flow of 2,350 m^3 s^{-1}, four months were enough for washing up the pollution sites. It was predicted that the pollution level with NB was very low around Harbin city at that time. The analytical data of ice and water samples collected from the Songhua River are shown in Table 1 and 2.

Table 1. Concentration of nitrobenzene in water and ice samples(1)

Results of analysis of water and ice

River water and ice sampled in March 2006

Samples at Harbin	Concn. of nitrobenzene
ice at surface	0.65 μ g/L
Ice at surface	0.04
Ice at surface	0.02
Ice under 20 cm	0.03
Ice under 100 cm	0.05
Water of down stream	0.19
River water of up-stream	0.03

Measurement: GC-MS using DB5 Capillary column deuterium-isomer of nitrobenzene(NB-d5)
Detection limit: 0.01 (μ g/L), Criteria in China: 17 (μ g/L)

Table 2. Concentration of nitrobenzene in water and ice samples(2)

River water sampled in May of 2006

Samples at Harbin	Concn. of nitrobenzene
Water of up-stream	0.03 μ g/L
Water of down-stream	0.03

River water sampled in October 2006

Samples at Harbin and Jilin	Concn. of nitrobenzene
Water at up-stream(Harbin)	0.04 μ g/L
Water in down-stream(Harbin)	0.04
Water in branch(Harbin)	0.02
Well water near river(Harbin)	0.02
Water on up-stream(Jilin)	0.05
Water in down-stream(Jilin)	n.d.
Water in Song-hue lake	0.11

These tables show that the NB concentrations in water samples are 0.02 to 0.19 μg L^{-1}. The concentration was much lower than the concentration (0.58 mg L^{-1}) of NB in the pollution plume which arrived at Harbin city on 25 November 2005. After passing the pollution plume away to the downstream, the concentration of NB in the river water decreased rapidly due to the water dilution, volatilization, decomposition, deposition on sediments and living bodies and so on.

Moreover, it was said that plenty of water from the Fengman hydroelectric power station was released into the river in order to dilute the pollutants. However, there was little information on the amount of water released. On the other hand, the concentrations of NB in ice samples were also sufficiently low except for the value of one ice sample near the surface (0.65 μg L^{-1}). If the ice was formed just during the pollution plume was passing through Harbin city, and if the concentration of NB in ice become one fourth of that in water (0.58 mg L^{-1}) as described in UNEP's report, then the concentration of NB in the ice might be about 0.15 mg L^{-1}. However, the concentration of NB in the ice samples was much lower than that value. Some possible reasons could be thought to explain the difference between the concentration of NB in the ice samples and the predicated one. One was, due to the fact that the surface water of the Songhua River in Harbin city was frozen after passing away of pollution plume. The second was that, when ice was formed, there was a special process for excluding NB from ice.

The concentration of nitrobenzene in fish samples are shown in Fig.2. These fishes were provided by fishermen who fish in the Songhua River. The species and the size of these fish are different each other. However, the concentration seems to be reduced date by date. The concentration of nitrobenzene in fishes sampled in Oct. 2007 was enough low. For some samples, nitrobenzene in muscle and internal organ was measured separately. However, we could not obtain the peculiar tendency. Nitrobenzene in sediment samples of the Songhua River was also analyzed. The concentration in the sediment near the outlet for waste water from many industries in Jilin was relatively high but others were low except the sample taken at a site in Harbin.

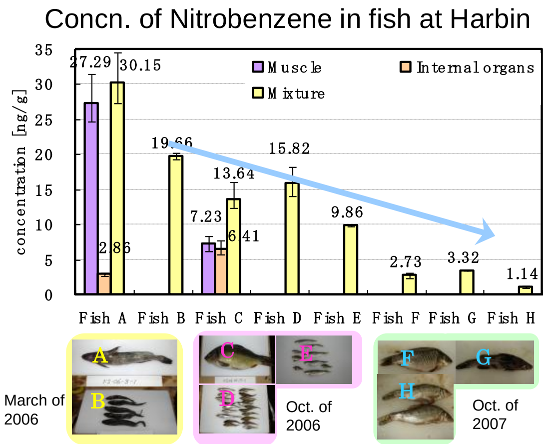

Figure 2. Concentration of nitrobenzene in fish samples

Development of Materials for the Countermeasure of Pollution

According to the report by UNEP, the following countermeasures were carried out for mitigation of the pollution in the Songhua River, (1) Release of water to the Songhua River from the Fengman hydroelectric power station. (2) Throwing activated carbon or a mixture of activated carbon, straw and maize stocks in a cage to near the inlet for water supply. However, the effects of these methods have not yet been reported in detail. We could not directly contribute to this accidental pollution of the Songhua River. However, similar accident can happen in future. Then we started the following studies,

(1) Low-cost carbon material as adsorbent for nitrobenzene.

(2) Hydrophobized magnetite for magnetic separation.

Low Cost Carbon Materials as Adsorbent

The carbon materials used in this study were produced during combustion of wood chips in a gasification power plant (Thomas Koch Corporation, Denmark) in Oshu City of Iwate prefecture in Japan. The power plant was built as a cooperative project by the regional energy promotion office of Oshu City, the Iwate prefecture, and the Hitachi Zosen Corporation. The wood chips used in this experiment were obtained from logging or thinning of trees (Japanese cedar and red pine after approximately 25 years of growth) during the summer of 2006. First, the woody chips were dried. Subsequently, the dried wood chips were pyrolyzed at 1073 K to 1273 K for gas extraction. Because the power-generation system can not use high-temperature gases, the extracted gas was cooled using thermal exchange, purified by filtration over bug filters, and subsequently fed into the electric power generator. Using the gasification furnace system, 5 wt% of the wood chips are converted into carbon material. The C1 carbon material was extracted from the bottom of the furnace in the wood biomass gasification power plant and was powdered using a crusher, Wonder Blender WB-1 (Osaka Chemicals Co., Japan). The carbon material C2 was extracted from the inside of the bug filter.

The NB adsorption capacities of C1 and C2 were compared with that of a commercially available, powdered, wood-based activated carbon (AC) (Wako Pure Chemicals Co., Tokyo, Japan). NB and Methylene Blue (MB) were purchased from Wako Pure Chemicals Co., Osaka, Japan. The adsorbents were dried for 24 h in an oven maintained at a constant temperature of 383 K (Yamato Scientific Co., Tokyo, Japan) prior to use.

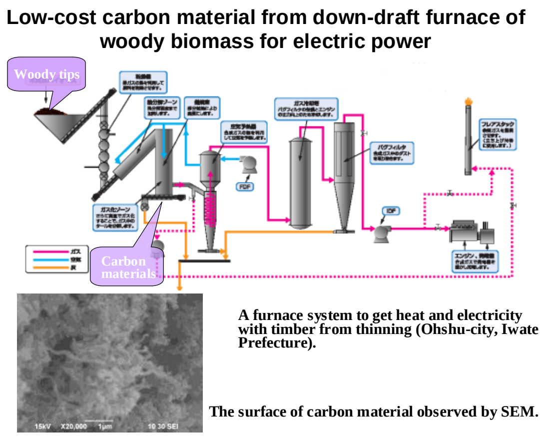

Figure 3. Carbon material from woody biomass

Adsorption Isotherms of Carbon Materials for NB

The adsorption isotherms for C1, C2 and AC were measured at 298 K and pH 5.8. Beforehand the effect of pH on the adsorption of NB and MB was investigated. The adsorption capacities of C1 and AC for NB were not affected by pH over the range examined in this study (pH 2-12). Therefore, we chose pH 5.8, which is the pH of distilled water after mixing, to study the adsorption isotherms. While, the adsorption ability of C1 for MB somewhat depended on the pH of the solution, especially, the adsorption ability increased in higher pH than pH_{PZC}. The effect of temperature on the adsorption isotherm of C1 was investigated using a solution of either NB or MB (pH 5.8). The adsorption isothermal curves of NB and MB showed were slightly affected by an increase in temperature. As indicated in Fig. 4 and 5, the isothermal curves of NB with C1 showed a typical Langmuir-type pattern. The relationship between the reciprocal of the amount of NB adsorbed on C1 and the reciprocal of the equilibrium concentration of NB in the solution was linear. The parameters in the following equation, which were determined from adsorption isotherms for C1 and AC, are summarized in Table 3.

$$q_e = \frac{Q_0 K_L C_e}{1 + K_L C_e},$$

Here, q_e is the amount adsorbed (mg/g); Q_O, the saturated adsorption amount (mg/g); K_L, the adsorption equilibrium constant (L/mg); and C_e, the adsorption equilibrium concentration (mg/L).

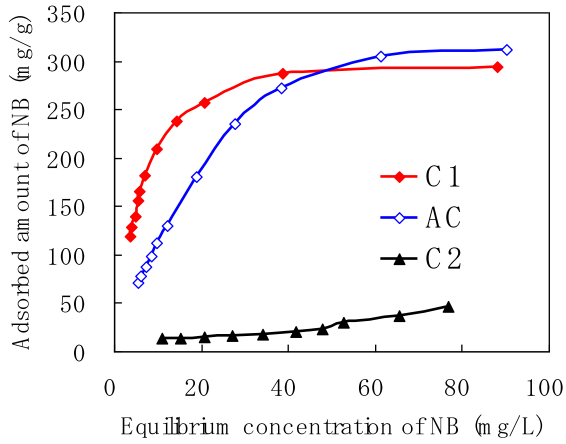

Figure 4. Langmuir isotherms for nitrobenzene

Unfortunately, the results obtained for C2 were too small to evaluate by fitting to the Langmuir-type adsorption isotherm. The surface areas of the micro-, meso-, and macropores in C2 are very small relative to those of C1 and AC.

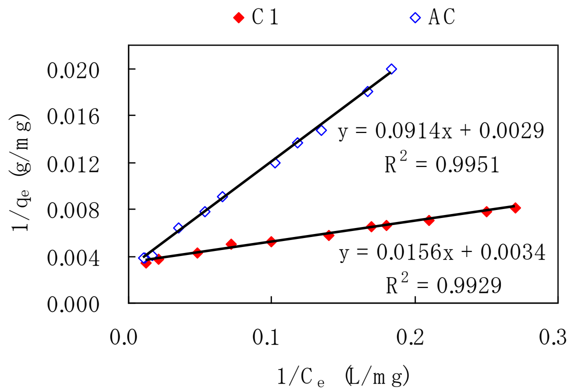

Figure 5. Linear expression of Langmuir isotherms

This result was apparently due to a tar-like substance covering both the micro- and mesopores. When a sample of C2 was shaken for a long time, the solution became dark in color, which is consistent with the presence of a tar-like substance on C2. For C1 and AC, the saturated adsorption amounts of NB were 294 mg/g and 344 mg/g, respectively.

Table 3. Langmuir parameters of C1 and AC

Samples	Q_0 (mg/g)	K_L (L/mg)	R^2
C1	294	0.22	0.99
AC	344	0.03	0.99

On the other hand, the adsorption equilibrium constant of C1 for NB was approximately 7-fold greater than that of AC. This result was probably due to the stronger interaction between the adsorbent (C1) and the adsorbing molecules (NB), as the surface hydrophobicity of C1 is greater than that of AC.

Removal of Pollutants by Magnetic Separation

Now how to remove and collect pollutants such as nitrobenzene spilled into river accident? We paid attention to the technology to collect oil spilled into sea by tanker accident, which was patented by Kawasaki Jyu-ko Co., Japanese company. That is, hydrophobized magnetite is prepared by coating the surface of magnetite with stearic acid or cholesterol. When hydrophobized magnetite is scattered over spilled oil, the magnetite adsorbs on oil by hydrophobic interaction and then we can collect the oil associated with magnetite by magnet as shown in Fig.6. We attempted to apply the method to remove and collect oily drop of nitrobenzene and hydrated nitrobenzene.

Fig.7 shows the removal behavior of some hydrophobic substances by hydrophobized magnetite. The left figure is for high concentration, containing oily drops and the right figure is for low concentration, completely dissolved.

Magnetic separation by hydrophobized magnetite (Patented by Kawasaki Jyu-ko Co.)

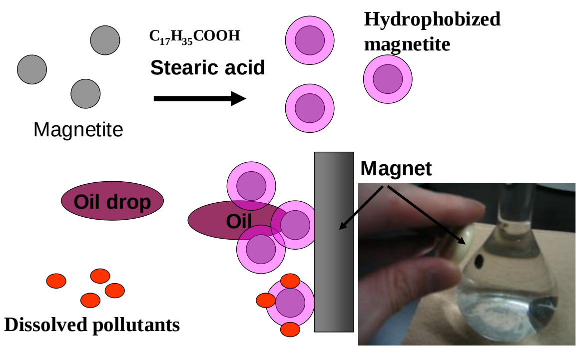

Figure 6. Image for magnetic separation

Magnetic separation was effective to remove oily drops of each substances, and most effective for removal of dichlorobenzene, whose solubility into water is smallest.

However, magnetic separation was not effective to remove substances at low concentration, all substances are completely dissolved (hydrorated) in water.

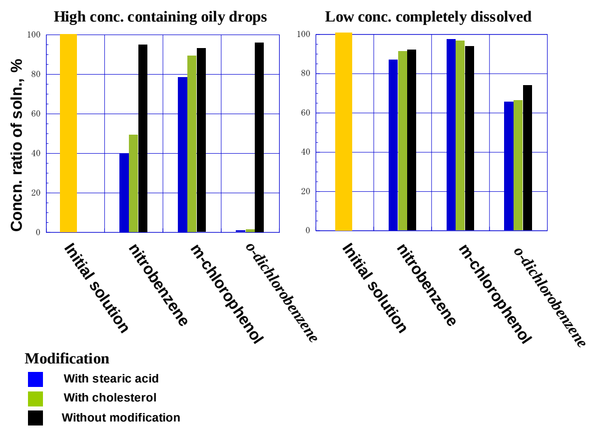

Figure 7. Removal of some benzene relatives by magnetic separation

CONCLUSIONS

The contamination of the Songhua River with nitrobenzene spilled from the accident is being solved now. However, we have to pay much attention to the pollution of Songhua River because the pollution may give severe damage on human health and aquatic ecosystem in not only China but also other countries. The similar accident can happen in every place and time. We have to prepare the methods and materials, which can be applied to remove and collect pollutants quickly and easily.

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SEISMIC INTENSITY, GROUND ACCELERATION AND BUILDING DAMAGE UNDER THE 27TH MAY 2006 JOGJAKARTA EARTHQUAKE

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ABSTRACT

The 27th May 2006 Jogjakarta earthquake has caused harmful for Jogjakarta and Central Java society, more than 5500 people killed and hundreds thousand's non-engineered buildings collapsed. The previous investigations were more emphasized on the earthquake parameters and distribution of building damage. It is necessary to investigate the seismic intensity, ground acceleration and building damage index. Direct investigation to the site to collect data concerning the severity distribution of objects, humans and environments has been done. Sites and respondents were determined according to purposive sampling to adjust as it happened at the sites. Data were analyzed according to standard rules, theory and models. Due to very limited data, very simple attenuation model was used. Results of the investigation show that in general isoseismic lines are in-line with Opak fault, local site effects seem dominant, the proposed attenuation relationship for seismic intensity and horizontal ground accelerations are matching well with previously research results and the distribution of building damage index has similar pattern with isoseismic lines.

Keywords: seismic intensity, isoseismic lines, ground acceleration, attenuation, damage index

INTRODUCTION

According to the global geology, the Australian plate at the south of Java Island submerged beneath the Eurasian plate with the angle nearly 90^{o} with respect to the plate boundary. Almost all of energy generated by Australian plate movement, accordingly, causes the subduction plate mechanism. As a result there is no significant strike slip fault such as great Sumatra fault occur at Java island. Among of some small and short faults are Cimandiri, Baribis, Lembang, Opak, etc. Several inland earthquakes that caused by the activity of those faults are Sukabumi (1993), Pandeglang (2003), Majalengka (2001), Banjarnegara (2004) and Jogjakarta (2006). Meanwhile some of the in sea or subduction earthquakes for instance are Jogjakarta (1934), Blitar (1988), Tasikmalaya (2009).

Inland earthquake is commonly termed as shallow crustal earthquake, in which the depth of focus is less than 20 km with magnitude M < 7 (Wyss, 2003). The exact boundary values depend on the earthquake magnitude and focal mechanism. Even though the earthquake magnitudes mostly are intermediate, but the earthquake has caused great devastation such as the 17th January 1995 Kobe earthquake (> 5500 fatalities), the 26th December 2003 Bam, Iran earthquake (> 40000 fatalities) and the 27th May 2006 Jogjakarta earthquake (> 5100 fatalities) etc. Shallow focus is one of the most dangerous aspects in the crustal earthquake.

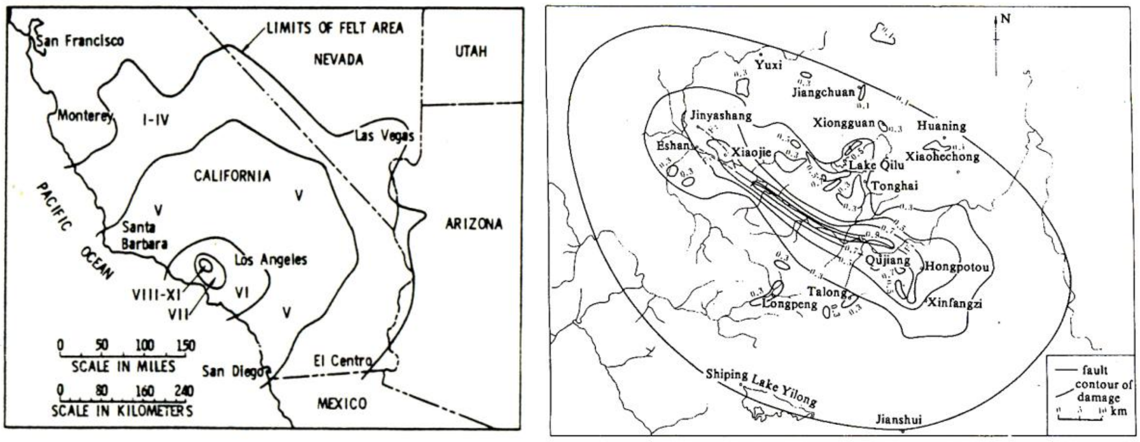
According to several sources (Walter et al., 2006; Tsuji et al., 2009), the focus of the 27th May 2006 Jogjakarta with Mw = 6.2 is just approximately 10 km depth and only 15 km away from Jogjakarta city. The epicenter of main shock and the distribution of the aftershocks are very close to the epicenter that determined by USGS. In addition Elnashai (2006) and Tsuji et al. (2009) stated that there are several versions of report regarding the location of the epicenter.

So far the investigation soon after the 27th May 2006 Jogjakarta earthquake were concentrated on the earthquake parameters such as earthquake magnitude, epicenter, focal mechanism (Walter et al.,2006), ground motions (Elnashai et al., 2006, Widodo and Trianto, 2008), non-engineered building damage and its distribution (Boen, 2006; Gousheng et al., 2006; Miura et al., 2007), effects of the soil condition on building damage (Kertapati and Marjiono, 2007), post disaster damage assessment by using satellite image (Yamasaki and Matsuoka, 2006) It is necessary therefore to extend the research especially emphasized on the earthquake intensity, ground acceleration and building damage. The main aim of the paper is to present the seismic intensity, ground acceleration and the non engineered building damage under 27th May 2006 Jogjakarta earthquake.

THE SEISMIC INTENSITY AND ITS DEVELOPMENT

Since few decades ago the seismic or earthquake intensity has been used by seismologists and engineers to describe the severity of the site under earthquake attack. The severity of the site mainly is described by the damage of the man made structures and the damage of environments (Trifunac and Brady, 1975). The level of human response due to anxiety, or discomfort, response of any object due to external disturbance, damage in particular types of structure and damage of environment are usual parameters that used in the survey.

The data collected from the site mostly are in term of qualitative expressions. The qualitative data then to be quantified in term of intensity scales, even though some uncertainty is still present in the results (Musson, 1998). The recent scale, especially the description of Modified Mercalli Scale (MMS) has been published in elsewhere. The interconnection of the site which is having the same seismic intensity scale is drawn as isoseismic lines. Examples of the isoseismic line for San Fernando and 1970 Tonghai earthquakes (Hu et al.,1996) respectively are presented in Figures 1.a and 1.b. The figures show that the shape of the isoseismic lines one is strongly affected by the earthquake mechanism.



(a) (b)

Figure 1. Isoseismic line due do San Fernando and Tonghai earthquakes

The seismic intensity can be determined by using traditional technique or human judgment such as direct interviewing the respondents and visiting the site. Further development in determining the seismic intensity is achieved by using ground motion records (Devenport, 1991; Karim and Yamazaki 2002). This is one of the developments of the technique/method in determining the scales. Several weaknesses of the traditional technique have been presented by researchers i.e. the it may content subjectively of both from respondents and interviewers, the quality of the structure it may differ each other, it may difficult to be applied in inhabitant area. To minimize the subjectively in the data collections, more briefly description of the seismic intensity scale and the well ability of the interviewer are required.

Freeman et al. (2004) presented further development of the seismic intensity i.e. by constructing the demand spectra. In this case the demand spectra is developed and combined with the seismic intensity to construct the spectra so called Earthquake Engineering Intensity Scale (EEIS). In this EEIS spectra the spectral displacement and spectral acceleration relationship is constructed by based on earthquake intensity scale I_{mm}. In further, the intensity scale also can be used in estimating the seismic risk analysis though the estimation the number of houses in the area of particular seismic intensity under consideration.

SEISMIC INTENSITY AND PEAK GROUND ACCELERATION RELATIONSHIP

In many countries, the availability of the ground motion records is still a big problem including in Indonesia. Several Indonesian strong earthquakes such as the 26th December 2004 Sumatera earthquake (Mw = 9.2), the 18 March 2005 Nias earthquake (Mw = 8.5) earthquake and the 27th May 2006 Jogjakarta earthquake (Mw = 6.2) occurred without any significant ground motion records. The availability of network stations, performance of instruments, file management and policies are several suspected aspects that lead to the main problem i.e unavailability of the earthquake ground motion records.

By considering the above problems, attempt to make any correlation between the seismic intensity and earthquake peak ground acceleration is a sound simple solution. As presented in many occasions that the site response Y is affected by several aspects starts from earthquake mechanism (F), earthquake magnitude (M), source to site path geology, epicenter distance (R), soil site and topographical effects. Meanwhile the site response can be represented as ground motion parameters. Those parameters respectively are ground acceleration (A), velocity (V), displacement (D), seismic intensity (I_{mm}) or Arias intensity (I_A). Relationship between seismic intensity and peak ground acceleration is the simplest one; meanwhile more refine relationship can be constructed by considering several aspects.

The correlation between these aspects based on particular site has been proposed by researchers. The parameter required in input motion is not only the peak ground acceleration but also the earthquake duration as well as the earthquake frequency contents. The simplest relationship model between site response Y and seismic intensity I_{mm} can be expressed in the form (Trifunac and Brady, 1975; Panza et al., 1997):

$$Log\,Y = b_o + b_1 . I_{mm} \qquad (1)$$

where b_o and b_1 are constants

As mentioned before that several aspects will affect the seismic intensity including the soil site condition. Dynamically, the soil site condition can be represented one by the predominant period T_G of the soil layers. Accordingly, Kanai (1967) proposed the mathematical model for the ground acceleration and seismic intensity relationship by,

$$A = a.T_G^{-b} 10^{c.I_{mm}} \qquad (2)$$

where a, b and c are coefficients, A is the maximum ground acceleration, TG is predominant period of soil layers and I_{mm} is Modified Mercalli seismic intensity.

SEISMIC INTENSITY ATTENUATION

Variations of the level of seismic intensity scale over the distance mean that the seismic energy was attenuated. Over the distance, the seismic energy spread out s in 3-dimension directions. Accordingly the imparted seismic energy per unit volume of soil mass will rapidly attenuate. The principle of seismic energy attenuation have been used in attenuations of peak ground acceleration, velocity, displacement, attenuation of Arias intensity as well as attenuation of seismic intensity.

As mentioned before, the seismic intensity will be affected by several aspects. Those aspects can be mathematically incorporated in the attenuation model. The numbers of aspect that can be involved in the model surely depend on the degree of availability of data. Dowrick (1992) and Szeliga et al. (2010) proposed the seismic intensity attenuation model in the form,

$$I = a + bM + c.r + d \log r \qquad (3)$$

where I is seismic intensity, a, b, c and d respectively are coefficients, M is earthquake magnitude, r is focal distance, second and third term in Eq.3) indicate the effect of earthquake magnitude and focal distance.

In addition, Dowrick (1992) also incorporated the effect of the earthquake mechanism in the attenuation model by setting different coefficients. Some times the required data is not completely provided. Another attenuation model as used by Karim and Yamazaki (2002), Moradi et al. (2004):

$$I = c_o + c.M + c_2 .Ln(R + \Delta) \qquad (4)$$

where c_0, c_1 and c_2 are coefficients, R is epicenter distance and Δ is particular value.

In case of the data is very limited such as in this study, the use of simpler attenuation is required, for example as presented by Sutardjo et al. (1985):

$$I_x = I_o.e^{-b.x} \quad (5)$$

where x is the distance (in km) from the center of maximum isoseismic line, I_x is the intensity level at x km from the center of isoseismic line, I_o is the maximum intensity level and b is the attenuation rate of the intensity.

THE BUILDING DAMAGE AND DAMAGE INDEX

Damage in general term can be defined as a something broken in physic, shape and function of a things and causes partially/mostly loss of its value. It is common the damage state of the building is classified into several levels such as presented in Table.1. Damage definition is still in term of qualitative meaning. Researchers have tried to transfer qualitative meaning to the quantitative one with term so called damage index, damage factor or damage ratio. Several quantitative concept of damage index/factor/ratio have been proposed by researchers. The value of damage indexes in Table 1 is just example of quantification of damage.

Table. 1. Damage state category (Qiwen et al., 1999)

No.	Damage state category	Damage description	Damage Index
1	No damage	Damage is negligible	0
2.	Slightly damaged	Minor cracks, can be used without repairing	0.2
3.	Seriously damaged	Part of wall collapsed, seriously cracks, can be used after repaired	0.35
4.	Collapsed	Roof fallen, partially collapsed, majority wall collapsed	0.65
5.	Demolished	Totally collapsed	1.0
Note : Few/part : ± 10-30 %, many : 30-50 %, majority : > 50 %			

METHODS OF RESEARCH

Parameters and Time

In order to get more reliable results, the main parameters for determining the seismic intensity scales should be clearly defined. Those corresponding parameters respectively are the human behavior during earthquake, response of any objects, the damage the structure and environment. Those parameters were used in this research, since there is no significant earthquake record during the 27th May 2006 Jogjakarta earthquake. The direct site surveys were carried out during the period March to September 2009 by Wijaya (2009) and the result is presented in this paper. The survey is preferable be carried out not to close to the event, since the society psychological effects after disaster should be considered.

Building Types

The building objects mainly are non engineered buildings such as un-reinforced clay brick buildings, partially reinforced clay brick building and only small amount of well reinforced clay brick buildings. Those types of non-engineered buildings which were mostly damage under earthquake. It is very difficult to collect precise data regarding the year in which buildings were built. However, most of them are constructed during 1960’s – 1970’s. The wooden and bamboo buildings were not included in this survey.

It cannot be avoided that the quality of the building is widely varies. The clay brick, mortar as well as the quality of the construction are aspects which strongly affect to the quality of the buildings. This is one of the weaknesses in determining the earthquake intensity.

Instruments, Respondents and Data

The instruments for collecting the site data mainly are maps, questionnaire sheets, question lists for interview, electronic camera, GPS and amount of supporting utensils. Questionnaire has been composed in such way all of the desire data can be collected. To avoid bias information, the quality of the respondents should be maintained. The head of villages, head of sub-villages and particular persons who able to give relatively accurate information were selected as respondents in the survey.

The data regarding the site response were collected in term of qualitative information. In addition, the plan, size and pictures of the damaged buildings are strongly required to compute/assess the level of building damage. The data were collected according to purposive sampling from 17 districts and covering 294 respondents. The secondary data such as earthquake magnitude, epicenter as well as the ground acceleration were also required.

Method of Analysis

The collected data were analyzed qualitative and quantitatively. Transferring the qualitative information to the seismic intensity scales were carried out qualitatively. Mean while the remaining results such as relation between seismic intensity and ground acceleration as well as relation between seismic intensity and distance were analyzed quantitatively.

RESULT AND DISCUSSION

Isoseismic Lines, Soil Liquefaction and Its Relationship

Construction of the isoseismic lines under the 27th May 2007 Jogjakarta earthquake is the primary aim of this study. This is because this kind of research is really seldom done by researchers with several reasons. Among of the reasons are lack awareness and attention of the usefulness of the isoseismic lines, time consuming and costly. Such as stated before, there were no significant records during the earthquake. Accordingly, the data were collected manually by direct interviewing and visiting to the sites.

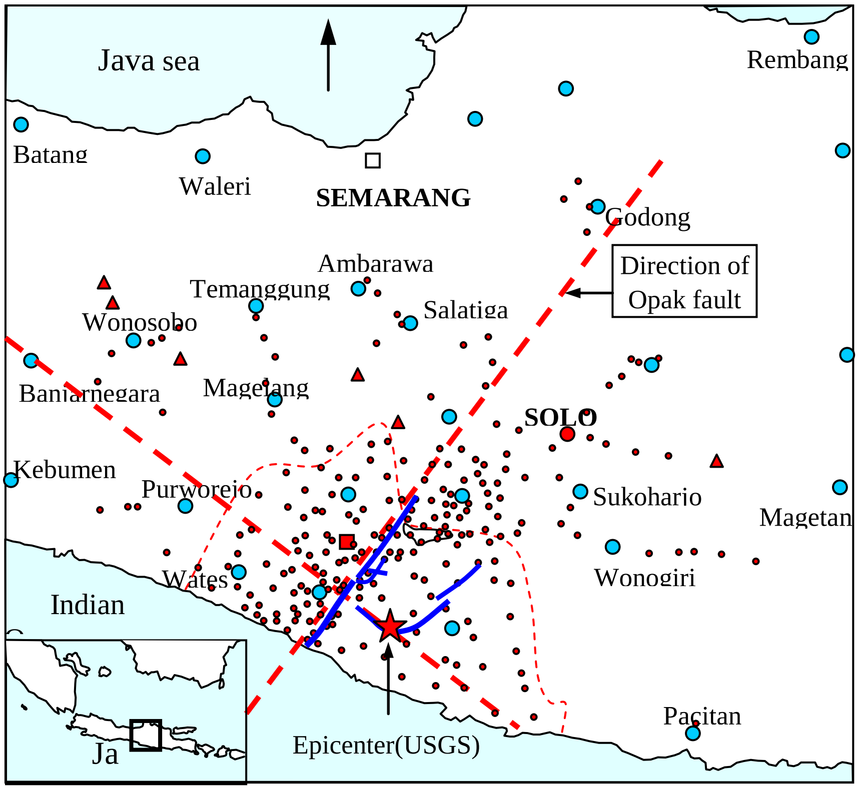


Figure 2. Distribution of individual seismic intensity scales

Standard method, procedures and instruments have been prepared and done. As mentioned before, the seismic intensity scales in the site were determined based on the result of interviewing and recording data on the sites. After removing unnecessary data, the distribution of individual intensity scales are presented in Figure 2. It shows in Figure 2 that most of the data are purposively concentrated in the area at surrounding Opak fault nearly the epicenter. The data are getting rare with distance from the fault.

By using standard package program (ArcView), the isoseismic lines can be drawn as presented in Fig.3. It is consider in-line and perpendicular directions of Opak fault. It can be seen from the figure that the maximum seismic intensity is I_{mm} = IX. Similar as presented in elsewhere, the maximum seismic intensity is not always coinciding with the location of epicenter. It shows that the shape of the isoseismic lines is not nearly circles but tends similar to isoseismic lines due to Tonghai earthquake as presented in Figure 1.b. The site effects seem play important role in the distribution of building damages. It is also clear that the direction of the isoseismic lines is not in-line/incline with the direction of Opak fault.

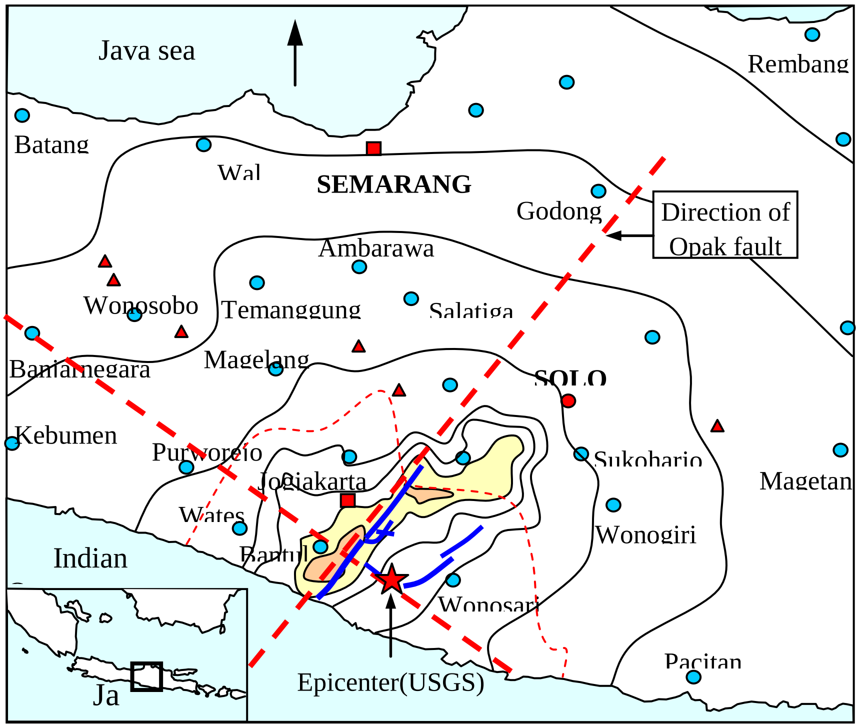


Figure 3. Isoseismic lines of the 27th May 2006 Jogjakarta Earthquake

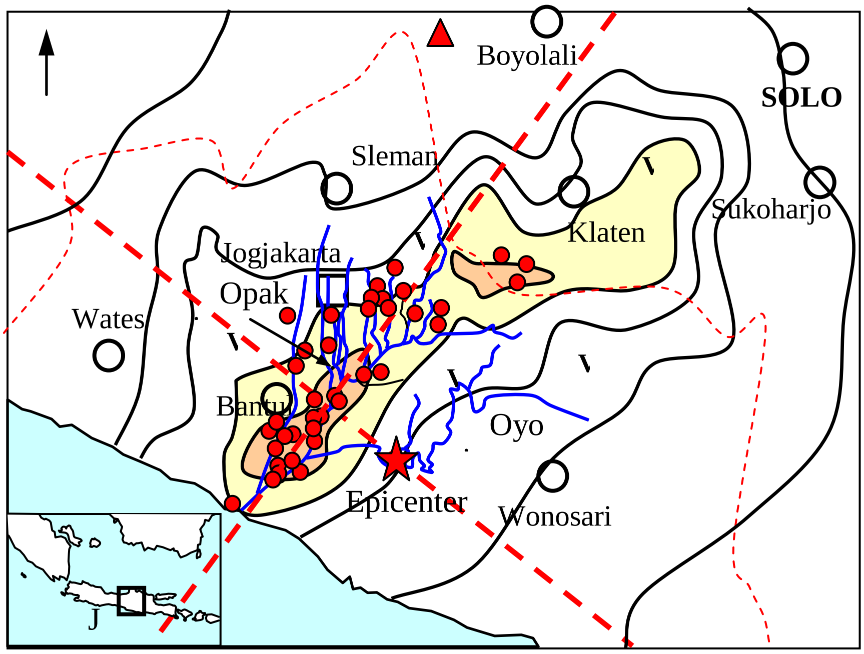


Figure 4. Isoseismic lines and distribution of liquefaction site (Eko et.al., 2006)

Seismic site effect is primary will occur at the deep soil deposit. Walter et al. (2006) illustrated the cross section of soft sediment soil deposit from Merapi mountain to Opak river/fault. According to Walter et al. (2006) the depth of soft sediment may reach 200 m. Meanwhile based on Nurwidyanto et al. (2007) studied, the Opak fault is buried by soil sediment with the depth is ranging approximately from 40 – 75 m. Based on this condition study of the potential liquefaction at surrounding Opak fault is important and has been carried out by Eko et al. (2007). According to their study the elevation ground water level is relatively high ranging from -0.60 – 4.0 m from the local ground surface. Result of this study then to be plotted with the isoseismic lines, and the result is depicted in Figure 4.

It is clearly shown in Figure 4 that Opak fault is exactly in-line with Opak River. As mentioned before that soil deposit at surrounding Opak fault is relatively deep, soft with relatively high ground water level. It is clearly shown in Figure 4 that the liquefied soil mostly occur at ground with seismic intensity I_{mm} = VIII and partly occur at the region with I_{mm} = VII. This result is exactly confirm with Anonim (2001) in which the moderate soil liquefaction mostly occur at seismic intensity I_{mm} = VIII and moderately low liquefaction will usually occur at I_{mm} = VII.

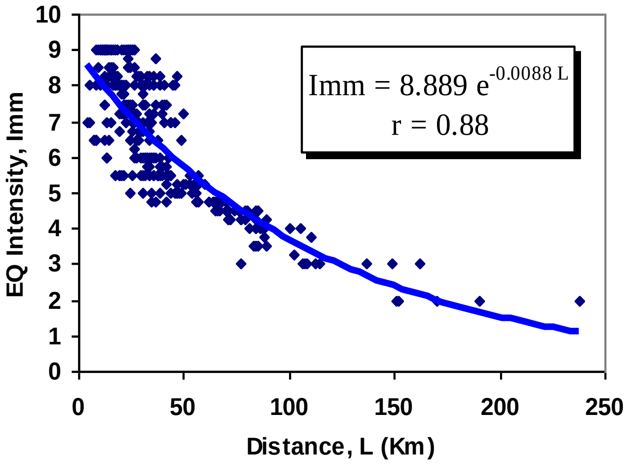
Seismic Intensity Attenuation

Result of the research that is presented in this paper is surely limited and only based on the data collected from the 27th May 2006 Jogjakarta earthquake. Limitations of the data mainly are caused by unawareness of the researchers to collect the data, limitation of time, funding support and partners. The great 2004 Aceh earthquake, the 2009 Tasikmalaya earthquake and the 2009 Padang earthquake just people let them gone without any further scientific memories. Those earthquakes are very interesting to be investigated. Overseas partners seem strongly invited to join the research cooperation.

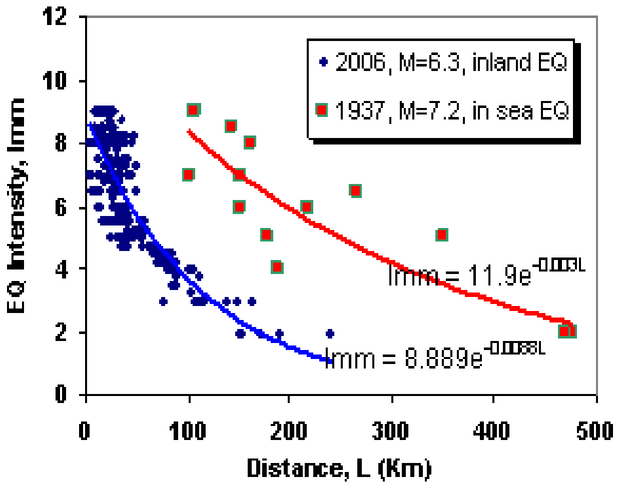
Based on those limited data, the seismic intensity attenuation model based on Eq.5 was used and the result is presented in Figure 5.a. This attenuation is constructed based on all data from all respondents. The attenuation is constructed according to the in-line direction to the Opak Fault such as presented in Figure 2 and mathematically can be expressed as,

$$I_{mm} = 8.889\,.e^{-0.0088.L} \quad (6)$$

where L is the distance from the center of isoseismic lines.



(a) I_{mm}-L relationship (inland EQ)



(b) I_{mm}-L relationship

Figure 5. Modified Mercalli intensity I_{mm} attenuation

Figure 5.b is the comparison between 2-seismic intensity attenuations i.e. attenuation for seismic intensity of the 27th May 2006 (in land earthquake) and the 27th September 1937 (in sea earthquake) Jogjakarta earthquake (Sutarjo, 1985). It shows in the figure that the in land earthquake attenuates faster than in sea earthquake. This result confirms to the common theory that the shallow crustal earthquakes attenuate faster than the in-sea /subduction earthquake. In this attenuation, the distance from the center of isoseismic line L is used instead of the epicenter distance R. This is because the maximum seismic intensity is not coinciding with the earthquake epicenter.

Long and Short Axes Seismic Intensity Attenuations

Seismic intensity attenuation such as presented in Eq.6 was established based on all data that collected from all respondents. Sometimes, it is necessary to identify the characteristic of attenuation which are in-line and perpendicular to the fault directions. Figure 6.a is the attenuation of seismic intensity for long axis in the direction of Opak fault (North-East) and attenuation of the seismic intensity for short axis perpendicular to Opak fault (North-West).

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SUSTAINABLE CONCRETE FOR FUTURE SUSTAINABLE CONSTRUCTION

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ABSTRACT

This paper reviews the growing role of waste materials, pozzolanic materials in sustainability of concrete construction. Focusing on the most relevant types waste materials that are increasingly being used to replace the traditional raw materials used in the production of sustainable concrete. Environmental impact of the sustainable concrete was further reduced through the use of pozzolanic materials as a cementitious material than are currently typical for structural concrete. Recent attempts to use expert systems and artificial intelligence to do the mix design of sustainable concrete in construction industry.

Keywords: *Sustainable concrete, Sustainable construction, Waste materials, Cement*

INTRODUCTION

Annual global production of concrete is about 5 billion tonnes and cement production is expected to rise to nearly 2 billion tonnes by year 2010. Approximately 7% of the world's carbon dioxide (CO_2) emissions are attributable to Portland cement (Mehta, 1999; Malhotra, 2000). In addition to CO_2 emissions, the burning of portland-cement clinker at temperatures around 1400 ^{0}C (2600 ^{0}F) is costly in terms of fossil fuel usage (Nehdi, 2001). Concrete and cement manufacturing consume considerable amounts of energy, with cement manufacturing accounting for about 80% of the total industry's electricity use and approximately 66% of its fuel consumption. On the other hand, the production of concrete requires large amounts of water, which is particularly burdensome in those regions of the earth that are not blessed with an abundance of fresh water. Finally, the demolition and need of disposal of concrete structures, pavements, etc., creates another environmental burden. Construction and demolition debris contribute a considerable fraction of solid waste in developed countries, and concrete constitutes its largest single component. These effects of cement and concrete production on environment and the depletion of the world's most valuable fossil energy resources have necessitated the exploitation of sustainable construction materials (Kartik et al., 2003).

The items listed above seem to indicate that the concrete industry has become a victim of its own success and therefore is now faced with tremendous challenges. But the situation is not as bad as it appears, because concrete is inherently an environmentally friendly material. The challenges listed above are more a result of the fact that Portland cement is not particularly environmentally friendly. One could therefore reduce these challenges to the following simple formula: use as much concrete, but with as little Portland cement as possible, this means to replace as much Portland cement as possible by supplementary cementitious materials, especially those that are by-products of industrial processes, and to use recycled materials in place of natural resources. This paper summarizes how the production and use of sustainable concrete can achieve the objectives of future sustainable development. It begins with sustainable development and life cycle perspective of concrete. Then it focuses on how sustainable concrete can be made by reducing CO_2 emissions in cement and concrete production. The research results obtained in this regard at the Faculty of Engineering and Built Environment (FKAB) of Universiti Kebangsaan Malaysia (UKM) are also reported. Finally the study puts light on the future trend of concrete technology and sustainable development.

SUSTAINABLE DEVELOPMENT

"Sustainable development is development which meets the needs of today's generation without compromising the ability of future generations to meet their needs." It covers a wide range of issues, including (Islam et al., 2009):

1. Effective protection of the environment
2. Prudent use of natural resources
3. Social progress that recognizes the needs of everyone
4. Maintenance of high and stable levels of economic growth and employment

In developing country such as Malaysia, concrete is consumed in vast quantities to shape the built environment. The quality and performance of concrete plays a key role for most of infrastructure including commercial, industrial, residential and military structures, dams, power plants and transportation systems. Therefore, for sustainable development, concrete used in all these infrastructures must be sustainable with the lowest possible environmental impact in all phases of its life cycle.

Life Cycle Perspective of Sustainable Concrete

Life cycle assessment (LCA) is today's sustainability buzzword. The International Organization for Standardization (ISO) defines LCA as the "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle." Nowadays, increasing emphasis is placed on the importance of examining all aspects of a structure: not just the building itself, but the embodied energy of materials, the long-term effects of manufacturing processes, the stages of construction, building performance and operations, durability and maintenance of existing structures, and in the end-demolition, materials recycling, and future land use ramifications. LCA is a measuring tool, pulling all the information into one place. What has happened historically is that we move pollution from one type to another, and an LCA can help make sure we are not doing that.

Concrete has something of a bad rap in certain circles. Some argue that cement production releases CO_2, that the embodied energy of the material is too high. But concrete can also contain recycled aggregates (derived locally), recycled steel (derived locally), and supplementary cementitious mixtures (often industrial by-products that would otherwise be landfilled). Concrete brings numerous lasting benefits that many believe far outweigh the front-end labor and energy. Locally available materials mean less transportation and pollution. Concrete also offers high thermal mass, contributing to energy efficiency and comfort. Many concrete structures are designed for a 100-year life span. The material's light color can provide reflectivity that reduces air conditioning loads and helps reduce the urban heat island effect. And when a project is demolished, much of the material can be recycled. This is not to say that the cement industry is sitting on its laurels. On the contrary, manufacturers are working harder than ever to make processes cleaner and more efficient.

REDUCTION OF CO_2 EMISSION FROM CEMENT PRODUCTION

The greatest scope for major reductions in CO_2 emissions from cement production lies in the replacement of conventional carbon based fuels by alternative low fossil carbon based fuels, and where possible by replacing the limestone with raw materials high in noncarbonated calcium sources. Almost all modern Portland cement clinkers contain 65% or more by mass of calcium as oxide, and the source of almost all of this calcium is calcium carbonate from natural limestone. Thus, the production of 1 ton of a modern OPC clinker emits, on average, about 0.53 tons of $RMCO_2$. The only way this figure can be reduced is by reducing either the amount of CaO in the clinker or by using alternative raw materials that contain a significant fraction of their calcium in a non-carbonate form. The simplest approach to this problem, and one that has been extensively studied, is to produce clinkers that are rich in belite (C_2S) and poor in alite (C_3S) (Popescu et al., 2003). This could reduce total $RMCO_2$ emissions by about 8%. The energy saving is also coming from the fact that we can reduce the amount of limestone that must be decarbonated (a very endothermic process) (Gartner, 2004). Thus, FD-CO_2 emissions should also be reduced by about the same percentage (8%) as RM-CO_2 emissions. Also the same order of CO_2 reduction can be obtained by blending OPCs with suitably reactive pozzolans, such as high-quality fly ashes or natural pozzolans. It is thus an alternative solution in cases where high-quality supplementary cementitious materials are not available. Of course, additional CO_2 emission reductions could be obtained by making blended cements based on such CSA-rich clinkers, diluted with a variety of supplementary cementitious materials.

Reduction of Clinker Contents in Cement

Probably the most effective means of achieving significant reductions in CO_2 emission lies in the replacement of Portland cement clinker by other suitable materials. These replacement materials can be added separately to the concrete or used to replace the clinker in composite cements. The latter is more commonly the situation in Europe, whilst in the US replacement materials are more commonly added to the concrete. Regardless of the relative merits of each approach, the overall reduction in CO_2 emissions associated with the reducing the amount of Portland cement clinker per m^3 of concrete is the same.

SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCMs)

Replacement materials that react with calcium hydroxide are commonly termed “Supplementary Cementitious Materials”, (SCMs). They include fly ash, granulated blast furnace slags (GBFS), rice husk ash (RHA), clinical ash, and natural pozzolans, and to a lesser extent silica fume, metakaolin, etc.

Rice Husk Ash

Rice husk can be burnt into ash that fulfils the physical characteristics and chemical composition of mineral admixtures. Pozzolanic activity of rice husk ash (RHA) depends on (i) silica content, (ii) silica crystallization phase, and (iii) size and surface area of ash particles. In addition, ash must contain only a small amount of carbon. RHA that has amorphous silica content and large surface area can be produced by combustion of rice husk at controlled temperature (Mehta, 1989). Suitable incinerator/furnace as well as grinding method is required for burning and grinding rice husk in order to obtain good quality ash. A simple furnace was designed and built for rice husk combustion at the Engineering Faculty of UKM. Schematic diagram of the furnace is shown in Figure 1. The design concept of this furnace was based on those reported by Loo et al. (1984) and Ramli (1993). In this research, three methods of rice husk combustion were used based on combustion fire, air supply, and cooling durations. The produced ash was ground to ensure that it meets the requirements of BS 3892 standard (1996). From the investigation, it was found that combustion period, chilling duration, and grinding process and duration are important in obtaining RHA of standard fineness and quality. In addition, air ducts in the furnace are very useful in order to supply air for proper burning of rice husk. Table 1 shows that RHA of adequate quality can be produced using the furnace designed and built at UKM.

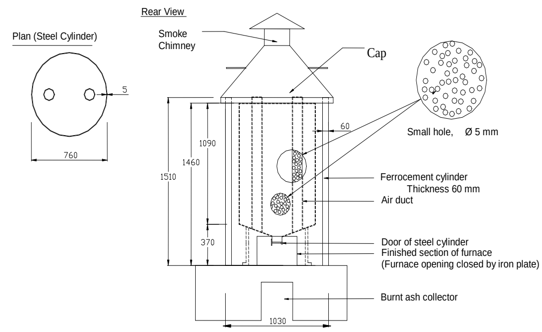

Figure 1. Schematic diagram of the furnace at UKM for burning rice husk.

Table 1. Comparison of chemical content of RHA produced using different methods

Element	Combustion methods at furnace of UKM			Results of other researchers			
	A	B	C	Cook et.al. (1976)	James & Rao (1986)	Zhang & Malhotra (1996)	Mahmud et. al. (1997)
Silicon dioxide (SiO_2)	79.84	80.72	86.49	93.15	95.00	87.2	92.7
Aluminium oxide (Al_2O_3)	0.14	0.08	0.01	0.41	-	0.15	0.20
Ferric oxide (Fe_2O_3)	1.16	1.10	0.91	0.20	0.71	0.16	0.40
Calcium oxide (CaO)	0.55	0.56	0.50	0.41	0.44	0.55	0.80
Magnesium oxide (MgO)	0.19	0.18	0.13	0.45	0.42	0.35	0.20
Sodium oxide (Na_2O)	0.08	0.00	0.05	0.08	0.41	1.12	0.20
Potassium oxide (K_2O)	2.90	3.14	2.70	2.31	1.05	3.68	-
Phosphorus oxide (P_2O_5)	0.80	0.90	0.69	-	-	0.50	-
Titanium oxide (TiO_2)	0.01	0.04	0.00	-	-	0.01	-
Sulphur trioxide (SO_3)				-	-	0.24	-
Manganese oxide (MnO)	0.07	0.06	0.07	-	-	-	-
Loss on Ignition (LOI)	14.26	13.22	8.45	2.77	-	8.55	4.40

Clinical Ash

Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. In addition, agricultural wastes such as rice husk ash, wheat straw ash, and sugarcane bagasse ash are being used as cement replacement materials (Mehta, 1977; Bentur, 2002; Biricik et al., 1999; Ganesan et al., 2007). Municipal solid waste incineration (MSWI) fly and bottom ashes are also being used in concrete as cement and aggregate replacement materials

(Aubert et al., 2004; Bertolini et al., 2004; Chang et al., 1999; Huang and Chu, 2003; Muller and Rubner, 2006; Pappu et al., 2007). However, hospital waste ash, commonly known as clinical ash, is rarely being used in concrete as a cement replacement material. Hospital waste causes a nuisance both to the health and environment when not properly disposed. The use of hospital waste ash or clinical ash as partial replacement of cement is new and this has twofold effects, i.e., reducing or total elimination of the material as a waste and reducing the quantity of cement used for concrete works resulting in reduction of cost of construction. Therefore, it is expected that research on clinical ash concrete will create an opportunity to use clinical ash in concrete as a partial replacement of cement, other than just reducing one of the waste materials. Fly ash produced from incineration of clinical waste of Tongkah Medivest Sdn Bhd (Malaysia), called clinical ash, was used in concrete as a partial replacement of cement, i.e. 0% (control), 5%, 10%, 15%, 20%, 25%, 30% and 35% by weight. Figure 2 shows the SEM of the clinical ash particles. Concrete mixes were designed using water-binder ratios of 0.35 and 0.50..

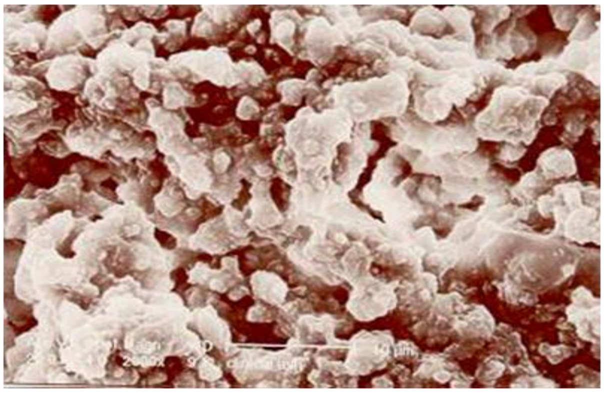

Figure 2. Scanning electron micrographs (SEM) of clinical ash particles (water/binder = 0.35)

Compressive strength tests of cylindrical samples were performed at 7, 14, 28, 56, 90 and 180 days as shown in Figures 4 and 5. Results show that compressive strength of clinical ash concrete depends on ash content, water-binder ratio and age of concrete. It was found that 5% cement replacement by clinical ash is an optimal value with respect to the compressive strength of concrete. It was also found that up to 15% cement replacement by clinical ash is possible for concrete having water-binder ratio of 0.50 without adversely affecting its strength. It appeared that clinical fly ash may be used as a cement replacement material more effectively and economically in normal strength concrete having high water-binder ratio.

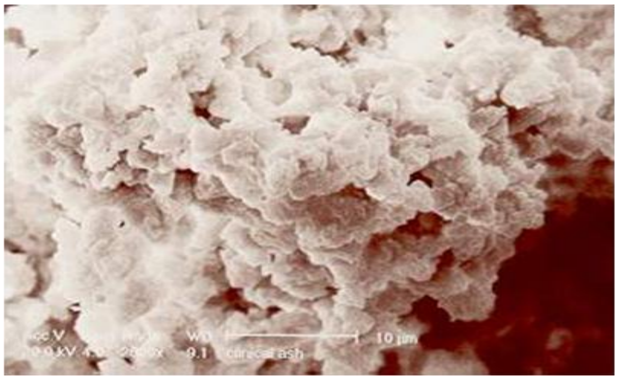

Figure 3. Scanning electron micrographs (SEM) of clinical ash particles (water/binder = 0.5)

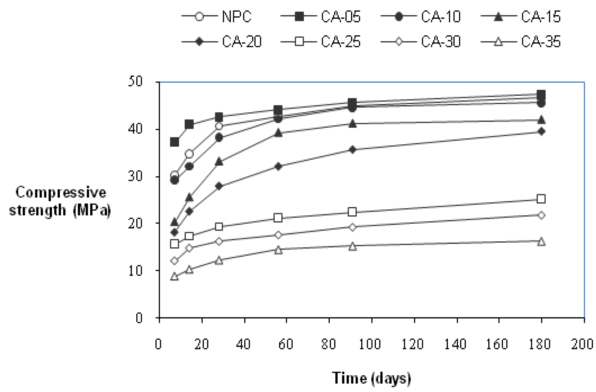

Figure 4. Compressive strength of clinical ash concrete (water/binder = 0.35)

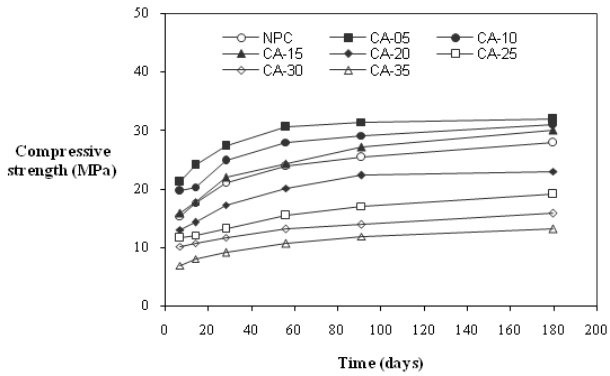

Figure 5. Compressive strength of clinical ash cocrete (water/binder = 0.5)

REDUCTION OF VIRGIN AGGREGATE CONCRETE

Recycling is receiving growing attention in the construction industry in general, and in cement and concrete technology in particular. The major area where recycling is of significant impact is obviously in the use of industrial by-products such as fly ash and blast furnace slag as components in blended and composite cements and as direct additions to the concrete.

A second developing area of recycling is that of the concrete itself, where two direct sources can be identified: concrete wastes discharged in the manufacturing process, and dismantling of old concrete structures (Tomasawa and Noguchi, 1996; Chandra, 1997; Hendriks et al., 1998; Hendriks, 2000; Uchikawa, 2000). At this stage, technologies have been developed to use the recycled concretes as a source of aggregate (Dhir et al., 1998). Special attention is given to the recycling of water in concrete plants, and this is now covered by standards, such as ASTM C94 and PrEN 1008 (Sandrolini and Franzoni, 2001).

Oil Palm Shells (OPS) as Coarse Aggregate

The oil palm industry in Malaysia accounts for over half of the world's total palm oil output and is set to grow further with the global increase in vegetable oil demand. However, it is also the main contributor to the nation's pollution problem, which includes the annual production of 2.6 million tonnes of solid waste in the form of oil palm shells (OPS) (Amiruddin, 1998). OPS are the hard endocarp that surrounds the palm kernel. The vast availability of this resource is still unutilized commercially. The current waste disposal practice of incineration within the industry is normally done in an uncontrolled manner and contributes significantly to atmospheric pollution. OPS are light and naturally sized; they are ideal for substituting aggregates in lightweight concrete construction. Being hard and of organic origin, they will not contaminate or leach to produce toxic substances once they are bound in concrete matrix. OPS concrete can potentially be utilized in lightweight concrete applications that require low to moderate strength such as pavements and infill panel for floorings and walls (Basri et al., 1999).

A study performed at UKM reports the results of compressive strength of OPS concrete under three curing conditions over a 56-day period (Basri et al., 1999). The influence of fly ash as a cement replacement admixture (pozzolan) on the concrete strength was also investigated in that study. Concrete with OPS as coarse aggregate was investigated for its workability, density, and compressive strength development. Fresh OPS concrete was found to have better workability while its 28-day air-dry density was 19-20% lower than ordinary concrete. Compressive strength after 56 days was found to be 41-50% lower than ordinary concrete. These results were still within the normal range for structural lightweight concrete. Fly ash was found to lower the compressive strength of OPS concrete, which was the opposite of its effect on normal concrete.

Quarry Dust as Fine Aggregate

The construction industry is facing a shortage of sources for natural sand. Therefore, alternative materials need to be identified to lessen or replace the demand for natural sand. Quarry waste fine aggregate could be an alternative to natural sand. It is a by-product generated from quarrying activities involved in the production of crushed coarse aggregates. Quarry waste fine aggregate is generally considered as a waste material and causes an environmental load due to disposal problem. Hence, the use of quarry waste fine aggregate would reduce not only the demand for natural sand but also the environmental burden. Moreover, the incorporation of quarry waste fine aggregate in HPC will offset the material cost of concrete. In brief, the successful utilization of quarry waste fine aggregate could turn this waste material into a valuable resource. The effect of quarry waste fine aggregate on key properties of fresh and hardened concretes was investigated at UKM. It was found that quarry waste fine aggregate enhanced the slump, slump flow, V-funnel flow, and unit weight of the fresh concretes. In case of hardened concretes, the pull-out strength, dynamic modulus of elasticity, ultrasonic pulse velocity, and initial surface absorption were increased whereas the compressive strength was slightly decreased. However, the best performance was observed when quarry waste fine aggregate was used in presence of silica fume. The overall test results indicate that quarry waste fine aggregate can be utilized as a good substitute of natural sand to produce high-performance concrete.

DEVELOPMENT OF SUSTAINABLE HIGH PERFORMANCE CONCRETE

Sustainable high performance concrete (SHPC) is vital for maintaining the equilibrium for these three environmental elements, that is, impact of pollution, intelligent allocation of scarce resources, and the social equality. The SHPC should be more durable and should be developed to satisfy socioeconomic needs at the lowest environmental impact. The cost of a project in the future will have to incorporate not only the present economic costs but also social and environmental costs ranging from the extraction of the raw materials, to their utilization, and also including their elimination at the end of the life cycle of the structures. The development of SHPC has brought forth the need for admixtures, both mineral and chemical. Mineral admixtures, being extremely fine materials, fill the microvoids in grain packing and thereby improves the compactness of the concrete matrix and at the same time the rheological properties of the fresh mix. Among the chemical admixtures, superplasticizers (SPs) come first because their volume of use in concrete is the largest of all. This type of admixture causes deflocculation of cement grains and this is the process by which the cement grains in suspension of water can recover their initial grain size. The incorporation of SP leads to an appreciable reduction in the quantity of mixing water because a lot of this water is no longer entrapped in the cement grain flakes (Malier, 1992). This property, coupled with the addition of mineral admixture particularly silica fume (SF), enables concrete to achieve high strength without loss of workability (Nawy, 1996). The other chemical admixture, which is often used in cold region concreting, is air-entraining admixture. Theoretically, there is no need for air-entraining agent (AEA) to be used in concrete in non-freezing environment such as in Malaysia. However, in order to improve handling, placeability, and finishability of concrete, it is strongly recommended to utilize a small amount of AEA in fresh concrete.

Expert System for Mix Design of Sustainable High Performance Concrete

Sustainable high performance concrete (SHPC) mix design involves complicated issues, and the correct ways to perform this can be achieved with experts' advice and experience (Bai and Amirkhanian, 1994). Mix design of SHPC is more complicated because SHPC includes more materials, like superplasticizer and supplementary cementitious materials (e.g., silica fume, fly ash, fillers etc.). In addition, maintaining a low water-binder ratio with adequate workability makes the design process more complicated. Traditionally, experienced civil engineers, largely based on their experiential knowledge, do the job of mix design (Islam et al., 2002). However, experts are not always available, nor do they always have time to consult all possible references, review available data, and so on. Some companies do not have personnel with the experience to make necessary decisions regarding concrete mix design. The conventional computer programs are useful only in manipulating the numerical data and providing mathematical reasoning for the final selection. They lack the intuitive reasoning based on heuristic knowledge such as experience and rules of thumb (Foo and Akhras, 1993). Many factors influence concrete mix design, and their mutual relationship is so complicated that it is impossible to formulate mathematical models to express their mutual actions and reactions (Oh et al., 1999). In addition, adjustments of trial mixes are always performed by taking into account the information from concrete quality tests, experts' advice and experience. It is believed that the problem of mix design and adjustment of SHPC can be alleviated if the engineer's knowledge can be augmented with some "expert system" for affirming his judgment. This section describes a prototype expert system called HPCMIX that was developed at UKM to provide proportion of trial mix of SHPC and recommendations on mix adjustment. The system is capable of selecting proportions of mixing water, cement, supplementary cementitious materials, aggregates and superplasticizer, considering the effects of air content as well as water contributed by superplasticizer and moisture conditions of aggregates. Figures 6, 7, and 8 show some of the features of the developed system. It was tested using a sample project. The system's selection of mix proportions and recommendations regarding mix adjustment were compared favorably with those of experts. The system is user-friendly and can be used as an educational tool (Zain et al., 2005).

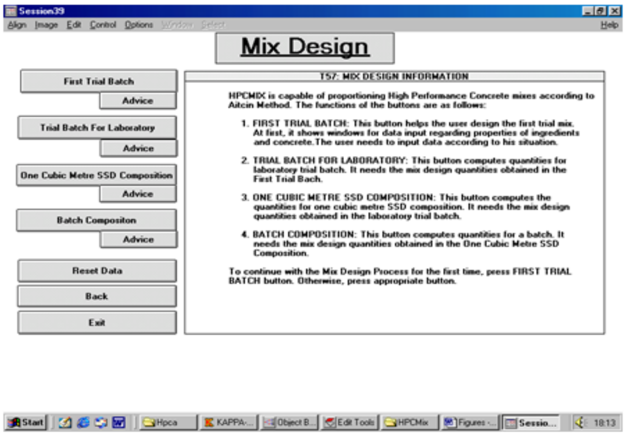

Figure 6. Interface window of the *Mix Design* module (Zain et al., 2005)

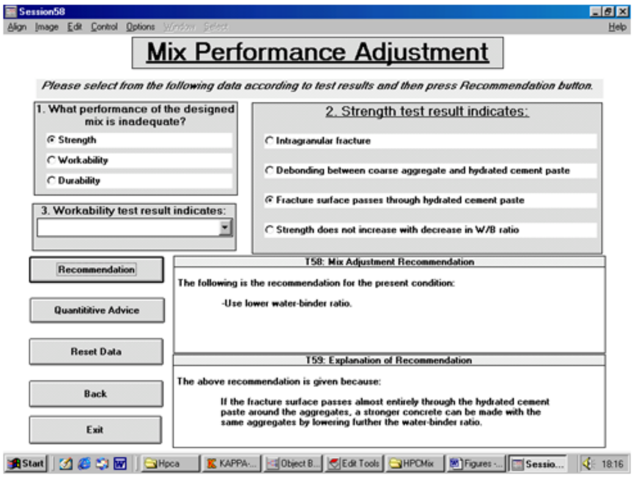

Figure 7. Interface window of the Mix Perfor-mance Adjustment module (Zain et al., 2005)

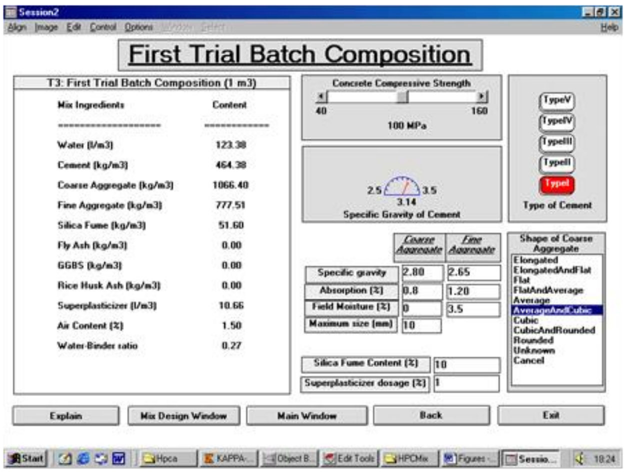

Figure 8. Window showing composition and kedata of *First Trial Batch* submodule (Zain et al., 2005)

Artificial Neural Network Simulation for Sustainable High Performance Concrete Mix Design

As mentioned earlier, sustainable high performance concrete (SHPC) mix design involves complicated issues, and the correct ways to perform this can be achieved with expert advice and experience (Yeh et al., 1993). The situation may be improved with the use of artificial intelligence that manipulates the human brain in the way of thinking and giving suggestion. The usefulness of artificial intelligence such as artificial neural networks (ANNs) in solving difficult problems has become recognized and their development is being pursued in many fields. Furthermore, ANN is also applied to many civil and structural engineering problems such as in modeling flexural behavior of Fiber Reinforced Concrete beams (Patodi and Purani, 1998), predicting large deflection response (Patodi and Sushantasingh, 1999), flexible pavement thickness modeling (Saltan et al., 2002) and many more. As the cost of materials and labor increase, optimizing SHPC mix proportions is more desirable. Furthermore, the complex properties and behavior of SHPC is hard to model with traditional mathematical tools. A study was performed at UKM with the aim of demonstrating the possibilities of adapting ANN in the development of simulator and intelligent system and to predict the compressive strength and workability of SHPC. Training and testing the network started immediately prior to the completion of the simulator development and data preparation. The training followed exactly to the designed algorithm of the simulator. The developed neural network simulator model using the back propagation architecture demonstrated its ability in training the given input/output patterns. The application of artificial intelligence in the field of SHPC mix design is very appropriate in order to preserve and disseminate valuable experience and innovation efficiently at reasonable cost. Figure 9 shows the multilayer free-forward neural network (MFNN) with back propagation training algorithm which was used at UKM for optimization of high performance concrete mix design (Jamil et al., 2009).

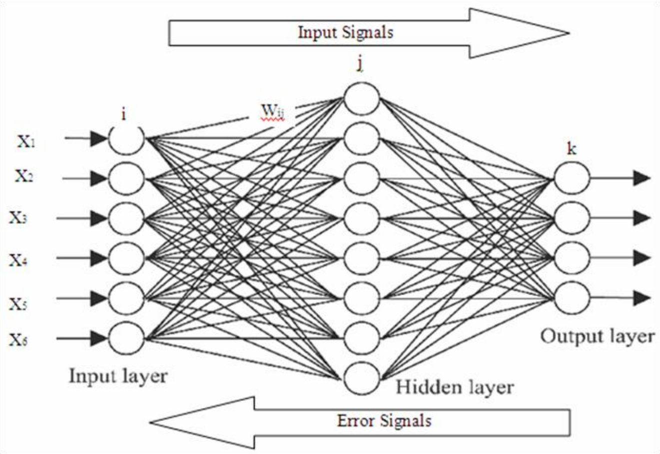

Figure 9. Multilayer feed-forward neural network (MFNN) with back propagation training algorithm (Jamil et al., 2009)

CONCLUSIONS

The principles of Sustainable Development and Green Buildings have penetrated the construction industry at an accelerating rate in recent years. The concrete industry in particular, because of its enormous environmental footprint, has a long way to go to shed its negative image. But as the preceding pages have shown, significant progress has been made in this regard. Whereas the idea of using recycled materials in concrete production was widely unknown only a few years ago, concrete producers now know that they need to change. The potential tools and strategies to meet the environmental challenges and sustainable construction can be summarized as follows: (1) to replace as much Portland cement as possible by supplementary cementitious materials, especially those that are by-products of industrial processes, such as fly ash, ground granulated blast furnace slag, and silica fume; (2) to use recycled materials in place of natural resources; (3) to improve durability and service life of structures, thereby reducing the amount of materials needed for their replacement; (4) to improve concrete's mechanical and other properties, which can also reduce the amount of materials needed; (5) to reuse wash water.

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Buildings and constructions

A REVIEW ON INDONESIAN TRADITIONAL TIMBER HOUSE SUSTAINABILITY

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ABSTRACT

This paper explores some important characteristics of two Indonesian traditional timber houses, Omo Hada of Nias Island and Joglo of Yogyakarta that have been found to survive even after many earthquakes. Their engineering characteristics are also elaborated with recent research outcomes for a fruitful discussion. One important key of their survival during earthquake is the mortise-tenon system of their connections. Together with high quality and large cross-section of wood members this connection system provides strong interlocking between the joint members with high frictional resistance or damping. This behavior is much similar to dynamic performance of log constructions in which all log layers response uniformly as a massive body below certain peak ground acceleration. More frictional damping of log houses could be attained when frictional action between two log layers is effectively developed for instance by inserting wooden dowels. A fully adoption of frictional damping as earthquake energy dissipating system by the present timber houses, however, is perhaps difficult due to limited sources of high-strength timbers and continuous traditional construction skill deterioration of the local people. In very active seismic areas therefore the lateral integrity of present timber houses that are built from fast-growing timbers has to be adequately designed as in the modern light-frame timber buildings: (1) Wooden walls or panels that tie together the main and supporting columns and allow the natural flexible wood structures to deform enough to absorb the earthquake energy; and (2) Strong anchorage system that secures a successful load transfer from the uppers structure to concrete foundation and into the ground.

Keywords: *earthquake, frictional damping, mortise-tenon joint, traditional timber houses*

INTRODUCTION

Recent earthquakes at many places in Indonesia have drawn building observers', engineers' and architects' attention toward a similar opinion in which wood or timber housing should be the solution. This conception is most probably due to the fact that wood assemblies offer high strength-to-weight ratios over those built with steel and concrete. This results in low inertial (lateral) force during earthquake. Moreover, since construction weight or mass is relatively small, timber constructions in general are flexible and ideally response to the ground motion with minimum damage. The word ideally here is being underlined since some timber structures which were poorly fabricated were leaning after the Mw 8.6 Northern Sumatra earthquake of March 28, 2005 (EERI, 2005). Actually the most visible fact is many traditional houses, which are completely or primarily built from timber, have been found to survive even after many earthquakes. Characteristics or construction method of the traditional timber houses which were transferred by tradition and developed by local people are referred as indigenous knowledge or local wisdoms by previous studies (Triyadi et al., 2009). This indigenous knowledge or tradition is often seen as static and unchanging, but in fact, it is influential and adaptable with respect to the local environment condition. This presented paper examines the sustainability of Indonesian traditional timber houses mainly based on their engineering aspects. The engineering aspects of these traditional timber houses are explored and elaborated with the recent research outcomes on timber building for a fruitful discussion.

CHARACTERISTICS OF INDONESIAN TRADITIONAL TIMBER HOUSES

One example of Indonesian traditional timber house is Omo Hada, an indigenous house of Nias people as shown in Figure 1. This house was built some 200 years ago and was survived with no damage after the M_w 8.6 Northern Sumatra Earthquake of March 28, 2005. Omo Hada has very light roof materials and has diagonal members or bracing made from round (solid) wood placed at the bottom, above the ground and below the floor. Four main columns of Omo Hada that support the roof system are laterally reinforced by diaphragm action of the wooden floor. The floor consisted of timber beams in grid system with thick wooden board Another example of the traditional timber house is Joglo houses shown in Figure 2, which are often found in Yogyakarta and surrounding cities. The Joglo houses are characterized by four wooden columns at the center that are simply placed on the foundation and connected at the top to multiple timber beams for their lateral stability. The size of these main columns is usually far larger than the other columns, which are placed at the perimeter. These two traditional houses have different earthquake-resistant levels and by tradition they are located at two areas with different seismic-hazard intensities. The latest seismic hazard map divides Indonesia into six zones where Nias Island is included in zone 6 with peak ground acceleration of 0.33*g* and Yogyakarta is located in zone 4 with peak ground acceleration of 0.24*g*, for dense soil basis.

Figure 1. Omo Hada of Nias Island
(Courtesy of Feri Latief, 2007)

Figure 2. Joglo house
(Courtesy of Virgina Veryastuti, 2008)

Omo Hada and Joglo houses (and probably most of traditional houses) adopted mortise and tenon joint system in their connections, for instance, beam to column joints or beam to beam joints. In this connection system no steel or metal fastener is used but mortise member or tenon member has an extent for interlocking purpose. In combination with high quality and large cross-section of wood members (which were not difficult during that time), the mortise and tenon joint system provides timber structures with more lateral integrity to resist the lateral forces of earthquakes. Great frictional resistance or damping developed among the mortise-tenon joint members absorbs most of the earthquake energy. Probably after some earthquake events, gaps or openings between the mortise-tenon joint members might be appeared but this can be repaired such as by inserting wooden pegs.

FRICTIONAL ACTION

The principle of frictional action previously mentioned will be further explored by reassessing the shaking table test results of log constructions (Awaludin et al. 2009). Despite the intensive use of timber, log construction is an eco-friendly building technique as far as pollution effects are being concerned. Lateral resisting elements of log constructions are consisted of friction between logs due to vertical loads and interlocks with notches between main and cross logs. The log model as shown in Figure 3 was a scaled one having clear size of 1200x600-mm^2 and 750-mm in height and was tested under two conditions: without and with wooden dowels between log layers. Under sine wave the interlayer slip (relative slip among log

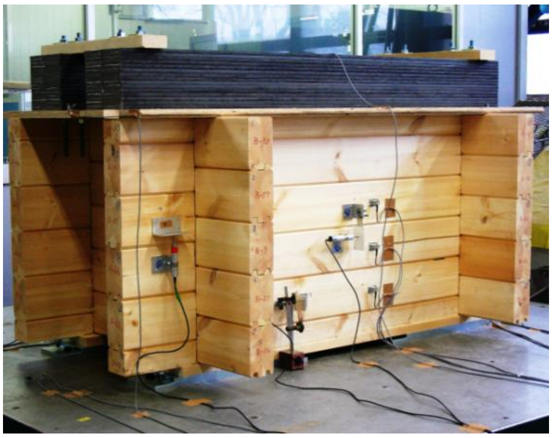

Figure 3. Shaking table test of log construction model (Awaludin et al., 2009)

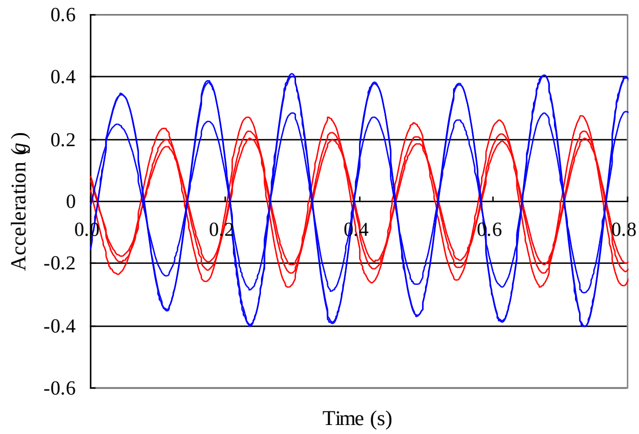

Figure 4. Time history acceleration of three log layers at interlayer-slip initiation (Red-lines, log without wooden dowels; Blue-lines, log with wooden dowels)

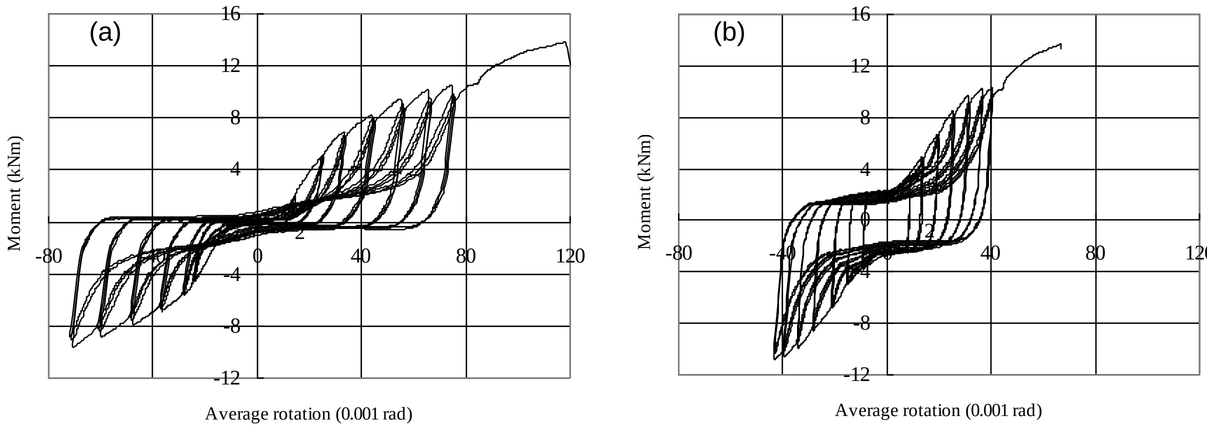

Figure 5. Hysteresis loops of timber joints:
(a) Without initial bolt tightening; (b) With initial bolt tightening

layers) of the log without wooden dowels was observed at peak ground acceleration (PGA) of 0.22*g*. While in the log with wooden dowels, interlayer slip started at PGA of 0.34*g* as shown in Figure 4. (*g* is gravitational acceleration, 9.8m/s^2.) Below these peak ground accelerations all log layers response uniformly as a massive body, no interlayer slip was recorded. The value of PGA during slip occurrence indicated frictional coefficient under dynamic loading or simply recalled as dynamic frictional coefficient. Improve the frictional action among the log layers such by adding wooden dowels clearly increased the dynamic frictional coefficient and overall lateral resistance of the log construction.

Another study described the role of frictional action in timber joints can be found in Awaludin et al. (2008) though the joint geometry discussed in this reference is bolted timber joints with steel plates as the outer members, which is not a typical of traditional timber joints. Double-shear test indicated that hysteretic damping or area enclosed by the loop of the joint increased significantly due to initial bolt tightening as shown in Figure 5. Frictional damping (hysteretic damping due to frictional action between joint members) has a square shape with its magnitude is controlled by bolt tightening force and friction coefficient between wood and steel plate. Hysteretic damping basically informs the amount of earthquake energy that can be dissipated by the joint system. The concept of frictional damping as passive energy dissipation system has been applied recently in many friction damper devices. This device is composed of several steel plates and friction pad disc that are being connected with a pretightened bolt. Several Bellevile washers are used in order to maintain a constant tightening force, frictional force on the interface of the friction pad disc and steel plates. A study on friction damper application on steel frames found that this damper presented a viable alternative to the earthquake-resistant design both for new constructions and for upgrading the existing structures (Mualla et al., 2002).

PRESENT CONDITION OF TIMBER CONSTRUCTIONS

Frictional action as previously explained has a crucial role on seismic-resistant of traditional houses and this action requires sufficient surface contact area, which can be fulfilled when large cross-section timber members are used. Considering intensive deforestation activities nowadays in Indonesian natural-forests for various reasons including forest fires and illegal logging, the sustainability of traditional houses is questionable. Another aspect that can be used to evaluate the traditional houses sustainability is the availability of skilled local people. Their expertise is unique for each region because it has been developed through years toward different local challenging. However, after rapid production of masonry houses in many places including rural areas this knowledge has been continuously deteriorated. Even after many casualties due to the M_w 6.3 Java Earthquake of May 27, 2006 were found in masonry houses especially the unreinforced ones, local people in Yogyakarta tended to prefer brick masonry for rebuilding their homes (Ohno et al., 2007).

Without any extra ordinary efforts to reforestation then timber engineers or architects should start to be friendly with fast-growing timbers. These timbers, which are commonly found in industrial plantation and community forests, were originally intended to provide raw material for pulp and paper production. Some species of these timbers are: *Acacia mangium*, *Pinus merkusii*, *Maesopsis eminii*, and *Paraserianthes falcataria* (Alamsyah et al., 2006 and Sulistyawati et al., 2008). *Maesopsis eminii* is widely planted in community forests in West Java, while *Acacia mangium*, *Pinus merkusii* and *Paraserianthes falcataria* are planted in industrial plantation forests. The fast-growing timbers have small cross-section and their strength properties are much less than those of the timber used by traditional houses. In this regard, glued-laminated system must be put into use seriously. Glued-laminated or glulam is a technique to overcome the scarcity of large timber cross-section. In this technique, small cross-section lumbers are arranged (or connected via finger or scarf joint system) and glued using adhesives, and then pressed to ensure a good interlayer contact during curing process. Besides this technique can produce any size of timber cross-section, it minimizes the non-uniform properties of timber lumbers including their natural defects such as knots or checks. Glulam actually is not a new timber product in countries such as Japan, U.S, Canada and European countries but it is a new and still limited in Indonesian timber markets. Those countries have been accustomed to use softwood species for structural elements as their hardwood species sources are very limited due to climate condition. Since the mechanical properties of Indonesian fast-growing timber species are not much different from mechanical properties of their softwood species, research results related to glulam using softwood species can be roughly adopted.

ENGINEERED TIMBER CONSTRUCTIONS

In very active seismic zones the present timber houses that are built from fast-growing timber species are vulnerable and might not be the solution unless they are engineered so that they can conform to earthquake-resistant requirements. Similar to lateral bracing concept of diagonal members in Omo Hada house, the present wood-frame houses can be made earthquake-resistant by the addition of plywood sheathing or panels. Plywood panels tie together the main and supporting columns and allow the natural flexible wood structures to deform just enough to absorb the earthquake energy without being disconnected. Racking test of a panel made from oriented strand board indicated that partial opening leads to a decrease of shear resistance but does not substantially deteriorate the ductility performance of the panel (Honma et al., 2008). Wooden shear wall system has been widely used in modern light-frame constructions of North America or Australia, and often the panels are combined with wooden bracing or diagonal members. A tremendous increase of energy dissipation capacity of plywood panels by installing hold-down device that incorporates Viscoelastic (VE) damper has been reported (Blasetti et al., 2008). Though there is little impact to cost, the resulting timber structures will be less susceptible to structural and non-structural damages due to earthquake. The research on VE damper has almost concentrated in steel, concrete and masonry constructions.

Another important characteristic of engineered timber buildings is their anchorage system. The upper structure is strongly connected to the concrete foundation via metal fasteners, to ensure a successful horizontal load transfer, forces from upper structures to foundation and into the ground. In contrast, most traditional houses used a different anchorage system in which columns are simply placed on stone foundation (Ihsan, 2008). In the latter system, the key factors are heavy weight of traditional houses and frictional coefficients: (i) friction between the timber column and the stone foundation; (ii) friction between the stone foundation and the soil. When frictional or Coulomb damping is exceeded, there will be a permanent slip between the column and foundation. However, the slip might be relatively small considering the rigidity of traditional houses and it would vanish or amplify when the next earthquake comes. In the case of light-frame timber houses, the adoption of traditional anchorage system definitely yields different mechanism and is vulnerable to earthquake forces. The upper structure may slip-off or displace completely from the foundation if it has sufficient lateral rigidity. And if it is not, besides a complete slip-off, wooden members will be disconnected and followed by injured people or even life lost.

FINAL REMARKS

Design of Indonesian traditional timber houses exhibits local wisdom or knowledge for timber engineers and architects that not only must be discovered but also must be readjusted to the current situation. In particular, this paper showed that frictional damping or Coulomb damping has been the key success of beam-column connections and anchorage systems of the Indonesian traditional timber houses. However, A fully adoption of this system by nowadays timber houses perhaps is difficult since high quality and large cross-section timber members are the major problems. Therefore, the present timber houses are not the solution for housing problem in very active seismic areas unless their lateral integrity is properly reinforced as in the modern light-frame timber constructions.

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OPTIMIZATION OF TUNED MASS DAMPERS USING REAL CODED GENETIC ALGORITHMS FOR BUILDINGS SUBJECT TO EARTHQUAKES

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ABSTRACT

Reducing structural vibration due to external lateral load has been a primary concern of structural engineers. One of the popular methods is by the addition of a small mass where its stiffness and damping are designed in a proper manner so that they tune to a specific frequency of the structure as tuned mass damper (TMD) systems. This method is gaining a vast attention from researchers and has been implemented in many buildings. The TMD system is easy to be implemented either as a new system or as a retrofit to the old building and does not require external power to operate. While in traditional method of optimization the building has to be transformed to a single degree of freedom system, the optimization of TMD by using genetic algorithms (GAs) do not require such a transformation since the physical model of the building is used in the computational procedures. In this paper real coded genetic algorithms (RC-GAs) are used instead of binary coded genetic algorithms (BC-GAs). In RC-GAs real numbers are used instead of binary ones. In opposed to the BC-GAs, RC-GAs do not require the lower and upper bounds of the design variables to be known beforehand. By using a specific crossover technique, RC-GAs are capable of exploring unknown domain of the optimum values. The optimization results in that the damping ratio of TMDs increases when the mass ratio increases. In addition, when the mass ratio increases results in the smaller frequency ratio of the damper. Numerical examples are then presented to show the effectiveness of the proposed procedure in optimizing damper parameters to reduce building response subject to earthquake excitations. From the simulation it can be shown that the response of the structure can be reduced by the addition of TMDs.

Keywords: *optimization, tuned mass dampers, real coded genetic algorithms, response reduction*

INTRODUCTION

In the earthquake prone area minimization of response is one of the primary concerns of structural engineers. Several approaches have been proposed to reduce the response of structures; such as passive and active control systems and their combinations. One of methods in passive control systems is tuned mass damper (TMD) systems.

Much research has been proposed to optimize the properties of tuned mass dampers (TMDs). In the early development much research concerning TMD considered only a simple single degree of freedom systems (Warburton and Ayorinde, 1980; Warburton, 1982; Den Hartog, 1947) or multi degree of freedom systems, such as buildings, but are modeled as single degree of freedom systems (Villaverde, 1985; Villaverde and Koyama, 1993; Sadek et al., 1997). Because the structures are modeled as SDOF systems the TMDs will tune to a single mode system only.

In order to model the structures in a realistic manner, Hadi and Arfiadi (1998) proposed the optimization of TMD by using binary coded genetic algorithms. In this case physical properties of the structures are used directly without necessarily converting the structures into a single mode model. Therefore, the vibration mode to be tuned does not necessarily to be known beforehand. One of the drawbacks of using binary coded genetic algorithms is that the range of the properties of the TMD should be supplied by designers. When the designers do not have experience concerning the range of the design values, the procedure may fail to obtain the optimum values. Other optimization method recently has also been proposed such as developed by Lee et al. (2006) employing frequency domain approach.

REAL CODED GENETIC ALGORITHMS

Genetic algorithms (GAs) are optimization procedures that mimic biological reproductions based on Darwinian survival of the fittest concept introduced by Holland in 1970s (Holland, 1992; Michalewicz, 2006; Goldberg, 1989). In the early development a binary coded genetic algorithms (BC-GAs) is used to solve the optimization problems. GAs optimize the problems by first introducing the population of the design variable. The initial population is randomly created such that it can be considered as searching optimum values from different starting points (Goldberg, 1989). Each individual in the population has its own fitness according to the objective function defined by designers. A number of fit individuals are selected from the population to experience recombination, i.e., mutation and crossover. In the mutation process the chromosome is changed genetically to introduce a new individual. In the crossover a pair of chromosomes is mated to produce a pair offsprings. This process is done generation per generation, such that the optimum values have been obtained or is terminated by a certain criterion. In general the GAs procedure is depicted in Figure 1.

In BC-GAs design variables are represented by a string containing 0 and 1. A string represents a real number according to the length of the string. Therefore, the length of string bounds the range of real numbers. Because of this, the approximate design, i.e. the upper and lower bounds of design variable, should be supplied by designers.

In RC-GAs an individual as candidates of design variables are represented by real numbers such as:

$$\mathbf{G} = [\mathbf{g}_1 \ \ \mathbf{g}_2 \ \ .... \ \ \mathbf{g}_r] \tag{1}$$

where g_i = any real numbers, r = total numbers of design variables. Therefore, there is no limitation on the boundary of the design variables and the approximate values of design variables do not necessarily to be known beforehand.

The crossover in RC-GAs taken in this paper is an arithmetic crossover (Herrera et al., 1998, Arfiadi and Hadi, 2001). In the arithmetic crossover, the parents $\tilde{\mathbf{G}}$ and $\overline{\mathbf{G}}$ produce offsprings:

$$\tilde{\mathbf{G}}' = a\,\tilde{\mathbf{G}} + (1-a)\,\overline{\mathbf{G}} \tag{2}$$

$$\overline{\mathbf{G}}' = (1-a)\,\tilde{\mathbf{G}} + a\,\overline{\mathbf{G}} \tag{3}$$

where a = random variable between 0 and 1.

The mutation in RC-GAs taken in this paper is a simple mutation (Hererra, 1998) as follows:

For the individual chosen for mutation the resulting individual after mutation is

$$\mathbf{G}' = [\mathbf{g}'_1 \ \ \mathbf{g}'_2 \ \ .... \ \ \mathbf{g}'_i \ \ .... \ \ \mathbf{g}'_r] \tag{4}$$

where $\mathbf{g}'_i = \alpha\,\mathbf{a}\,\mathbf{g}'_1$, $\alpha \rangle 1$ and $\mathbf{a}$ = random variable between 0 and1.

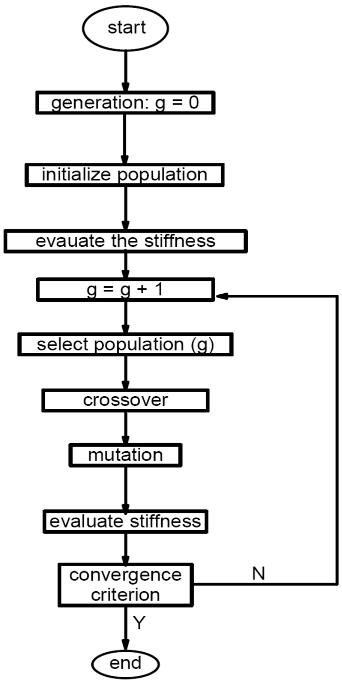

Figure 1. Standard genetic algorithms

OPTIMIZATION OF TMDS

A nine-story asymmetric building is considered in this paper as shown in Figure 2. The building plan of the 1st up to the 5th floors is square; the 6th up to the 9th floors is of the L shape.

In the analysis, mass of building is lumped at every floor, where translation mass (m) and rotational mass (m_I) of floors 1-5 are: m = 169,101 t, m_I =16233.696 kN-s^2/rad, floors 6-8: m = 126,826 t, m_I =11160.688 kN-s^2/m, roof: m = 105,688 t, m_I =9300.544kN-s^2/m. The structural properties of columns and beams are shown in Table 1.

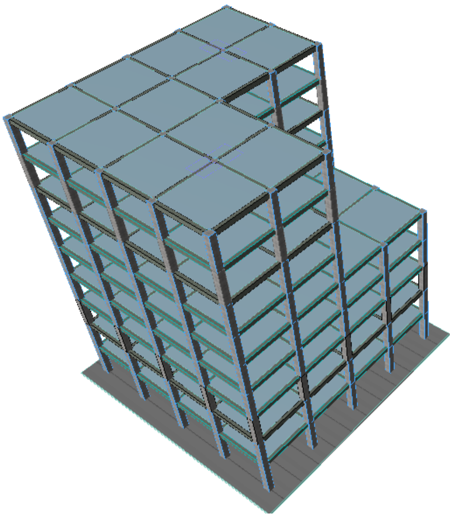

Figure 2. A nine story building

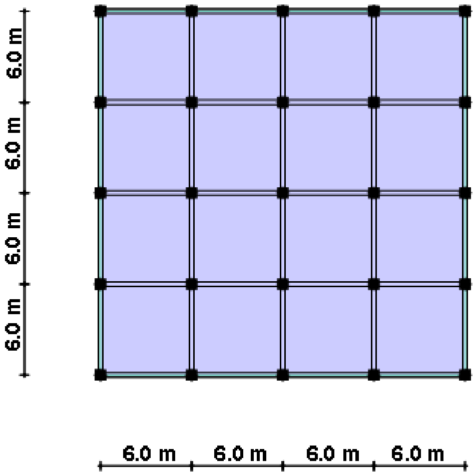

Figure 3. The 1^{st} – 5^{th} floor plan

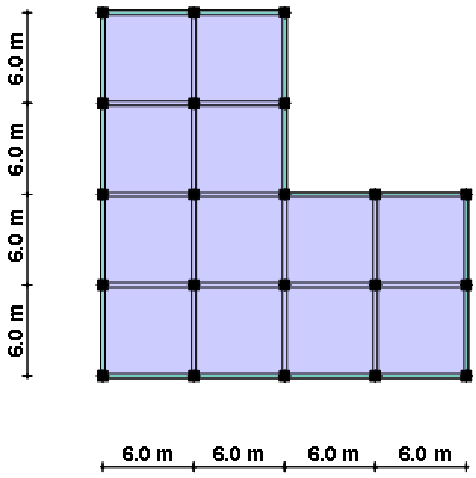

Figure 4. The 6^{th} – 9^{th} floor plan

The stiffness matrix of building is built by assuming rigid floor diaphragm where three degrees of freedom are assigned to each floor so that the size of the stiffness matrix is 27 × 27. The building's stiffness matrix is built according to the method developed in Arfiadi and Hadi (2000).

The equations of motion under unidirectional ground motion can be written as:

$$[M_{3D}]\{\ddot{U}_{3D}\} + [C_{3D}]\{\dot{U}_{3D}\} + [K_{3D}]\{U_{3D}\} = -[M_{3D}]\{e_0\}\ddot{u}_g \quad (5)$$

where $[M_{3D}]$ = n×n mass matrix, $[C_{3D}]$ = n×n damping matrix, $[K_{3D}]$ = n×n stiffness matrix, $\{U_{3D}\}$ = n×1 displacement vector, the dot represents derivative with respect to time, $\ddot{u}_g$ = unidirectional ground acceleration, n = total degrees of freedom, and

$$\{e_0\} = \left[\{e_{0,1}\}^T \ \{e_{0,2}\}^T \ \ldots \ \{e_{0,n}\}^T\right]^T \quad (6)$$

$$\{e_{0,1}\}^T = [\cos\beta \quad \sin\beta \quad 0] \qquad i = 1,2,\ldots,n \quad (7)$$

where β = direction angel of earthquake

In the analysis, stiffness proportional damping is assumed where the first modal damping ratio is taken equals to 2%. The building's model has also been verified using ETABS v. 8.4.5 where a good result has been obtained.

Table 1. Structural properties

Story (Floor) No	Column size (mm)	Beam size (mm)
1	650 × 650	300 × 500
2	650 × 650	300 × 500
3	650 × 650	300 × 500
4	500 × 500	300 × 500
5	500 × 500	300 × 500
6	500 × 500	300 × 500
7	400 × 400	300 × 500
8	400 × 400	300 × 500
9	400 × 400	300 × 400

EFFECT OF TMDS

Consider a mass damper that is installed at floor-n and attached at a point with arbitrary orientation as shown in Figure 5. Assuming that the damper can only move in one direction, the displacement of the structure at the attachment point in the direction of mass damper can be written as

$$\mathbf{u}_0 = \mathbf{a}_0 \, \mathbf{U}_{3Dn} \quad (8)$$

$$\mathbf{A}_0 = [\cos\alpha_D \quad \sin\alpha_D \quad \mathbf{d}_0] \quad (9)$$

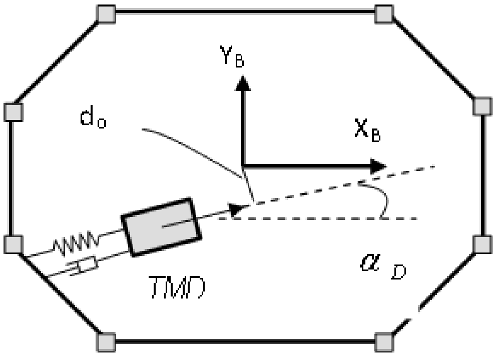

Figure 5. Effect of TMD

in which α_D = counter clockwise angle from the X-Global Building Coordinate System to the line of action of the damper's displacement and d_o = distance from the origin to the line of action of the damper's displacement. The value of d_o is taken positive when the floor displacement causes positive displacement of the damper and negative otherwise.

The effect of inclusion of the mass damper to the equations of motion can be obtained using the Hamilton's principle (Clough and Penzien, 1975; Meirovitch, 1992) and defining the kinetic energy and potential energy as

$$\mathbf{T} = \tfrac{1}{2}\dot{\mathbf{U}}_{a3D}^{T}\mathbf{M}_{3D}\dot{\mathbf{U}}_{a3D} + \tfrac{1}{2}\mathbf{m}_d\dot{\mathbf{u}}_{ad}^{2} \quad (10)$$

$$\mathbf{v} = \tfrac{1}{2}\mathbf{U}_{a3D}^{T}\mathbf{K}_{3D}\mathbf{U}_{a3D} + \tfrac{1}{2}\mathbf{k}_d\left(\mathbf{u}_d - \mathbf{u}_0\right)^2 \quad (11)$$

The variation of work done by the non-conservative forces is

$$\delta\mathbf{W}_{nc} = \mathbf{f}_{3D}\delta\mathbf{U}_{3D} + \mathbf{f}_d\delta\mathbf{u}_d - \mathbf{C}_{3D}\mathbf{U}_{3D}\delta\mathbf{U}_{3D} - \mathbf{c}_d\left(\dot{\mathbf{u}}_d - \dot{\mathbf{u}}_0\right)\delta\left(\mathbf{u}_d - \mathbf{u}_0\right) \quad (12)$$

By defining the Lagrangian L = T − V and applying the Hamilton's principle

$$\int_{t1}^{t2}\left(\delta L + \delta\mathbf{W}_{nc}\right)dt = 0 \quad (13)$$

following integration by parts, the equations of motion can be obtained.

For building considered in this paper, the first TMD is placed in the X direction and second TMD is placed in the Y direction so that it can react to bidirectional earthquakes. The equations of motion of structure with TMD can be written as:

$$[\mathbf{M}_s]\{\ddot{\mathbf{u}}\} + [\mathbf{C}_s]\{\dot{\mathbf{u}}\} + [\mathbf{K}_s]\{\mathbf{u}\} = -[\mathbf{M}_s]\{\hat{\mathbf{e}}_0\}\ddot{\mathbf{u}}_g \quad (14)$$

where

$$\mathbf{M}_s = \begin{bmatrix} \mathbf{M}_1 & \mathbf{0} & \cdots & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{M}_2 & \cdots & \mathbf{0} & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ & & & \mathbf{M}_n & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{0} & [\mathbf{m}_d] \end{bmatrix}_{(n+n_d)\times(n+n_d)} \quad (15a)$$

$$[\mathbf{K}_s] = [\mathbf{K}_{3D}] + \sum [\mathbf{K}_D]$$

(14b

$$\{\mathbf{u}_s\} = \left[\{\mathbf{U}_{3D}\}^T \quad \mathbf{u}_{dx} \quad \mathbf{u}_{dy}\right]^T$$

........(14c

$$[\mathbf{m}_d] = \begin{bmatrix} \mathbf{m}_{dx} & 0 \\ 0 & \mathbf{m}_{dy} \end{bmatrix} \quad (15b)$$

$$\{\hat{\mathbf{e}}_0\} = \begin{Bmatrix} \{\mathbf{e}_0\} \\ \cos\beta \\ \sin\beta \end{Bmatrix}_{27x1} \quad (15c)$$

The size of $[\mathbf{K}_{3D}]$ = (n+n_d)×(n+n_d), n_d = the number of dampers = 2. $[\mathbf{K}_D]$ is the contribution of each TMD to the new stiffness matrix in the form

$$[\mathbf{K}_D] = \begin{bmatrix} [\mathbf{a}_o]^T[\mathbf{k}_d][\mathbf{a}_o] & -[\mathbf{a}_o]^T[\mathbf{k}_d] \\ -[\mathbf{k}_d][\mathbf{a}_o] & [\mathbf{k}_d] \end{bmatrix}_{4\times4} \quad (16)$$

where [a_o] is the transformation matrix from each TMD to the global stiffness matrix as follows

$$[\mathbf{a}_0] = [\cos\alpha_D \quad \sin\alpha_D \quad \mathbf{d}_0]$$

.........(16

α_D = angle between displacement of TMD and global X axis, d_o = distance from CM of the floor and to the TMD. For TMD in X direction

$$[\mathbf{a}_{0x}] = [\ 0 \ \ \text{-}8\ ] \quad (17)$$

and for TMD in Y direction

$$[\mathbf{a}_{0y}] = [\ 0 \ \ \text{-}8\ ] \quad (18)$$

The optimum properties of TMDs are carried out by using RC-GAs.

Note that RC-GAs used in this paper utilize a type of crossover so that it is capable of exploring the unknown domain of design variables. In addition elitist strategy (Grefenstette, 1986) is utilized so that the best individual (design variable) is always passed to the next generation. Another modification of GAs procedure taken in this paper is that after crossover and mutation a portion of new individual is inserted so that to increase the variability of the population. The modification procedure is shown in Figure 7.

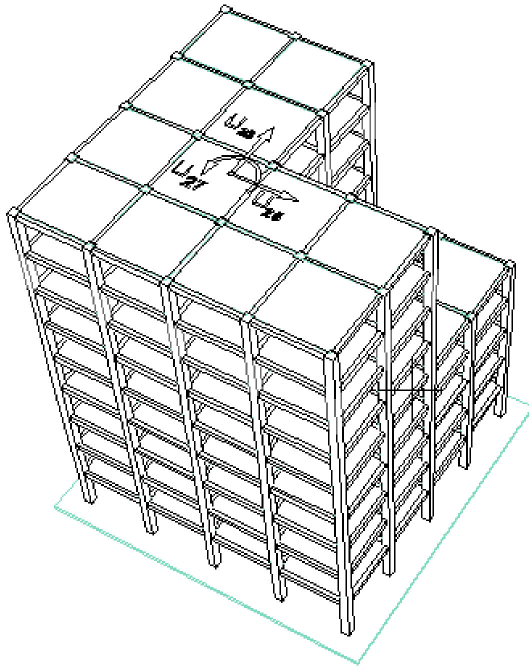

Figure 6. DOFs for top floor

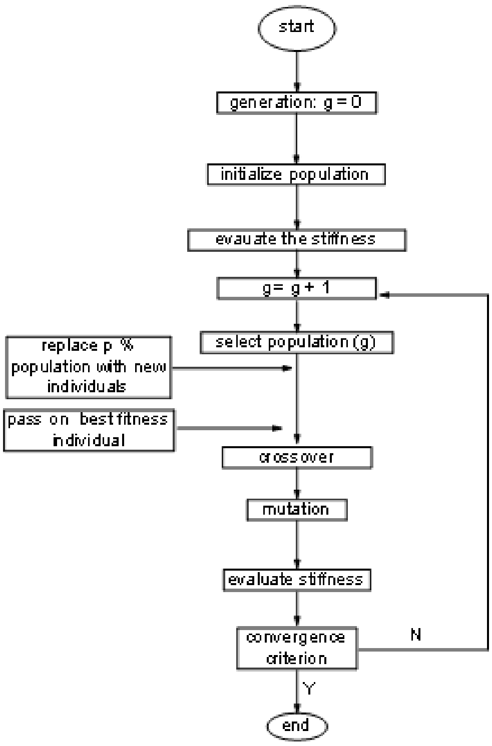

Figure 7. Modified GA procedure

The equation of motion in (13) can be converted to a state space equation in the form

$$\{\dot{z}\} = [A]\{z\} + \{E\}w \tag{19}$$

where

$$\{z\} = \begin{Bmatrix} \{u_s\} \\ \{\dot{u}_s\} \end{Bmatrix} \tag{20a}$$

$$[A] = \begin{bmatrix} [0] & [I] \\ -[M_s]^{-1}[K_s] & -[M_s]^{-1}[C_s] \end{bmatrix} \tag{20b}$$

$$\{E\} = \begin{Bmatrix} \{0\} \\ -[M_s]^{-1}\{\hat{e}_b\} \end{Bmatrix} \tag{20c}$$

$$w = \ddot{u}_g \tag{20d}$$

The objective function is H_2 norm of the transfer function from disturbance to the displacement of structure, where the unidirectional earthquake is applied with $\beta = 45^o$ to activate the properties of both TMDs. The objective function can be written as follows:

$$J = \left\{ tr\left([C_z][L_c][C_z]^T \right) \right\}^{1/2} \tag{21}$$

where $[C_z]$ is a matrix to relate the response that is minimized with the state vector in the form

$$\{\tilde{z}\} = [C_z]\{z\} \tag{22}$$

For example when is identity matrix, then is a vector that contain displacements and velocities of the structure.

Matrix $[L_o]$ can be obtained from Lyapunov equation (Doyle et al., 1989; Lublin et al., 1996)

$$[A]^T[L_0] + [L_0][A] + [C_z]^T[C_z] = [0] \tag{23}$$

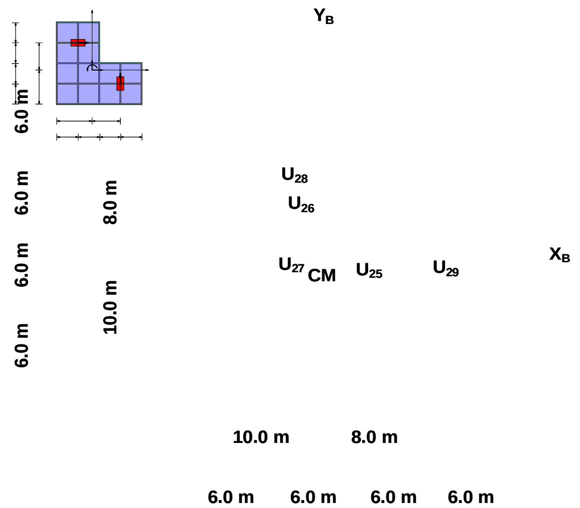

Figure 8. Placement of TMDs

Several masses of TMDs are evaluated to reduce the vibration of building. i.e., mass of each TMD is 6.66 tons, 13.32 tons, 24 tons, 50 tons, 67 tons, 79.9 tons, 93.22 tons and 106.53 tons, respectively. In these cases the mass of each TMD is about 0.5%, 1%, 1.5%, 1.8%, 3.8%, 5%, 6%, 7% and 8% of the total mass of building, respectively. Because of the geometry of the building, the properties of TMDs are taken as $k_{dx} = k_{dy}$, and $c_{dx} = c_{dy}$.

RCGAs with probability of crossover p_c=0.8, probability of mutation = 0.01, population size = 20 is employed for the optimization. To increase the variability of the population, 10% random new individual are inserted to the population replacing some portions of old populations in every generation. The resulting optimization after 500 generations can be seen in Table 2.

Table 2. Results of optimization

$m_{dx} = m_{dy}$ (ton)	$k_{dx} = k_{dy}$ kN/m)	$c_{dx} = c_{dy}$ (kN-s/m)	ω_d (rad/s)	ξ_d
6.66	293.2013	5.1594	6.64	5.8%
13.32	569.2573	14.3941	6.54	8.3%
19.92	829.6629	26.103	6.45	10.2%
24	979.43	34.1	6.39	11.1%
50	1828.4	97.4	6.05	16.1%
67	2282.12	146.02	5.84	18.7%
79.9	2579.449	185.2286	5.68	20.4%
93.22	2848.035	227.1106	5.53	22.0%
106.53	3080.679	269.8919	5.38	23.6%

APPROXIMATION FORMULA FOR OPTIMUM TMDs

From the optimization results, the frequency ration can be plotted versus single mass ratio as shown in Figure 9. By using Excel the relationship has the following form:

$$\omega_r = 4.472 m_r^2 - 2.903 m_r + 1.015 \quad (24)$$

where

$\omega_r = \omega_d / \omega_1 = \text{frequency ratio}$

$m_r = m_d / M_{tot} = \text{mass ratio}$

$\omega_d = \sqrt{k_d / m_d} = \text{natural frequency of TMD}$

$\omega_1 = \text{first circular frequency of structures, and}$

$M_{tot} = \text{total mass of buildings}$

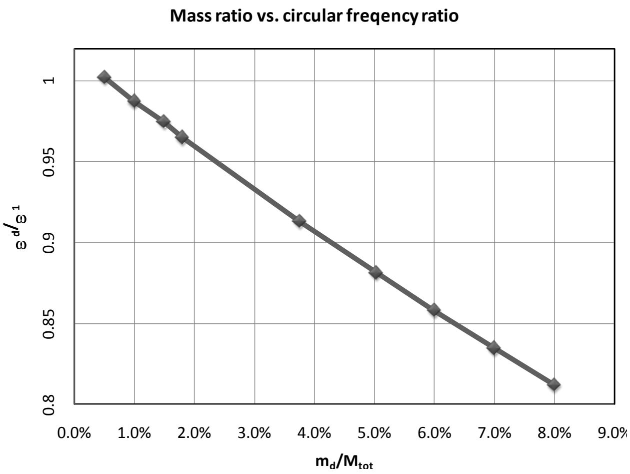

Figure 9. Mass ratio vs. frequency ratio

Similarly, the damping of TMD is also depicted in Figure 10. From Figure 10 it can be shown that the damping ratio of TMD increases with the increase of mass ratio. Again by using Excel it can be shown that

$$\xi_d = 0.841\, m_r^{0.503} \quad (25)$$

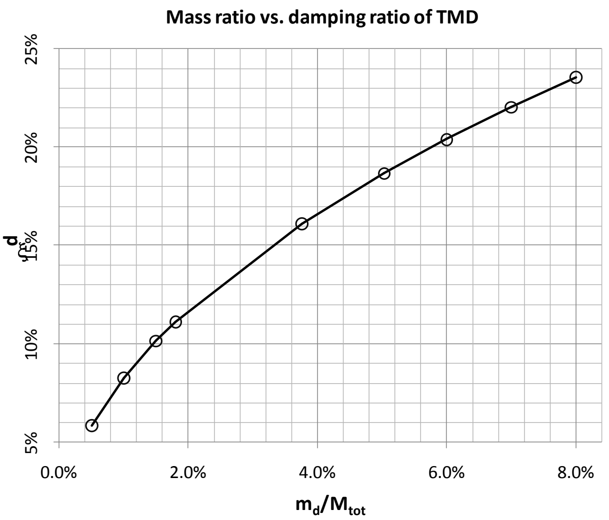

Figure 10. Mass ratio vs. damping ratio of TMDs

As expected when the mass of the damper increases the response reduction increases as shown in Figure 11.

From Figure 11, for example, by using each mass of TMD of about 1% of the total mass of the building the response reduction that can be achieved is about 13.8 % for top floor displacements and 9.4% for the average story displacements, respectively. For practical purposes the mass ratio has to be limited. When for a certain mass ratio, the response reduction is still not effective, active control systems may be used to increase the effectiveness of the response reduction.

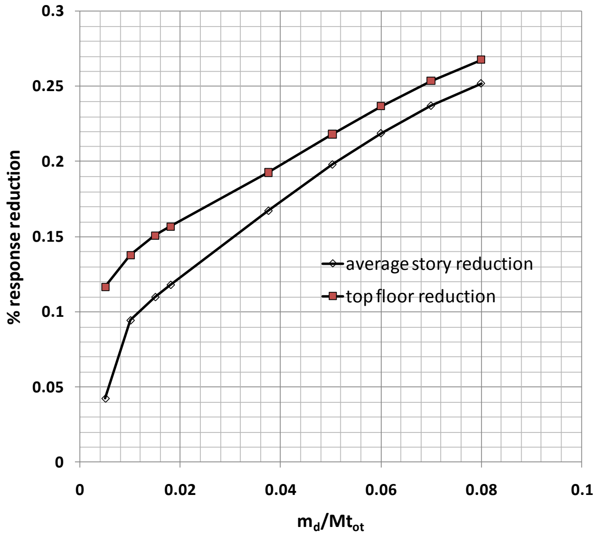

Figure 11. Mass ratio vs. response reduction

Time history simulations are then plotted in Figures 12-15 for earthquake excitations in x direction (β = 0°) and in Figures 16-19 for earthquake in the direction of β = 45°.

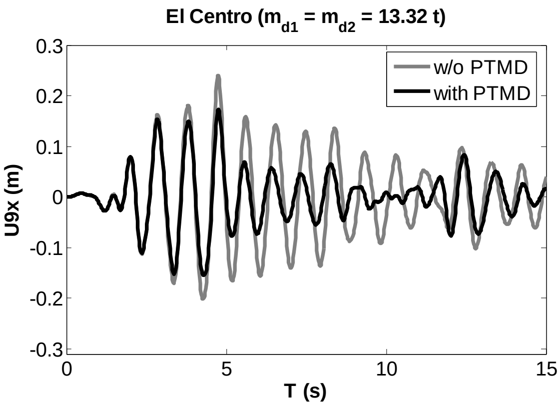

Figure 12. X displacement of 9th floor due to El Centro earthquake β = 0°

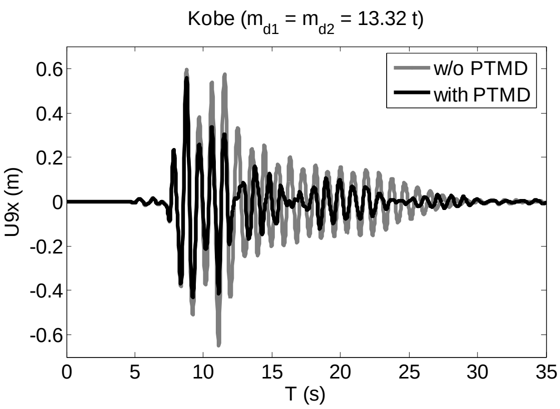

Figure 13. X displacement of 9th floor due to Kobe earthquake β = 0°

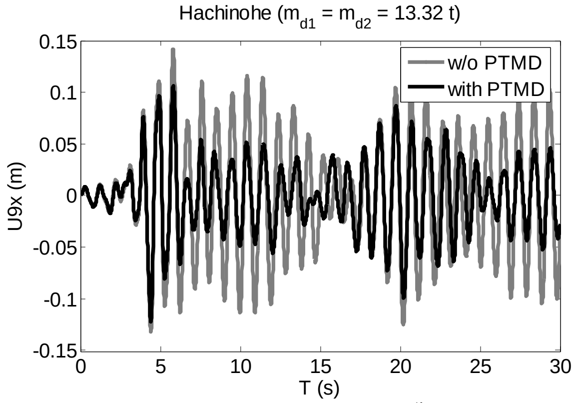

Figure 14. X displacement of 9th floor due to Hachinohe earthquake β = 0°

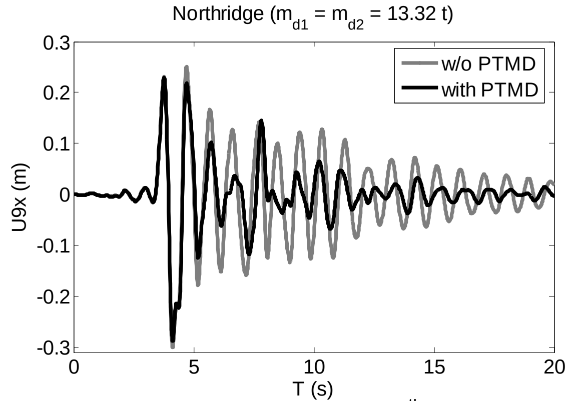

Figure 15. X displacement of 9th floor due to Northridge earthquake β = 0°

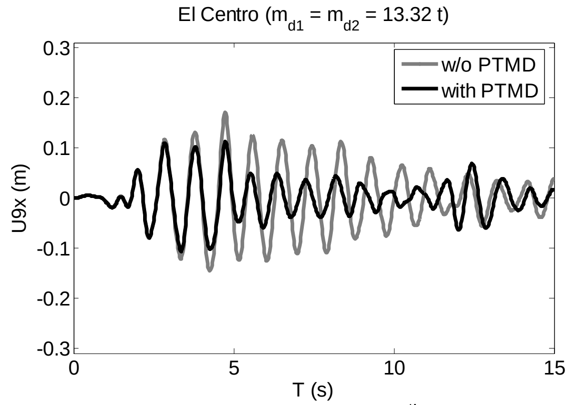

Figure 16. X displacement of 9th floor due to El Centro earthquake β = 45°

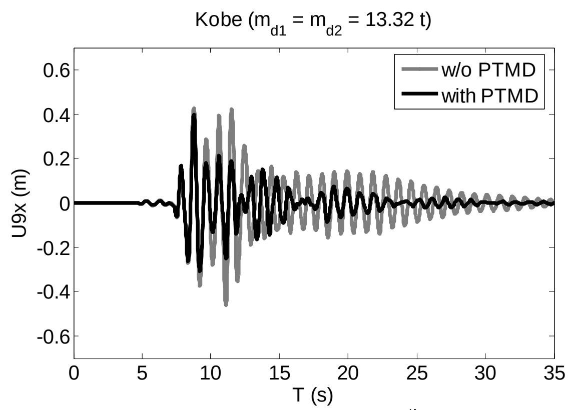

Figure 17. X displacement of 9th floor due to Kobe earthquake β = 45°

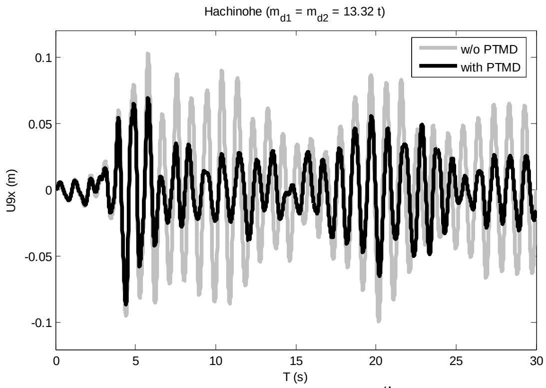

Figure 18. X displacement of 9th floor due to Hachnohe earthquake β = 45°

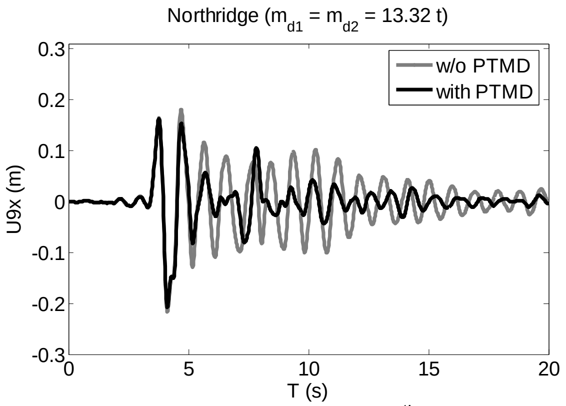

Figure 19. X displacement of 9th floor due to Northridge earthquake β = 45°

Peak responses for sampling earthquake, i.e., Hachinohe earthquake applied in x direction are shown in Table 3 and Figure 20 for several masses of the damper.

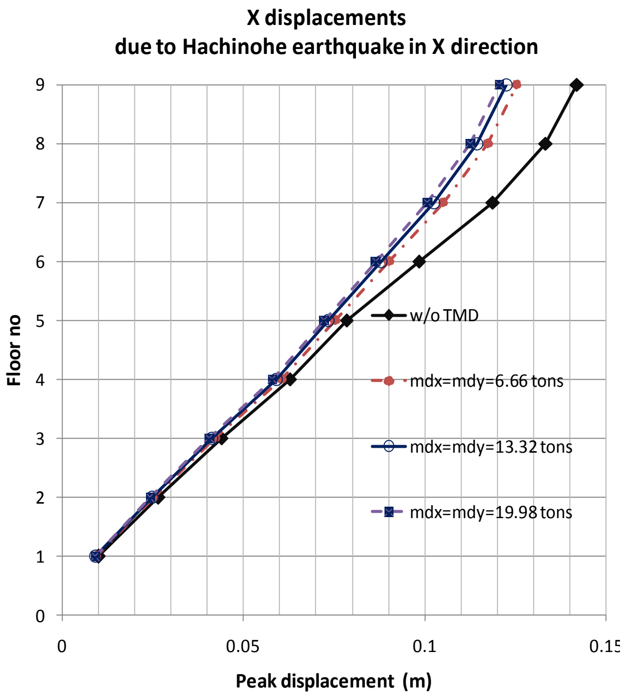

Figure 20. Peak displacement due to Hachinohe earthquake

Table 3. Peak displacement due to Hachinohe earthquake in X direction

Fl. no	X displacements (m)				
	w/o TMD	m_d (ton)			
		6.66	13.32	19.98	24
1	0.0101	0.0096	0.0094	0.0092	0.0091
	0.0266	0.0253	0.0248	0.0244	0.0241
3	0.0440	0.0423	0.0413	0.0406	0.0402
4	0.0629	0.0606	0.0592	0.0581	0.0575
5	0.0786	0.0754	0.0735	0.0722	0.0715
6	0.0984	0.0902	0.0881	0.0865	0.0857
7	0.1188	0.1052	0.1025	0.1007	0.0999
8	0.1333	0.1174	0.1145	0.1126	0.1117
9	0.1420	0.1255	0.1225	0.1206	0.1198

CONCLUSIONS

The optimization of TMD for building structures has been discussed in this paper where real coded genetic algorithms are used to optimize the damper properties. One of the advantages of using RC-GAs is that designers do not need to supply the lower and upper bounds of the design variables as needed in BC-GAs.

From the results of the optimization it is found that by increasing the mass ratio of the dampers results in the smaller frequency ratio. On the other hand, the damping ratio of the damper increases with the increase of the mass ratio.

Simulations under Hachinohe earthquake showed that response reduction can be achieved. By using each mass of TMD of about 1% the response reduction that can be achieved is about 13.8 % for top floor displacements and 9.4% for the average story displacements, respectively.

For practical purposes the mass ratio has to be limited. When for a certain mass ratio the response reduction is still not effective, active control systems may be used to increase the effectiveness of the response reduction.

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DYNAMIC LOADING ON HIGHWAY BRIDGE

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ABSTRACT

The loads in designing of the highway bridge are coming from vehicles and pedestrians pass through the bridge, the choice of design loads that are used for selection of the parts of superstructure and other part of bridge. Dynamic loading is very importance in highway bridge design, when the bridge subjected to moving loads, the induced dynamic deflection and stresses can be higher than static case. The numerical simulation is presented for the case of vehicle load passes over uniform simply supported bridge in constant speed. The relationship between vibration and vehicle speed was determinates.

Keywords: *Bridge, Dynamic, Load, Model, Numeric*

INTRODUCTION

The loads in designing of the highway bridge are coming from vehicles and pedestrians passes over the bridge, the choice of design loads that are used for selection of the parts of superstructure and other part of bridge. There are many load for designing highway bridge (Shaw and O'Connor, 2000) 1. the self-weight of the structure, 2. vehicle weights, 3. horizontal vehicle loads, 4. dynamic vertical loads, caused by dynamic interaction between primary service vehicles and the bridge and influenced by such factor as road roughness and vehicle suspension characteristics, 5. the weight of pedestrians, 6. loads applied by vehicles or pedestrians to railing and kerbs, 7. stream loads on the on the substructure, 8 wind load, where in some cases in may be necessary to consider the aero elastic interaction between wind and bridge leading possibly to aerodynamic instability, 9. wind buffering of the bridge that is placed closely down-wind from a neighboring structure, 10. collision forces caused by a service vehicle striking the structure, 11. earthquake load and 12. thermal effects.

It has been observed when a bridge (Inglis, 1934; Yang and Lin, 2004) is subjected to moving loads, induced dynamic deflection and stresses that significantly higher than those observed for static case.

The failure of a bridge occurs whenever it's unable properly to fulfill its function, may be unable to carry design loads. Failure (Shaw and O'Connor, 2000) is generally a consequence, not only of the geometry of the structure, but also of the nature of the material include stone, timber, steel and concrete of which it is composed. Relevant modes of failure covered following: 1. tension, 2. compression, 3. shear, 4. fatigue, and 5. brittle fracture failure.

There are two means of investigating the bridge–vehicle load interaction problem: 1. experimental and 2. analytical approaches. The experimental method requires considerable time, facilities and cost while the analytical approach represents an economical way to examine the bridge–vehicle load interaction. The analytical approaches to examine the problems concerning bridge–vehicle load interaction has been a method using one- or two-dimensional models of bridges and vehicles load. The two-dimensional system can provide good analytical results for investigating the dynamic responses of whole bridge structures induced by moving vehicles. The three-dimensional bridge–vehicle load interaction system is usually adopted to simulate the responses of local bridge components such as deck slabs and cross beams, and to investigate bridge responses induced by vehicles with paths that do not follow the centre line of the bridge.

The investigation of bridge vibrations namely the vehicle (Timoshenko, 1922; Tan and Shore, 1968; Fryba, 1972; Olson, 1997; Yang et al., 1997) called moving load, (Jeffcott, 1929, Ting et al., 1974; Stanisic, 1985; Sadiku and Leipholz, 1987; Akin and Mofid, 1989; Lee, 1996; Foda and Abduljabar, 1998) called moving mass and (Biggs, 1964; Yang and Yau, 1997; Yang and Wu, 2001; Pesterev, 2001) called moving sprung mass models.

The large increase in the proportion (Esmailzadeh and Jalili, 2003) of heavy and articulated trucks and high-speed vehicles in highway and railway traffic, the dynamic interaction problem between vehicles and bridge structures attracted much attention during the last three decades, simulating of the vehicle load bridge interaction normally considered simply supported beam with single load moving at constant speed along its span. The solution of the dynamic moving load (Esmailzadeh and Ghorashi, 1993) based on the Euler-Bernoulli beam theory and referring the interaction with the simple supported beam.

In the new era and development of the rapid transportation and interaction of each other modes of rapid transportation its essential to study the moving vehicle load passes over a bridge at low until high speed.

This paper describes the dynamics of vehicle load interaction of bridge passes over a bridge. The vehicle total load is modeled a planar vehicle which moving on span and bridge modeled in the simple supported Euler-Bernoulli beam.

VEHICLE LOAD MODEL

The moving vehicle load model as shown in Fig. 1, in the form of simple quarter vehicle model. The dynamic analysis of this problem is moving one concentrated force moving in constant magnitude. The moving vehicle load as dynamic with degrees of freedom (DOF) are 2, M_1 and M_2 are unsprung mass and sprung mass of the moving vehicle load respectively (Esmailzadeh and Jalili, 2003), the tire contact with the support beam all the time and the moving tire is the same displacement assupport beam. The vertical displacements of the unsprung mass and sprung mass respective to their displacement posisition are $y_1(t)$ and $y_2(t)$.

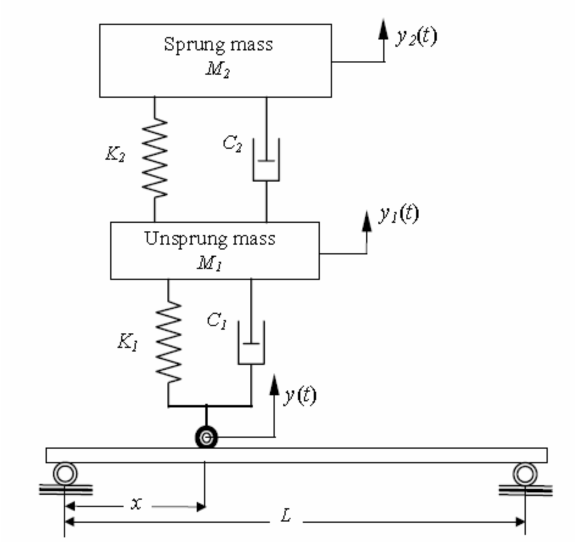

Figure 1. Schematic of a suspension bridge traversed by a moving quarter vehicle model (E. Esmailzadeh and N. Jalili. 2003).

The horizontal position of the center of the mass of the moving vehicle measured from the fixed reference point, such as the left end of the support beam, is denoted by x(t). The horizontal velocity is a and acceleration of the moving vehicle is v.

The vertical interaction force F(t) on the moving vehicle load can be written from free body diagram of the moving vehicle load as (Esmailzadeh and Jalili, 2003)

$$F(t) - C_1\left[\frac{\mathrm{d}y(t)}{\mathrm{d}t} - \frac{\mathrm{d}y_1(t)}{\mathrm{d}t}\right] + K_1[y(t) - y_1(t)]$$
$$- M_1 g + M_1\frac{\mathrm{d}^2 y_1(t)}{\mathrm{d}t^2} + C_2\left[\frac{\mathrm{d}y_1(t)}{\mathrm{d}t} - \frac{\mathrm{d}y_2(t)}{\mathrm{d}t}\right] + K_2[y_1(t) - y_2(t)], \quad (1)$$

and g is the acceleration due to gravity.

The path of the vibration due at simple supported span and the assumption no loss contact between tire and upper support beam, the expression of vertical displacement, velocity and acceleration of tire ia the curvelinier path can be written as

$$y(t) = \{ y(x,t) + r(x)\}_{x=x(t)} \quad (2)$$

$$y(t) = \frac{dy(t)}{dr} - \left\{ \frac{\partial y}{\partial x} + v\frac{\partial y}{\partial x} + v\frac{\partial r}{\partial x} \right\}_{x = x(t)} \quad (3)$$

$$y(t) = \frac{d^2y}{dr^2} = \left\{ \frac{\partial^2 y}{\partial t^2} + 2v\frac{\partial^2 y}{\partial x \partial t} + v^2\frac{\partial^2 y}{\partial x^2} + a\frac{\partial y}{\partial x} + v^2\frac{d^2}{dx^2} + a\frac{dr}{dx} \right\}_{x=x(t)} \quad (4)$$

y(x,t) is upward dynamic deflection of the supported beam and r(x) is the roughness of the surface of the supported beam. At right part of the equation 4 as shown 6 part of variables as part 1 is the support beam acceleration, part 2 is acceleration, part 3 is centripetal accelaeration of the moving vehicle load, part 4 is acceleration component in vertical; direction, part 5 is acceleration component when speed of moving vehicle is not constant, part 6 is acceleration when speed is constant.

This paper focus on vehicle load and bridge interaction, effect of the Timoshenko beam is not describing, but the model in simple and described by Euler-Bernouly beam.

As shown in Figure 2, (Esmailzadeh and Jalili, 2003).assumed that the vehicle advances along the bridge with the velocity u(t); where u(t) is the position of the center of gravity(c.g.) of the vehicle body measured from the left-end support of the bridge at $t = 0$ the front tire of the vehicle initiallyenters the bridge, from the left-end support, and both the front and rear tires remain in contact with the bridge surface at all times.

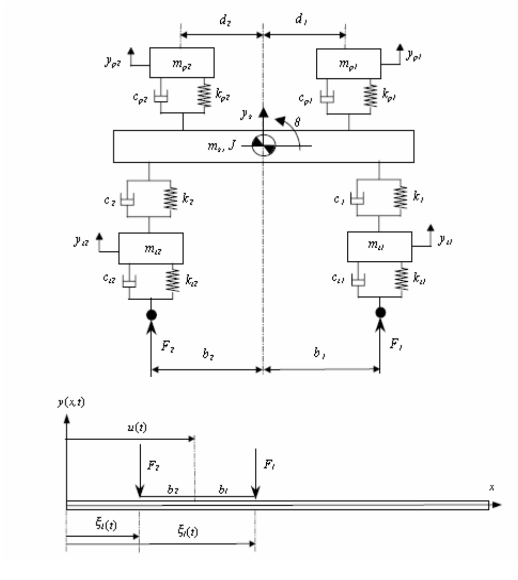

Figure 2. Suspension system of 6 Degrees of Freedom vehicles model (E. Esmailzadeh and N. Jalili. 2003).

The vehicle is assumed as a half-car model with 6 degrees of freedom consists of a body (spring mass), two axles (unsprung masses). The body is considered to have the vertical motion (bounce) and the angular motion (pitch), with every axle having its own bounce. The compliances of the suspension system, the tires, and the passenger seats are modelled by the combination of linear springs and viscous dampers connected in parallel arrangements.
The bridge is modelled as a uniform simply supported beam and initiallyis considered free of any load or deflection, and hence is horizontal at the equilibrium position under its own weight (unloaded). The steady state displacements of the vehicle are also measured from their static equilibrium positions obtained just before the vehicle enters the bridge. Therefore, the gravitational effect of the vehicle weight forms an additional part of the variable moving loads acting on the bridge.

EQUATION OF THE MOTION

To generate equation of the motion vehicle load bridge interaction model applied by energy method and under assumption can be expressed (Esmailzadeh and Jalili, 2003) as

$$T = \frac{1}{2}\left\{ \int_0^L \rho[\dot{y}^2(x,t)]\,dx + m_s\dot{y}_s^2(t) + J\dot{\theta}^2(t) + m_{p1}\dot{y}_{p1}^2(t) + m_{p2}\dot{y}_{p2}^2(t) + m_{t1}\dot{y}_{t1}^2(t) + m_{t2}\dot{y}_{t2}^2(t) \right\}, \quad (5)$$

and the potential energy as

$$U = \frac{1}{2}\left\{ \int_0^L EI[y''^2(x,t)]\,dx + k_{p1}[y_s(t) + d_1\theta(t) - y_{p1}(t)]^2 + k_{p2}[y_s(t) - d_2\theta(t) - y_{p2}(t)]^2 + k_1[y_s(t) + b_1\theta(t) - y_{t1}(t)]^2 + k_2[y_s(t) - b_2\theta(t) - y_{t2}(t)]^2 + k_{t1}[y_{t1}(t) - y(\xi_1(t),t)]^2 H(x - \xi_1(t)) + k_{t2}[y_{t2}(t) - y(\xi_2(t),t)]^2 H(x - \xi_2(t)) \right\}, \quad (6)$$

The equation of the vehicle motion derived facilitated the analysis an assumption expansion of the mode and using Lagrange equation.

$$\int_0^L \rho\phi_i(x)\phi_j(x)\,dx = N_i\delta_{ij} \quad (7)$$

$$\int_0^L EI\phi_i''(x)\phi_j''(x)\,dx = S_i\delta_{ij}, \quad (8)$$

The Lagrange's formulation used for determining of the effect of vehicle load weight acting on the supported beam and dissipating of the damping foprces. The time variying gravitational force expressed as,

$$f_g(x,t) = \left(m_{r1} + m_s\frac{b_2}{b_1+b_2} + m_{p1}\frac{b_2+d_1}{b_1+b_2} + m_{p2}\frac{b_2-d_2}{b_1+b_2}\right)gH(x-\xi_1(t)) + \left(m_{r2} + m_s\frac{b_1}{b_1+b_2} + m_{p1}\frac{b_1-d_1}{b_1+b_2} + m_{p2}\frac{b_1+d_2}{b_1+b_2}\right)gH(x-\xi_2(t)) - \{f_{g1}H(x-\xi_1(t)) + f_{g2}H(x-\xi_2(t))\}. \quad (9)$$

and the Raleigh formula as,

$$R = \tfrac{1}{2}\{c\dot{y}^2(x,t) + c_{p1}[\dot{y}_s(t) + d_1\dot{\theta}(t) - \dot{y}_{p1}(t)]^2 + c_{p2}[\dot{y}_s(t) - d_2\dot{\theta}(t) - \dot{y}_{p2}(t)]^2 + c_1[\dot{y}_s(t) + b_1\dot{\theta}(t) - \dot{y}_{r1}(t)]^2 + c_2[\dot{y}_s(t) - b_2\dot{\theta}(t) - \dot{y}_{r2}(t)]^2 + c_{r1}[\dot{y}_{r1}(t) - \dot{y}(\xi_1(t),t)]^2H(x-\xi_1(t)) + c_{r2}[\dot{y}_{r2}(t) - \dot{y}(\xi_2(t),t)]^2H(x-\xi_2(t))\}, \quad (10)$$

c is the coefficient of the dumping supported beam.

The 6 variables, including the vector of vehicle load and the generalized of force can be written as,

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{p}_k(t)}\right) - \frac{\partial T}{\partial p_k(t)} + \frac{\partial U}{\partial p_i(t)} + \frac{\partial R}{\partial \dot{p}_k(t)} = 0, \quad k = 1,2,\ldots,6,$$
$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i(t)}\right) - \frac{\partial T}{\partial q_i(t)} + \frac{\partial U}{\partial q_i(t)} + \frac{\partial R}{\partial \dot{q}_i(t)} = Q_i, \quad i = 1,2,\ldots,n, \quad (11)$$

The vehicle load model deriving the equation of motion with 6 linier second order linier equations. The equation of vertical motion and angular motion of sprung mass, the vertical motion of driver and passenger, vertical motion front axle and rear axle as, Equations (12), (13), (14), (15)

$$m_s\ddot{y}_s(t) + c_1[\dot{y}_s(t) + b_1\dot{\theta}(t) - \dot{y}_{r1}(t)] + c_{p1}[\dot{y}_s(t) + d_1\dot{\theta}(t) - \dot{y}_{p1}(t)] + c_2[\dot{y}_s(t) - b_2\dot{\theta}(t) - \dot{y}_{r2}(t)] + c_{p2}[\dot{y}_s(t) - d_2\dot{\theta}(t) - \dot{y}_{p2}(t)] + k_1[y_s(t) + b_1\theta(t) - y_{r1}(t)] + k_{p1}[y_s(t) + d_1\theta(t) - y_{p1}(t)] + k_2[y_s(t) - b_2\theta(t) - y_{r2}(t)] + k_{p2}[y_s(t) - d_2\theta(t) - y_{p2}(t)] = 0, \quad (12)$$

$$J\ddot{\theta}(t) + c_1b_1[\dot{y}_s(t) + b_1\dot{\theta}(t) - \dot{y}_{r1}(t)] + c_{p1}d_1[\dot{y}_s(t) + d_1\dot{\theta}(t) - \dot{y}_{p1}(t)] - c_2b_2[\dot{y}_s(t) - b_2\dot{\theta}(t) - \dot{y}_{r2}(t)] - c_{p2}d_2[\dot{y}_s(t) - d_2\dot{\theta}(t) - \dot{y}_{p2}(t)] + k_1b_1[y_s(t) + b_1\theta(t) - y_{r1}(t)] + k_{p1}d_1[y_s(t) + d_1\theta(t) - y_{p1}(t)] - k_2b_2[y_s(t) - b_2\theta(t) - y_{r2}(t)] - k_{p2}d_2[y_s(t) - d_2\theta(t) - y_{p2}(t)] = 0. \quad (13)$$

$$m_{p1}\ddot{y}_{p1}(t) + c_{p1}[\dot{y}_{p1}(t) - \dot{y}_s(t) - d_1\dot{\theta}(t)] + k_{p1}[y_{p1}(t) - y_s(t) - d_1\theta(t)] = 0, \quad (14)$$

$$m_{p2}\ddot{y}_{p2}(t) + c_{p2}[\dot{y}_{p2}(t) - \dot{y}_s(t) + d_2\dot{\theta}(t)] + k_{p2}[y_{p2}(t) - y_s(t) + d_2\theta(t)] = 0. \quad (15)$$

$$m_{r1}\ddot{y}_{r1}(t) + c_1[\dot{y}_{r1}(t) - \dot{y}_s(t) - b_1\dot{\theta}(t)] + c_{r1}[\dot{y}_{r1}(t) - \dot{y}(\xi_1(t),t)D_1] + k_1[y_{r1}(t) - y_s(t) - b_1\theta(t)] + k_{r1}[y_{r1}(t) - y(\xi_1(t),t)D_1] = 0 \quad (16)$$

$$m_{r2}\ddot{y}_{r2}(t) + c_2[\dot{y}_{r2}(t) - \dot{y}_s(t) + b_2\dot{\theta}(t)] + c_{r2}[\dot{y}_{r2}(t) - \dot{y}(\xi_2(t),t)D_2] + k_2[y_{r2}(t) - y_s(t) + b_2\theta(t)] + k_{r2}[y_{r2}(t) - y(\xi_2(t),t)D_2] = 0. \quad (17)$$

The n second order differential equations of the supported beam as,

$$N_i\ddot{q}_i(t) + S_iq_i(t) + D_1\phi_i(\xi_1(t))\{f_{g1} + c_{r1}[\dot{y}(\xi_1(t),t)D_1 - \dot{y}_{r1}(t)] + k_{r1}[y(\xi_1(t),t)D_1 - y_{r1}(t)]\} + D_2\phi_i(\xi_2(t))\{f_{g2} + c_{r2}[\dot{y}(\xi_2(t),t)D_2 - \dot{y}_{r2}(t)] + k_{r2}[y(\xi_2(t),t)D_2 - y_{r2}(t)]\} = 0, \quad i = 1,2,\ldots,n \quad (18)$$

All equations above can be simplified (Esmailzadeh and Jalili, 2003) as,

X(t) = A(t)x(t) + f(t) (19)

From the equation (19) should be noted is the vehicle load itself, vehicle pass over the support beam caused vibration of the support beam. The trasnversal vibration has amplitude indicated difference position of support beam and that difference posisition indication of deflection as function of the time. Four parameters or variables that must be considered in designing of the support beam are transversal deflection, bending moment, amplitude and vehicle speed.

The maximum deflection of the support beam can be calculated by applying formula as,

y(max) = max {[y(x,t)], $0 \le x \le L$, $0 \le t \le tm$} (20)

and the bending maximum moment also representation of elasticity (E) and inertia (I) of the support beam as,

M(max) = max {[M(x,t)], $0 \le x \le L$, $0 \le t \le tm$} (21)

DEFLECTION

The maximum deflection of the support beam is depend on location of the bending moment caused by moving vehicle are passing over the support beam. The dynamic deflection of the support beam depend on the vehicle load parameter (Yoshimura et al., 1998) and the speed is being used Esmailzadeh (2003) founded their research and compared the bending moment with time respond, the maximum values of dynamic deflection depend on instant time. See Figures 1, 2, 3, and 4.

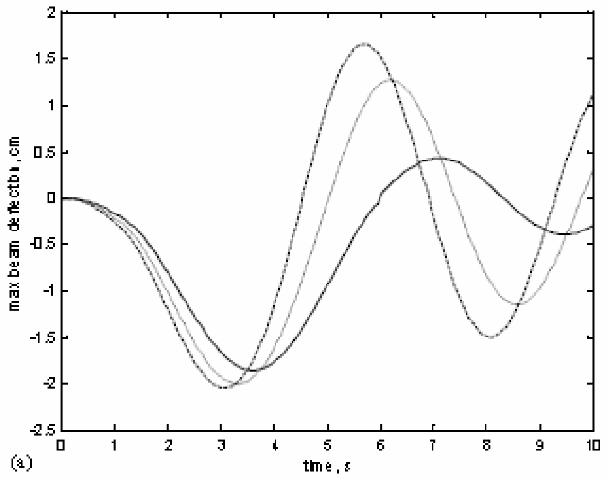

Figure 3. Maximum dynamic beam deflection different speed (Esmailzadeh and Jalili, 2003).

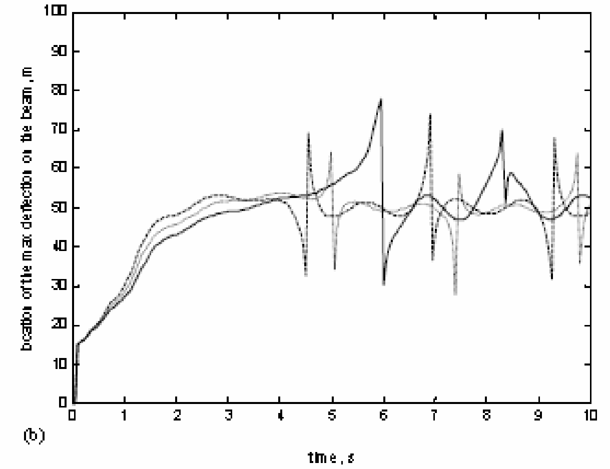

Figure 4. Maximum dynamic beam deflection in different location (Esmailzadeh and Jalili, 2003).

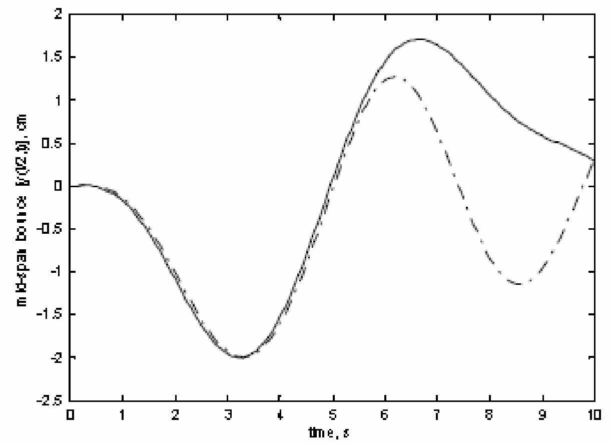

Figure 5. Comparison between deflection location and moment location (Esmailzadeh and Jalili, 2003)

BENDING MOMENT

Bending moment is one of the concerned by engineer for designing of bridge structure, dynamic vehicle load analysis accommodating the different frequency and speed of the vehicle load caused different bending moment and also depend on (Pinkaew and Asnachinda, 2007) regulation, detail in Figures 3 and 4.

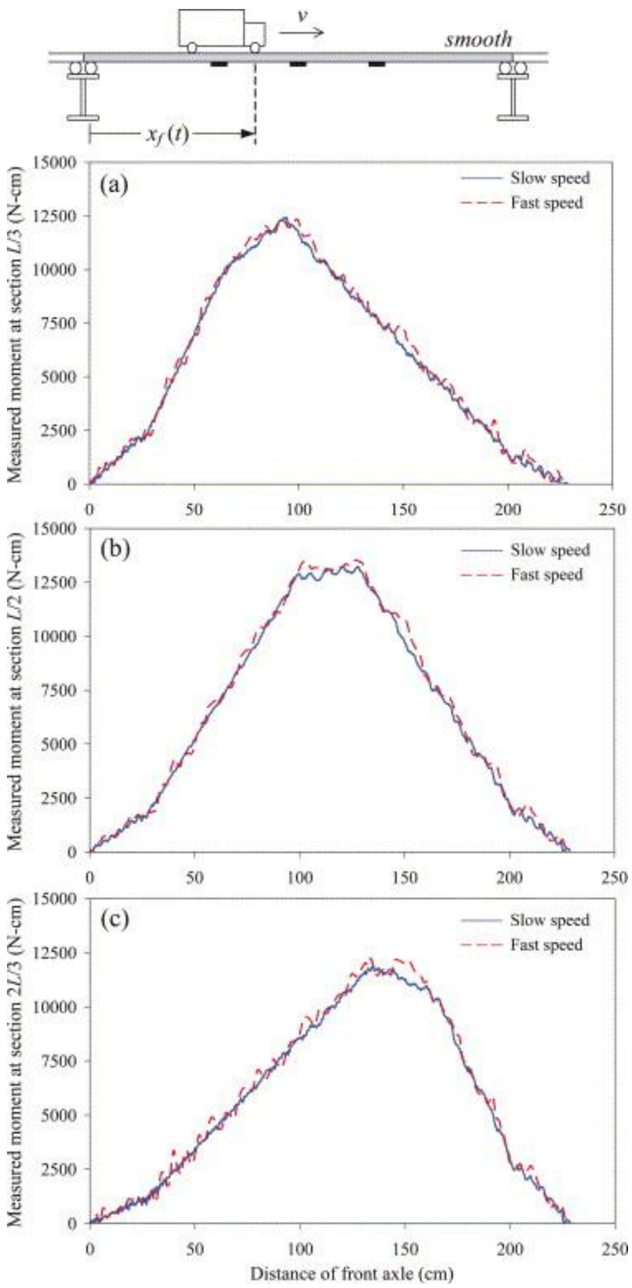

Figure. 6. Typical bending moments under vehicle moving on smooth bridge surface (Pinkaew and Asnachinda, 2007)

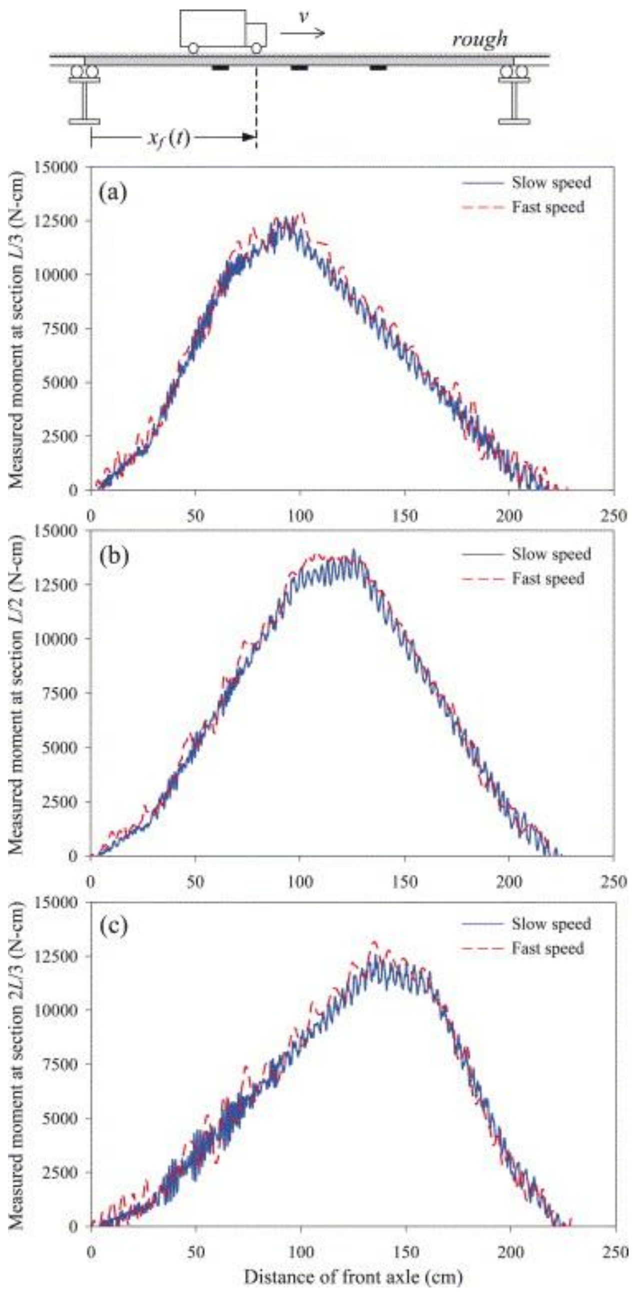

Figure 7. Typical bending moments under vehicle moving on rough bridge surface (Pinkaew and Asnachinda, 2007)

Esmailzadeh and Jalili (2003) found on their research, the bending moment and location depend on the speed of the veicle, as Figure 6.

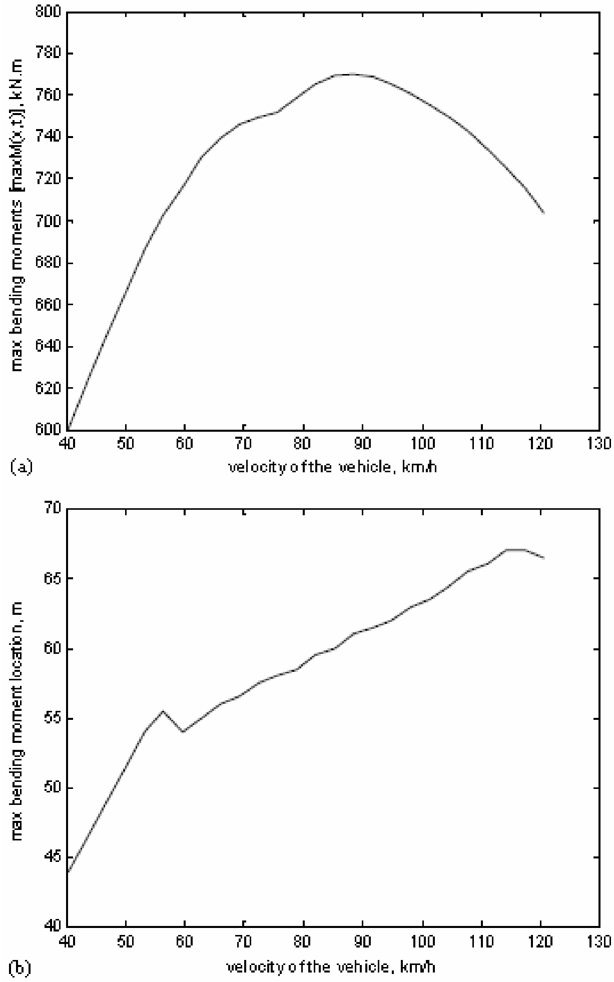

Figure 8. (a) The maximum bending moment and (b) location versus vehicle velocity (Esmailzadeh and Jalili, 2003)

The result of the Esmailzadeh and Jalili (2003) study is based on data as,

Bridge data:

$$L = 100\ \mathrm{m}, E = 207\ \mathrm{GPa}, I = 0.174\ \mathrm{m}^4, \rho = 20\,000\ \mathrm{kg/m}, c = 1750\ \mathrm{Ns/m}.$$

Vehicle data:

$$m_s = 1794.4\ \mathrm{kg}, m_{r1} = 87.15\ \mathrm{kg}, m_{r2} = 140.4\ \mathrm{kg}, m_{p1} = m_{p2} = 75\ \mathrm{kg},$$

$$J = 3443.05\ \mathrm{kgm}^2, b_1 = 1.271, b_2 = 1.716, d_1 = 0.481, d_2 = 1.313\ \mathrm{m},$$

$$k_1 = 66824.4, k_2 = 18615.0, k_{r1} = k_{r2} = 101115.0, k_{p1} = k_{p2} = 14000.0\ \mathrm{N/m},$$

$$c_1 = 1190, c_2 = 1000, c_{r1} = c_{r2} = 14.6, c_{p1} = 50.2, c_{p2} = 62.1\ \mathrm{Ns/m}.$$

CONCLUSION

The vehicle load support beam and their interaction between vehicle pass over the support beam was resume. The vehicle load was modelled in 6 degrees of freedom and the supporty beam assumed as euler-Bernaulli Beam. Based on these modeled the stiffness of support beam provoke different dynamic vibration and different deflection of the support beam, speed of the vehicle olso provoke the maxsimum bending moment, location of the deflection and the frequensy of the vibration support beam

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PRELIMINARY SURVEY OF SCHOOL BUILDINGS TO BE RETROFITTED ON REDUCING VULNERABILITY OF SCHOOL CHILDREN TO EARTHQUAKES IN BANDUNG, INDONESIA

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ABSTRACT

Indonesia is located on one of the most prone earthquake regions in the world with many major earthquakes occurred recently and earthquakes are foreseen in the future. Past earthquakes reveal that children are more susceptible to earthquake. Damages on school buildings due to earthquakes caused many injuries and fatalities to children, since high number of student were at school during the days. Since school buildings were often used for social gathering activities and for emergency facilities or shelters in the post disaster recovery efforts, damages on school buildings also caused economic loss to the society and hampered post earthquakes activities. Therefore, efforts should be made to ensure that in the future, school buildings in Indonesia can perform satisfactory during earthquakes, thus minimizing economic loss and fatalities. UNCRD and CDM ITB are conducting a collaborative research to reduce the vulnerability of existing school buildings. The objective of this research is to retrofitting and strengthening of school buildings, and other activities to improve school community preparedness regarding earthquakes. A selection of school building to be retrofitted was carried out. The procedure was conducted throughout a series of site visits and preliminary surveys to a number of school buildings considered as the top candidates for the programs. Four locations of school buildings were found to be good candidates for retrofitting activities. These are SD Cirateun Kulon II, SD Padasuka II, SD Sukajadi, and SD Legok Jambu. Therefore, a selection process was carried out based on the needs of these schools to determine the two school buildings to be involved in the program. Based on the structural conditions, deficiencies, and locations of the buildings, SD Cirateun Kulon II and SD Padasuka II were selected as the school buildings to be retrofitted. Then, the retrofitting was designed based on the structural deficiencies/weak parts and their accessibilities, weighing in factors of retrofit on buildings life time, earthquake resistance capacity, buildings function, and appropriate retrofit strategy/techniques. The design of retrofit strategy also considered factors of continuation of normal function availability of materials and skilled construction workers, needs of upgrades for non structural components, and total costs.

Keywords: *school buildings, earthquakes, preliminary survey, retrofitting*

INTRODUCTION

Indonesia is located on one of the most prone earthquake regions in the world with many major earthquakes occurred recently and earthquakes are foreseen in the future. Past earthquakes reveal that children are more susceptible to earthquake. Damages on school buildings due to earthquakes caused many injuries and fatalities to children, since high number of students were at school during the days. Since school buildings were often used for social gathering activities and for emergency facilities or shelters in the post disaster recovery efforts, damages on school buildings also caused economic loss to the society and hampered post earthquakes activities. Therefore, efforts should be made to ensure that in the future, school buildings in Indonesia can perform satisfactory during earthquakes, that minimizing economic loss and fatalities.

UNCRD and CDM ITB are conducting a collaborative project to reduce the vulnerability of existing school buildings in the corridor of School Earthquake Safety Initiative (SESI) project. The objectives of the project are:

1. reducing vulnerability of school children to earthquakes,

2. reducing number of victims due to earthquakes,
3. preparing school communities/elements in facing earthquake disaster.

Two school buildings, each in Bandung City and in Bandung County, were selected for this project due to the dire needs of improvement and severe deficiencies of earthquake resistant systems. The project includes retrofitting and strengthening of school buildings, and other activities to improve school community preparedness regarding earthquake.

SELECTION OF SCHOOL BUILDINGS TO BE RETFOFITTED

The first step in this project was to select school buildings that were considered as the most priority for retrofitting. A preliminary survey was conducted for selecting the school buildings. With the assistance from local government of Bandung City and Bandung County as well as local officers from Ministry of Education, a list of school buildings that require retrofitting was produced. Then, CDM ITB and local officers of the government visited these school buildings that were considered as the candidates for the project.

The preliminary survey was mostly visual observation. During the site visit, experts from CDM ITB tried to extract information that can be used for selecting the school buildings for retrofitting. Several factors used for consideration in selecting school buildings were:
1. locations and building layouts,
2. type and quality of existing structures,
3. number of occupants (students and teachers),
4. effect of retrofitting to the school communities,
5. possible retrofitting strategies,
6. total cost estimated for retrofitting.

After the school buildings were selected, complete surveys which cover structural and geotechnical investigation were to be conducted. Earthquake risk and other possible hazards were assessed. The structural surveys include on-site tests and laboratory tests to confirm the structural systems and material properties to be used in the analytical studies. Then, the retrofitting strategy was designed. The retrofitting design should consider the structural deficiencies/weak parts and their accessibilities, effect of retrofitting on buildings life time, earthquake resistance capacity, buildings function, and appropriate construction techniques. The design of retrofit strategy should also considered factors of continuation of normal function for the school, availability of materials and skilled construction workers, needs of upgrades for non structural components, and total costs.

PRELIMINARY SURVEY OF SCHOOL BULDINGS IN BANDUNG CITY AND COUNTY

In total, 8 school buildings were visited for the project, scatted in the area of Bandung City and Bandung County. From the 8 school buildings, 4 locations were found to unacceptable for the projects, since the structural conditions were found to be adequate, and in some cases these schools underwent mahor repair recently. Other 4 locations were found to be good candidates for the SESI program, and they are explained below.

SD Cirateun Kulon II

The local government of Bandung City affirmed that SD Cirateun Kulon II was the top priority for major renovation at the time the preliminary survey was conducted. The school building was located at Kec. Sukasari, Jl. Dr. Setiabudi Km 10,7 Bandung. The location is in the northern part of the city, and within the vicinity of the main road to North Bandung and Lembang. The school building consisted of 2 buildings, each with 4 rooms. The total area of the school buildings is approximately 223 m^2. The school has 423 students and 14 teachers, and is occupied from 7AM to 5PM on Monday to Friday.

Building 1 which has 3 classrooms and a common room for teachers was built in the 1950's. Building 2 which has 3 classrooms and a room for the headmasters was built in the 1970's, but was renovated approximately on 1997. The school was not able to get some funding for the necessary maintenance and repair, thus in dire need of retrofitting for fear that the building may have some damage in the near future.

Visual observation revealed that the buildings were located in a slope, although no possibility of landslide was seen for the buildings. The structures were likely to be masonry structures or reinforced concrete frames with masonry in filled walls. The roof trusses were made of timber, and in some places were deteriorated. The finishing exterior showed wear and tear, with loose plasters, missing floor tiles, and leaking roof. Sanitary facilities also needed improvement, especially for toilets and drainage systems.

The school community was found to be very eager to participate in the retrofitting projects. The school committee (parents and teachers) were receptive to earthquake risk faced by the school buildings, and they looked forward to participate in the dissemination activities of earthquake mitigation strategy, which included earthquake drills.

Based on the preliminary survey, experts from CDM agreed that the SD Cirateun Kulon II was a very good candidate for the retrofitting activities under SESI program. A complete investigation of the school buildings were then conducted for next stages of the retrofitting activities.

Figure 1. SD Cirateun Kulon (title-board)

Figure 2. SD Cirateun Kulon II

SD Padasuka II

The local government of Bandung County listed SD Padasuka II as one of their top priorities of school buildings in needs of repair ad retrofitting. The school was located at Kecamatan Soreang, Bandung County. The location is close to the main road from Bandung, and in the suburb area of the Bandung City. The school building consisted of consisted of 2 buildings with four rooms each. The school has approximately 400 students, and is occupied from 7AM to 5PM on Monday to Friday.

The preliminary survey showed that the buildings were located on a hill foot, although no possibility of landslide of flood was seen for the buildings. The structures are made of RC frames and masonry wall, and relatively new, built in circa 1990's. The foundation was found to be hanging on some places, due to missing stones/boulders underneath the tie beams. The walls were cracked on some place and some of the gaps were quite large. The roof trusses were made of timber and showed wear and tear, with visible deflection appeared in the middle part of the roof. The overall finishing exterior was dilapidated, with loose plasters, broken tiles, and leaking roof. Sanitary facilities also needed improvement, especially for toilets and drainage systems.

The site visit also revealed that the school community was very eager to participate in the retrofitting projects. The school committee (parents and teachers) were receptive to earthquake risk faced by the school buildings, and they looked forward to participate in the dissemination activities of earthquake strategy, which included earthquake drills.

Based on the preliminary survey, experts from CDM decided that the SD Padasuka II was another very good candidate for the retrofitting activities under SESI program. A complete investigation of the school buildings were then conducted for next stages of the retrofitting activities.

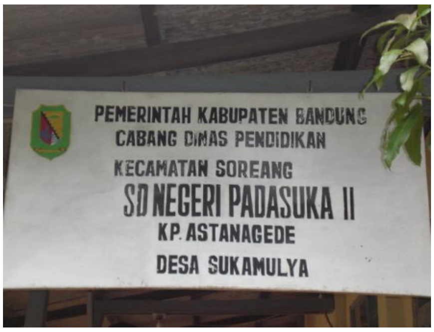

Figure 3. SD Padasuka II (title-board)

Figure 4. SD Padasuka II

SD Sukajadi

The list from the local government of Bandung County showed that SD Sukajadi was another priority of school buildings in needs of retrofitting. The school was located at Kecamatan Soreang, Bandung County. The location is on the main road from Bandung to Ciwidey, and in the suburb area of the Bandung City. The school buildings consisted of 2 buildings with four rooms each. ‘The school has approximately 400 students, and is occupied from 7AM to 5PM on Monday to Friday.

The preliminary survey showed that the buildings were located a foot hill, on the high part of the neighborhood. The location was stable, with no possibility of landslide or flood was seen for the buildings. The structures are made of RC frames and masonry walls. The structural condition was found to be mostly acceptable, although some structural deficiencies or weakness were still found on the structure. Most of the damage appeared on the non structural elements and the finishing exterior of the structure, with loose plasters, broken floor tiles, and leaking roof. Sanitary facilities also needed improvement, especially for toilets and drainage systems.

The school community itself was accommodating and very supportive with the idea of SESI program. The school committee (parents and students) were responsive when introduced to the earthquake risk faced by the school buildings, and they looked forward to participate in any dissemination activities of earthquake mitigation strategy, which included earthquake drills.

Based on the preliminary survey, experts from CDM decided that the SD Sukajadi would have to wait for the next opportunity for the retrofitting activities, due to the existing structural conditions. The buildings were in better condition than the previous two school visited by CDM experts.

Figure 5. SD Sukajadi (a)

Figure 6. SD Sukajadi (b)

SD Legok Jambu

SD Lego Jambu was also among the elementary schools listed by the local government of Bandung County as a priority of school building in needs of repair and retrofitting. The school was located at Kecamatan Soreang, Bandung County. The location is in the vicinity of the main road from Bandung to Ciwidey, and in the suburb area of the Bandung City. The school building consisted of 2 buildings with four rooms each. The school as approximately 400 students, and is occupied from 7AM to 5PM on Monday to Friday.

The site visit revealed that the buildings were located on a stable area, with no possibility of landslide or flood was seen for the buildings. However, the location was remote and away from roads passable by car, and could only be reached by walking or using motorcycles. As other typical elementary school buildings, the structures are made of RC frames and masonry walls. The structural condition was found to have some structural deficiencies or weaknesses. Some of the damage occurred on structural components, such as cracks on columns, and deterioration of finishing exterior of the structure, with loose plasters, broken floor tiles, and leaking roof. Sanitary facilities also needed improvement, especially for toilets and drainage systems.

The school community itself showed positive response and eager to participate in SESI program. They were receptive to earthquake risk faced by the school buildings, and they looked forward to participate in the dissemination activities of earthquake mitigation strategy, which included earthquake drills.

Based on the site visit, experts from DCM decided that the SD Legok Jambu would also have to wait for the next opportunity for the retrofitting activities. Two main reasons that the school was not selected were, first, the existing structural conditions were considered better, compared to the first two schools visited by

CDM experts. Next, the location of the buildings which is somewhat isolated might cause problems for mobilization of workers and materials during the retrofitting activities.

Figure 7. SD. Legok Jambu

CONCLUSIONS

Prior to conducting retrofitting activities under SESI program, a selection of school buildings to be retrofitted was carried out. The procedure was conducted throughout a series of site visits and preliminary surveys to a number of school buildings considered as the top candidates for the programs. The surveys were conducted by the experts from CDM ITB with officers of local governments.

Four locations of school buildings were found to be good candidates for retrofitting activities. These are SD Cirateun Kulon II, SD Padasuka II, SD Sukajadi, dan SD Legok Jambu. Therefore, a selection process was carried out based on the eeds of these schools to determine the two school building to be involved in the program. Based on the structural conditions, deficiencies, and locations of the buildings, SD Cirateun Kulon II dan SD Padasuka II were selected as the school buildings to be retrofitted. A more detail survey and investigation were then conducted for these school buildings.

Then, the retrofitting was designed based on the structural deficiencies/weak parts and their accessibilities, weighing in factors of retrofit on buildings life time, earthquake resistance capacity, buildings function, and appropriate retrofit strategy/techniques. The design of retrofit strategy also considered factors of continuation of normal function, availability of materials and skilled construction workers, needs of upgrades for non- structural components and total costs.

ACKNOWLEDGEMENT

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PROGRESSIVE COLLAPSE OF MULTY STOREY REINFORCED CONCRETE BUILDINGS DUE TO A VEHICULAR COLLISION

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ABSTRACT

This paper aims to explore an alternative progressive collapse analysis method associated with vehicular collision on reinforced concrete structures. The study was conducted by using advanced nonlinear-time-history finite element analysis which incorporates the nonlinear material and geometric nonlinearities. The steel reinforcements in the structural elements are also explisitly modeled in the analyses. Analysis procedures for a vehicular collision and clear removal of column scenarios were developed. A four storey reinforced concrete building designed per Progressive Collapse Analysis and Design Guidelines for New Federal Office Building and Major Modernization Projects by the General Service Administration, US (GSA, 2003) was employed. The structural response on vehicular collision scenario was compared with that of clear removal of column scenario.The results show that the response of structure on a vehicular collision scenario is very similar with that of a clear removal of column scenario. Thus, the progressive collapse analysis associated with vehicullar collision could be conducted using a clear removal of column scenario.

Keywords*: progressive collapse, vehicular collision, advanced nonlinear-time-history finite element analysis*

INTRODUCTION

The alternate load path approach for progressive collapse analysis is generally based on the dynamic responses of a structure to the clear and instant removal of load bearing elements, such as columns. The approach is easily applied because of its simplicity and directness (Nair, 2006) and its independence of causes (Ellingwood and Leyendecker, 1978). However, it is still necessary to understand the characteristics of the responses of a structure to specific causes and the extent of the damage.

An example of the building collapse due to a vehicular collision is shown in Figure 1. This is a 5-storey precast concrete building. A car impacting the ground floor load-bearing element at the corner of the building resulted in the loss of the load-bearing element on the ground floor and caused the floor above to collapse (Allen and Schiever, 1972).

Type of building that vulnerable to vehicular collision is open-ground-storey building. This type of building is very common around the world often called a soft storey or weak storey building. Generally, the soft storey exists at ground level, but it could exist at any level of the building.

Figure 1. A building in New York after a vehicular collision (Allen and Schiever, 1972)

In soft storey buildings that have an open ground storey, the ground floor is usually used as a car park. In this case, the exposed columns at the ground floor level are vulnerable to vehicle impact, which may lead to progressive collapse.

Study on vehicular collision has been a focus of research since the 1960s (Wu et al., 2004). Most of the research that has been conducted relates to traffic barriers, such as guardrails or bridge piers (Wu et al., 2004; Wekezer et al., 1993; El-Tawil et al., 2005). However, the author was not aware of any published literature on the analysis of the progressive collapse of buildings subjected to vehicle impact.

Analysis of progressive collapse of a building associated with vihicular collision is very complicated. It involves very large stuctural model both a building structure and a vehicle with extensive nonlinearities (material and geometric nonlinearities). A simplified analysis method is required to enable ordinary engineers to do it. This paper aims to explore an alternative methode for pregressive collapse analysis associated with vehicular collision. Simplified analysis procedures were also developed.

A four storey reinforced concrete building is selected as a case study. The structure is designed per Progressive Collapse Analysis and Design Guidelines for New Federal Office Building and Major Modernization Projects by the General Service Administration, US (GSA, 2003). The vehicular collision forces used in this study were adopted from the work of El-Tawil et al. (2005). The static and dynamic response of structures was calculated using program DIANA release 9.1 (de Witte and Kikstra, 2005).

STRUCTURE AND MATERIAL MODELS

The plans and elevations of the RC framed structure model used in this study are shown in Figure 2. All columns have dimension of 400x400 mm^2; dimension of girders is 500x300 mm^2; dimension of primary beams and secondary beams is 450x250 mm^2; and thickness of floor slabs is 120 mm.

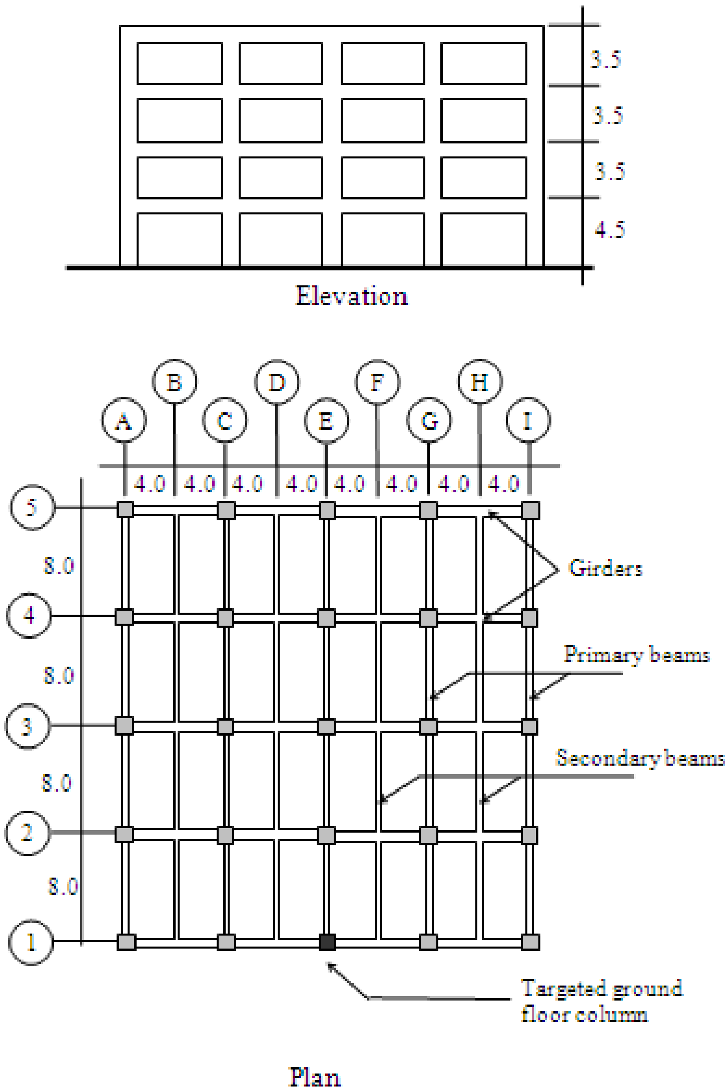

Figure 2. Detail of Prototype structures showing the location of targeted column

First, the Prototype structure was designed based on the load combination (1.2DL+1.5LL) as per the Australian/New Zealand Standard AS/NZS 1170.0 (2002) for permanent and imposed action. Live load, LL, was taken as 3 kPa, based on AS/NZS 1170.1 for office and work areas. The loads transferred by the slabs to the beams were assumed based on the standard distribution model.

Then, the Prototype structure was redesigned to meet the progressive collapse design criteria based on linear static analysis of the GSA (2003) guidelines. Nine cases were considered for the linear static analysis, which took advantage of the symmetry of the structure. Each analysis considered the single column failure scenario. The maximum member force of each element calculated from each case is selected as the design member force. It should be noted that the GSA (2003) guidelines allow the use of a Demand Capacity Ratio (DCR) of 2 for a typical reinforced concrete structure. Thus, reinforcements were calculated based on the design member force divided by the DCR value.

Furthermore, the reinforcements calculated based on GSA (2003) were standardized. In the standardized arrangement, same reinforcement was maintained throughout the beam to simplify the section properties for the DIANA analysis. Reinforcement ratio of columns is 2 %; reinforcement ratios (top/ bottom) of exterior girders are 1.25%/ 0.75%; reinforcement ratios of interior girders are 1.73%/ 1.24%; reinforcement ratios of exterior primary beams are 1.48%/ 1.10%; reinforcement ratios of interior primary beams are 1.58%/ 1.15%; reinforcement ratios of secondary beans are 1.18%/ 0.88%; and reinforcement ratios of floor slabs are 0.45/ 0.41% on both direction.

A revised structure is then developed to observe the effect of structural geometry i.e.: girder and primary beam dimensions to the response of structures. In order to observe the effect of beam dimensions on the response of a structure, particularly the dynamic load factor (DLF), the girder and primary beam dimensions were increased so their second-moment-of-area increased by approximately 70%. The dimension of the girders was increased from 500x300mm^2 to 600x300mm^2, while the dimension of the primary beams was increased from 450x250mm^2 to 500x300mm^2. The reinforcement ratios of the girders and primary beams were kept the same as that of the Prototype structure. The dimensions and reinforcement ratios of the columns, secondary beams and slabs are the same as that of the Prototype structure.

The concrete material used in this paper is based on the fixed-crack model. A perfect bond of the reinforcement and the surrounding concrete material was assumed. Thus, the reinforcement strains are computed from the displacement field of the surrounding concrete material in column, beam or slab elements. Shear reinforcements were not considered. The material properties are presented in Table 1. A total of 6478 elements were used (590 of column, 1790 of beam and 4096 of slab elements).

The structure model enables to behave inelastically to represent the response of structures due to a column removal. The displacement-load factor relationship of the Prototype and Revised structure calculated using push down static analysis are presented in Figure 3.

Table 1. Material properties for nonlinear static and dynamic analyses

Properties	Value
Concrete:	
- Compressive strength (MPa)	32
- Density (kg/m^3)	2400
- Modulus of elasticity (GPa)	31.7
- Poison ratio	0.2
- Tensile strength (MPa)	3.5
- Crack bandwidth (mm)	48
- Rayleigh damping (%)	5
- Fracture energy, Gf1 (N/m)	67.9
Reinforcing Steel:	
- Modulus of elasticity (GPa)	210
- Plastic modulus (GPa)	3.15
- Yield strength (MPa)	420

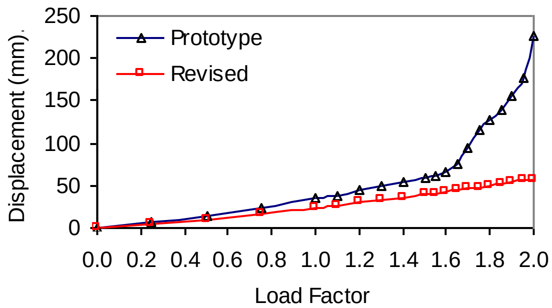

Figure 3. Load factor displacement relationship

In this case, Column E1 (see Figure 2) at ground floor level was removed. The displacement was measured in column removal point. To obtain the load-displacement relationship for down static analysis, the load combination

DL+0.25LL was gradually applied to the whole structure until a load factor of 1 was reached. Then, an additional load combination of DL+0.25LL was applied at the collapse area until a cumulative load factor of 2 was reached. The deformation of Prototype structure at load factor equal to 2 is presented in Figure 4.

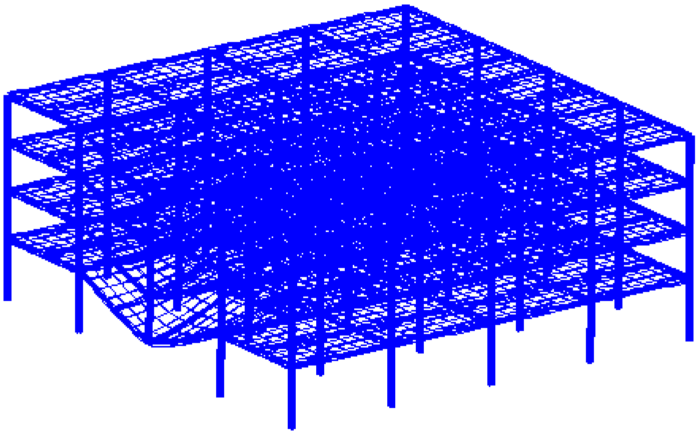

Figure 4. Prototype structure deformation at load factor equal to 2

VEHICULAR COLLISION FORCES

As explained previously, the vehicular collision forces used in this study were adopted from the work of El-Tawil et al. (2005) on bridge piers. Two vehicle models were utilized in their simulation: a 14 kN Chevrolet (Chevy) truck and a 66 kN Ford truck. The Chevy truck represents a light truck and the Ford truck represents a medium weight truck.

The finite element model of Chevy truck is presented in Figure 5. The Chevy truck model used by El-Tawil et al. (2005) has been previously validated with two collision tests by Zaouk et al. (1996). The first test is a frontal impact with a fully rigid wall, with a vehicle approaching speed equal to 55kph. The second test is a 25^o glancing impact with a vertical concrete barrier, with a vehicle approaching speed equal to 100kph. The numerical model showed good agreement with the experimental tests.

Two reinforced concrete pier models were used by El-Tawil et al. (2005) in their study. The first pier has a rectangular cross-section with an area 1.450m x 1.375m and 16.3m high. Pier I has 24 longitudinal bars with a 35mm diameter and stirrups with a 16mm diameter. Pier II has a circular cross-section with a diameter of 1.075m and is 9.925m high. Pier II has 14 longitudinal bars with a 35mm diameter and round hoops with a 16mm diameter.

Piers I and II have the same superstructure. Pier I is supported by 12 pre-stressed concrete piles and Pier II is supported by six pre-stressed concrete piles.

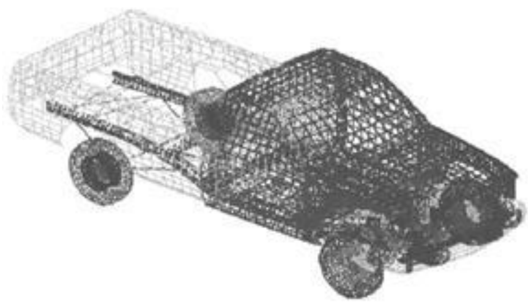

Figure 5. Finite element model of 14-kN Chevy truck (El-Tawil et al., 2005)

The time history of the impact forces as a result of the collision of the Chevy truck with Pier I are shown in Figure 6. Figure 6 shows that the peak impact force is mainly affected by the vehicle's speed. Other factors that affect the impact force are the vehicle mass, vehicle characteristics (energy absorption by vehicle components), the surface and stiffness of the impacted structure.

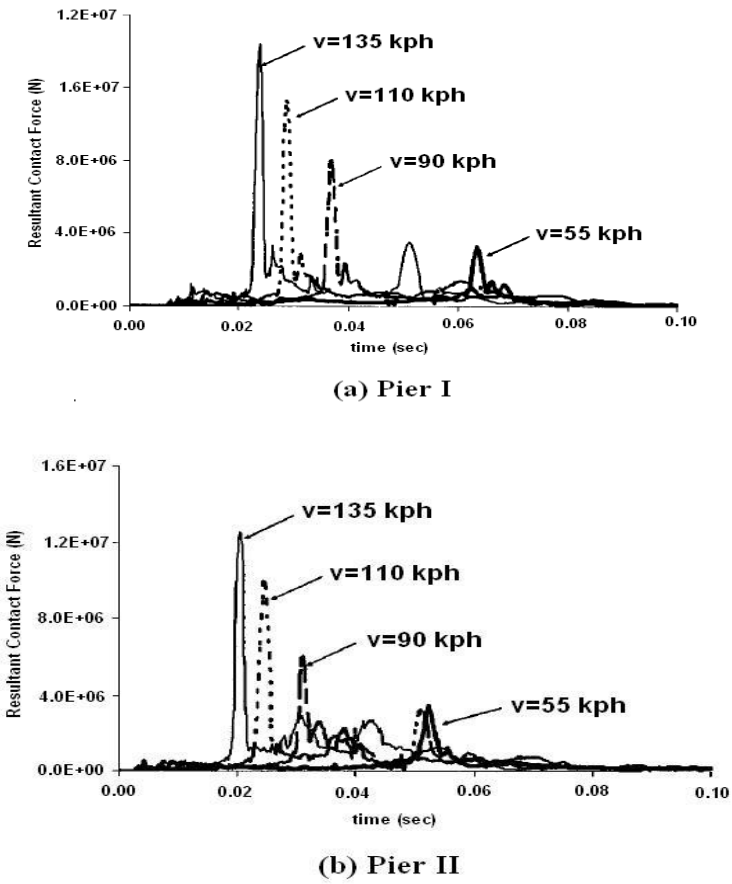

Figure 6. Impact force of the Chevy truck at various speeds on Pier I and II (El-Tawil et al., 2005)

A static analysis of Pier I and Pier II with simple supports (fixed at the base and pinned on top) conducted in this study showed that the stiffness of Pier I at the point of collision is 3.7 times the stiffness of Pier II. However, the impact forces at Pier I are only slightly higher than the impact forces at Pier II. It could be concluded that the stiffness of the impacted structure does not have much influence on the impact forces.

VEHICLE-COLUMN COLLISION MODEL

An analysis of the RC frame responses to vehicular collision showed that the maximum velocity of the structure's element (column) at the collision point is much smaller than the approaching speed of the vehicle just before impact. The maximum velocities of the column calculated due to vehicular collision at the collision point are 1.02 and 2.59 m/s for a vehicle approaching speeds equal to 55 kph (15.3 m/s) and 90 kph (25 m/s) respectively. This shows that for a vehicle approaching speed equal to 55 kph, the maximum velocity of the column at collision point is about 7% of the vehicle's approaching speed. For a vehicle approaching a speed equal to 90 kph, the maximum velocity of a structure at collision point is about 10% of the vehicle's approaching speed. These facts show that the influence of a structure's motion on the impact force is relatively insignificant. However, as the column dimension used in this study (400mm) is much smaller than vehicle width, the actual impact force acting on the column could be lower than the impact forces acting on Pier I. The study on the influence of the contact surface of the collision is beyond the scope of this paper. Thus, for simplicity, the impact forces used in this study are assumed to be the same as the impact forces acting on Pier I.

The vehicle impact on the column was modelled as shown in Figure 7. The time history of impact forces transferred by vehicle to the column was assumed as uniformly distributed to the column face along a 1m height.

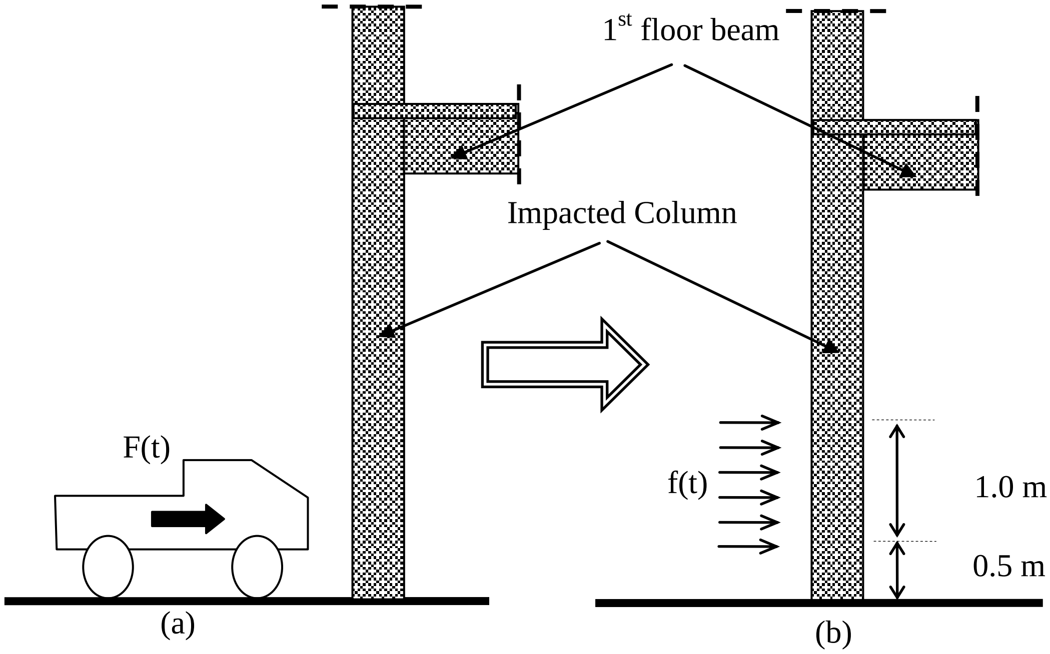

Figure 7. Impact force distribution on the impacted column: (a) real; (b) idealized

ANALYSIS PROCEDURES

Two dynamic analyses reported in this paper. The first is dynamic analysis on clear removal of column scenario. The second is dynamic analysis on vehicular collision scenario.

To conduct the dynamic analysis on clear removal of column scenario, an initial value problem utilizing the ramp function of force was adopted (Elvira et al., 2004). A schematic description of dynamic analysis is presented in Figure 8.

Force R_s in Figure 8 represents the column reactions due to static load, *w*. The static system shown in Figure 8 changes to a dynamic system if the reaction force R_s is removed dynamically. In this study, a ramp function of force $R_c(t)$ is utilized to represent the removal of reaction force R_s (removal of a column). The maximum value of the demolishing force $R_c(t)$ is equal to the reaction force of the expected failed column but the direction of the demolishing force is opposite to the direction of the reaction force. The variable T_c, in Figure 8, is column removal period.

The steps for dynamic analysis on clear removal scenario are as follows:

1. Conduct static analysis for the initial condition to calculate the upper end reaction of expected removed column, R_s.
2. Remove the failed column from the system; apply static upper end reaction of removed column, R_s instead.
3. Conduct static analysis for initial condition.
4. Conduct dynamic analysis by applying the ramp function of force representing the column removal, $R_c(t)$

The procedure used for the dynamic analysis on vehicular collision scenario is similar to that used in the dynamic analysis on clear removal of a column scenario. However, in the case of vehicular collision, the time histories of the upper end reactions of the expected failed column subjected a vehicular collision are introduced in the analysis. The procedure is as follows:

1. Conduct static analysis to calculate reaction forces at the upper end of the expected failed column, R_s, for initial condition.
2. Conduct dynamic analysis by applying impact forces at the targeted column until the column fails. Record time history of the reaction forces at the upper end of the failed column, R_d.
3. Subtract the static reaction forces from the dynamic reaction forces history at the upper end of the failed column, $R_d' = R_d - R_s$. Remove the failed column from the system; apply static reaction forces at the failed column point, R_s. Conduct static analysis for the initial condition.
4. Conduct dynamic analysis by applying: (1) the subtracted reaction force history of the failed column at the failed column point, R_d'; and (2) the ramp function of the force representing the column removal scenario, R_c (refer to Figure 9).

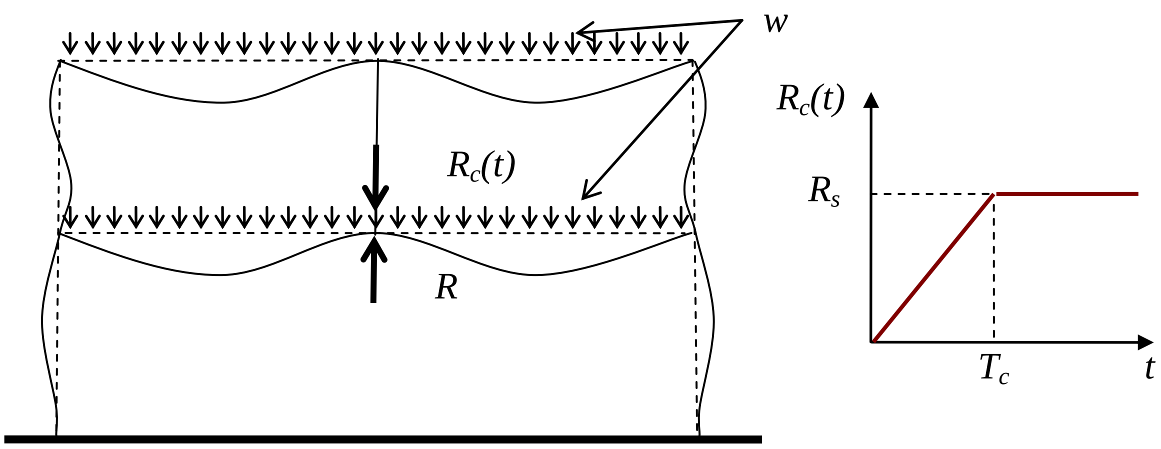

Figure 8. Schematic explanations of dynamic analysis procedures for progressive collapse on clear removal of column scenario

Where, t_1 and T_c, in Figure 9, are column failure point and column removal period respectively.

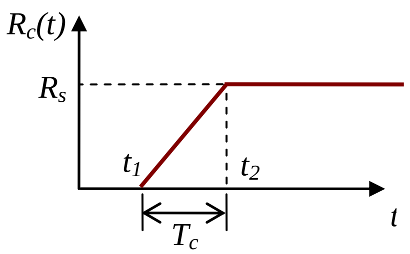

Figure 9. Ramp function of force in vehicular collision scenario

NUMERICAL SYMULATION RESULTS

Failure Mechanism of Column

Dynamic analysis of the vehicular collision scenario showed that the impacted column failed in shear. This is in good agreement with El-Tawil et al. (2005). The shear failure occurs at the point of impact on the column. After the column failed in shear, it is assumed that the column is completely failed. The upper end reaction forces of the column, which are imposed on the structure for dynamic analysis, are based on the history of reaction forces until this point. After this point the column is assumed to have no capacity either to carry or transfer any loads from or to the remaining structure.

It is reasonable that due to vehicular impact a column will not complately fail. Some part of the column may remain hanging after the collision. However, for reasons of simplicity, the forces from the hanging column after the column failed in shear are not considered in this study.

Responses of Structure in the Vehicular Collision Scenario

A comparison of the vertical displacement of Prototype structure at the failed column point in the vehicular collision scenario for approaching speed of 55kph and the clear removal of column scenario is presented in Figures 10. It could be inferred from Figure 10 that the vertical displacement histories for both scenarios are only different in phase. The displacement time history calculated from the clear removal of a column scenario is about 90ms earlier than that of the vehicular collision scenario. It could be concluded that, in response to vehicular collision, the column requires about 80ms to completely fail. After that time, the floor system above the failed column falls down freely, making the displacement history similar to that of the clear removal of a column scenario. Thus, the peak displacements in both scenarios are nearly the same.

Similarly, a numerical simulation on vehicular collision scenario with an approaching speed of 90 kph was also conducted. The responses of a structure in terms of the displacement at the failed column point in a vehicular collision scenario with approaching speed of 90 kph is only different in phase with that of a vehicular approaching speed of 55 kph (compare Figure 10 and 11). The displacement response to vehicular collision with an approaching speed of 90 kph is 30 ms earlier than that of a vehicular approaching speed of 55 kph.

The same numerical simulations were also conduted for Revised structure. The results show that the displacement response of Revised structure shows similar characteristic with the response of Prototype structure. The response of structure due to vehicular collison scenario could be calculated using the clear removal of column scenario.

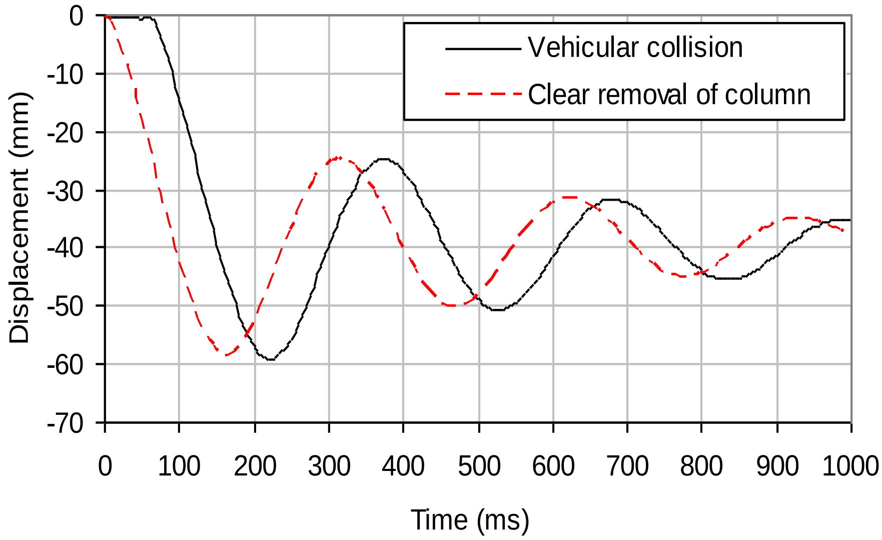

Figure 10. Comparison of displacement histories calculated from the vehicular collision scenario with approaching speed of 55kph, with a clear removal of column scenario for the Prototype structure

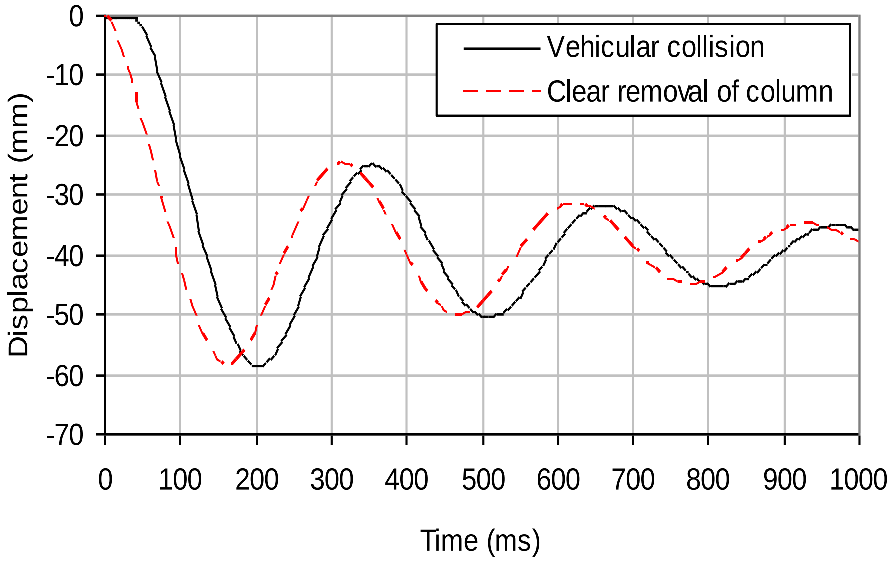

Figure 11. Comparison of displacement histories calculated from a vehicular collision scenario with an approaching speed of 90kph, with a clear removal of column scenario for the Prototype structure

Discussion

The responses of a structure to vehicular collision can be modelled by applying a load transferred by the impact of a vehicle. Numerical simulation showed that the vehicular impact on the column would not initiate any significant damage in the adjacent elements. The effect of the impacted column's motion on the responses of a structure is also not significant.

Numerical simulation results presented previously show that the vehicle speed does not have much effect on the responses of a structure. Additional numerical simulation utilizing a Ford truck showed that the type of vehicle also does not have much effect on the responses of a structure.

The responses of structure to vehicular collision are similar to the responses of a structure to the clear removal of a column scenario. Importantly, both cases create nearly the same level of peak displacement. Therefore, the progressive collapse analysis of a structure in a vehicular collision scenario could be conducted by using the clear removal of a column scenario.

The comparison of the maximum dynamic displacement calculated from dynamic analyses and that of static analysis shows that the load factor for static equivalent analysis is around 1.5. The load factor calculated from these numerical simulations much lower than the load factor of 2 recommended by GSA (2003) guidelines. It could be concluded that the buildings that design per GSA (2003) guidelines will be survive from progressive collapse risk on vehicular collision scenario.

CONCLUDING REMARKS

The analysis of progressive collapse due to vehicular collision has been developed in this study. The impact forces used to represent the vehicular impact were adopted from the work of El-Tawil et al. (2005). The numerical simulations showed that the vehicle's approaching speed and the type of vehicle have no significant effect on the responses of a structure. The responses of a structure to vehicular collision have been compared with the responses to the clear removal of a column. This showed that vehicular collision only affects the response time (phase) of vertical displacement at the failed column point. However, the maximum displacement is nearly the same as that obtained from analysis of the clear removal of a column.

Numerical simulations were also cunducted to observe the influence of beam and girder dimensions on the response of structures. A revised strcuture was developed by increasing the dimension of beam and girder of Prototype structure. The results from the simulations show that the Revised and the Prototype structure have the same response characteristics. It could be concluded from the numerical simulations that analysis of progressive collapse due to vehicular collision could be conducted using the clear removal of a column method. However, further study is required to observe the influnce of structural geometry such as number of storey and number of span

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INFLUENCE OF MATRIC SUCTION ON THE VOLUME CHANGE CHARACTERISTICS OF UNSATURATED BRITTLE CLAY USING BIAXIAL APPARATUS

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ABSTRACT

The volume change characteristic of unsaturated soil is quite different from those of fully saturated soil because of the influence of suction. Results obtained from theory of saturated soil could not be directly applied to solve the problems related to the unsaturated soil. This study was undertaken to delineate the effects of soil water suction and net normal stress on volume change characteristics of unsaturated brittle kaolin clay by the use of biaxial apparatus as well as triaxial test set up, according to the fact that field problems involving geotechnical structures are often trully or close to plane strain situation. A modification of the conventional triaxial apparatus wass used in this study. As the interface between the unsaturated soil and the pore water pressure measuring system a high air-entry disc (HAED) was used in this experimental laoratory. The overall volume change of unsaturated soil defined as a change in void ratio in response to a change in the stress state is presented in a three dimensional void ratio and water content constitutive surfaces curve and compared with the known soil behaviour from previous working.

Keywords*: unsaturated soil, matric suction, volume change and biaxial*

INTRODUCTION

Unsaturated soils form the largest category of materials that cannot be classified by classical saturated soil mechanics concepts. Although soils are generally assumed fully saturated below the groundwater table, they may be semi saturated near the state of full saturation under certain conditions. The presence of matric suction pressure is the main difference between saturated and unsaturated soil mechaics. It has been observed that several stability problems, involving soils used as construction materials are associated with variability of water content that occur periodically in nature and consequently in changes of matric suction.

The soil suction is an important part in the behaviour of unsaturated soil, especially in the volume change characteristics of the soil structure. There are two components of total suction, namely osmotic suction and matric suction. Matric suction is the dominant component compared to osmotic suction, therefore the emphasis will be on this former. The matric suction can be measured as the difference between the pore air pressure and pore water pressure

A three phases, soil solids, water, and air, is well known as the characteristics of unsaturated soil. Fredlund and Morgenstern (1977) was introduced an additional independent phase, a so called the air–water interface or contractile skin. Based on multi phase continuum mechanics, a theoretical stress analysis of unsaturated soil has been presented (Fredlund and Morgenstern, 1977; Fredlund and Morgenstern, 1976). The analysis concluded that any two of three possible normal stress variables can be used to describe the stress state of an unsaturated soil. This is in contrast to saturated soil, where it is possible to relate the mechanical properties of the soil to the effective stress only.

The mechanical properties of unsaturated soil is routinely interpreted from conventional triaxial testing or axisymmetric conditions; whereas, testing of soil using the biaxial device would be more useful information, as more geotechnical field problems such as landslide problems, failure of soils beneath shallow foundations, and failure of retaining structures are basically occur in these situations. It was reported by Mochizuki et al. (1993) that when soil is tested under plane strain conditions, it, in general, exhibits a higher compressive strength and lower axial strain. The biaxial testing on the behaviour of fined grained sands had been reported (Alshibli et al., 2004; Alshibli and Sture, 2000; Bizzarri, 1995; Marach et al., 1984; and Mochizuki et al., 1993). However, the biaxial testing of clay soils have only been initiated recently (Alshibli and Akbas, 2007; Fauziah and Nikraz, 2008; Fauziah and Nikraz, 2007; Lo et al., 2000; and Viggiani et al., 1994,) and published data of such tests especially for brittle clay material are very limited.

This paper presents the result of experimental study on the influence of matric suction on the volume change relationship of unsaturated stiff clay specimens by the use of biaxial apparatus, although the behaviour of overconsolidated clay (Fauziah and Nikraz, 2007) and fracture characteristics of brittle clay may also be determined by this test apparatus. Some results of the testing will be compared with the known soil behaviour and previous working.

VOLUME CHANGE CHARACTERISTICS

Unsaturated soil consists of two phases that are mobile, known as the air and the water phases. Upon the application of stress, the phases will come to equilibrium consequent to the dissipation of the pressures built up in the phases. The used of net normal stress and matric suction as stress state variables for partially saturated soil was presented by Fredlund (1975) and Fredlund and Morgernstern (1977). The overall volume change of unsaturated soill can be defined as a change in void ratio in response to a change in the stress state (Fredlund and Morgernstern, 1976):

$$de = \frac{\partial e}{\partial(\sigma - u_a)} d(\sigma - u_a) + \frac{\partial e}{\partial(u_a - u_w)} d(u_a - u_w), \qquad (1)$$

in which *e* represents void ratio, □ is total nomal confining stress, u_a is pore air pressure, u_w, and is pore water pressure.

Equation (1) can be viewed as having two parts, namely a part that is designation of the stress state (i.e., net normal stress, $(\sigma - u_a)$ and matric suction, $(u_a - u_w)$ and a part that is designation of the soil properties. The soil properties can be viewed as the slope of the void ratio constitutive surfaces (Figure 1) and water content constitutive surfaces (Figure 2). The soil properties are moduli that vary as a function of the stress state. The moduli associated with the net normal stress, $(\sigma - u_a)$ and matric suction, $(u_a - u_w)$.

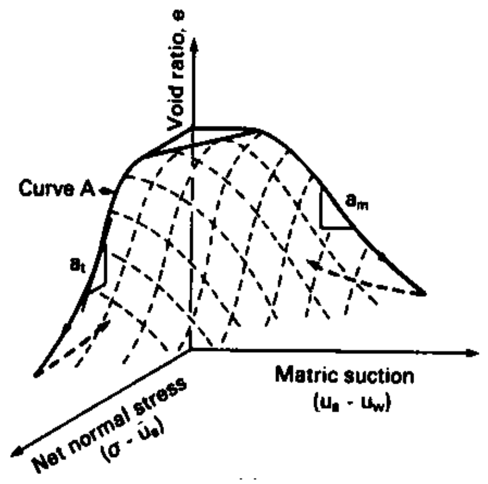

Figure 1. Three dimensional void ratio constitutive surfaces for unsaturated soil (Fredlund and Rahardjo, 1993)

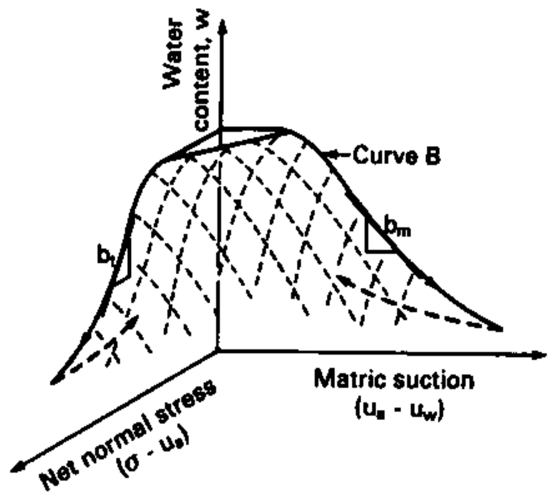

Figure 2. Three dimensional water content constitutive surfaces constitutive surfaces for unsaturated soil (Fredlund and Rahardjo, 1993)

The degree of saturation of the unsaturated soil, *S* and its matric suction $(u_a - u_w)$ can vary as the stiff soil loaded. The degree of saturation, S at any stage of net normal stress and matric suction may be obtained from the constitutive surfaces of void ratio e and water content w which are themselves obtained experimentally. Following the procedure proposed by Fredlund and Rahardjo (1993) although adapted to plane strain condition (Lo, et al, 2005). The pore pressure parameters may be deduced from the volumetric deformation coefficients C_t, C_m, D_t, D_m, which in turn, be determined experimentally. The slope along any constant net total stress plane on the volume change constitutive surface is a function of the void ratio (Figure 3). In which $(m_1^s)_{e_1}$ is coefficient of volume change with respect to a change in net normal stress at void ratio of e_1, while $(m_2^s)_{e_1}$ is coefficient of volume change with respect to a change in matric suction at void ratio of e_1

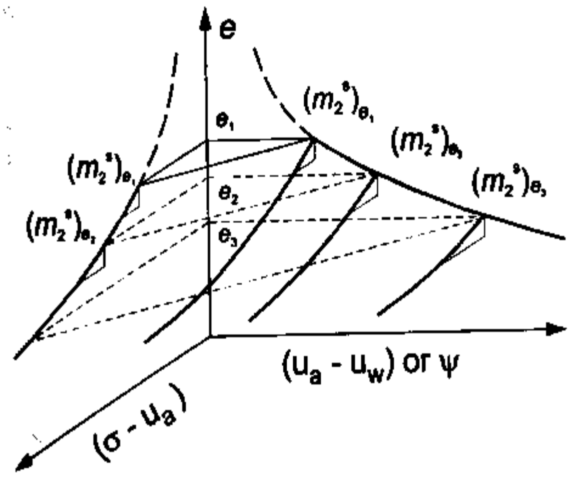

Figure 3. Illustration of the definition the void ratio constitutive surface (Fredlund et al, 2000)

The compression indices C_t and C_m, would be determined under plane strain loading condition. C_w is the water compressibility, h is the proportion of dissolved air in the water, $\bar{u}_a$ is the absolute air pressure, n is the porosity and $m_{1p}, m_{2,} m_{1p}$ and m_2 are the volumetric deformation coefficients which may be evaluated from the compressive indices C_t, C_m, D_t and D_m obtained from laboratory testing, as follows:

$$m_{1p}^s = \frac{0.435 C_t}{(1+e_0)(\sigma_{ave} - u_a)_{mean}} \quad , \tag{2}$$

$$m_2^s = \frac{0.435 C_m}{(1+e_0)(u_a - u_w)_{mean}} \quad , \tag{3}$$

$$m_{1p}^w = \frac{0.435 D_t G_s}{(1+e_0)(\sigma_{ave} - u_a)_{mean}} \quad , \tag{4}$$

and

$$m_2^w = \frac{0.435 D_m G_s}{(1+e_0)(u_a - u_w)_{mean}} . \tag{5}$$

In which $(\sigma_{ave} - u_a)_{mean}$ and $(u_a - u_w)_{mean}$ are the averages of the initial and final net normal stresses and matric suction for increment. The subscript *m* on the compression indices C_t (void ratio) and D_t (water content) are corresponding to matric suction, while the subscript *t* on the compression indices C_t and D_t are corresponding to net normal stress.

LABORATORY WORKS

Apparatus and Specimen Preparation

The biaxial apparatus used in this experimental study was a modification of the conventional triaxial apparatus (Figure 4). The biaxial arrangement is placed in a cell, with the height of 300 mm, 200 mm internal diameter and 30 mm wall thickness. A specimen with an initial width of 36 mm, height of 72 mm, and thickness of 72 mm, so that the aspect ratio is 2, is placed on the base pedestal where it is restrained laterally by two rigid perspex plates to restrain its out-of plane movement. To prevent any air from passing through the disc into the measuring system, provided that the matric suction did not exceed the air-entry value of the disc, a high air-entry disc (HAED) was used as the interface between the unsaturated soil and the pore water pressure measuring system. Four pore pressure transducers were used to measure the applied cell pressure, back pressure pore pressure and flush pressure of the specimen. The global volume change of specimen is monitored by an automatic volume change unit which is connected to the back-pressure line. To record the displacement, loads, pressure and volume change reading a data acquisition system consisting of data logger and a set of microcomputer were used. Package software was used to convert digital bit data from the ADU (Analogue digital Unit) to engineering units based on the calibration of the relevant measuring unit. A more detail description of this biaxial equipment can be found in the previous working (Fauziah and Nikraz, 2007; Fauziah and Nikraz, 2008; and Fauziah and Nikraz, 2009).

The material used in this study was kaolin clay, which is a product of UNIMIN PTY LTD, Australia, with a specific gravity G_s =2.6, Liquid Limit LL = 53.5 % Plasticity Index PI= 22.74 %

and plastic limit PL = 30.76 %. A kaolin clay sample was first slurried to a uniform consistency of 1 ½ times its liquid limit, then consolidated at a maximum pressure of 300 kPa in three stages. The soil was extruded from the mould into lubricated formers when the consolidation process completed. Following this, the specimen and the former were wrapped in plastic film sheeting after sealing both their faces with liquid wax. To obtain even pore water pressure, the specimens were placed in the dehumidifier for at least 2 days until it was tested.

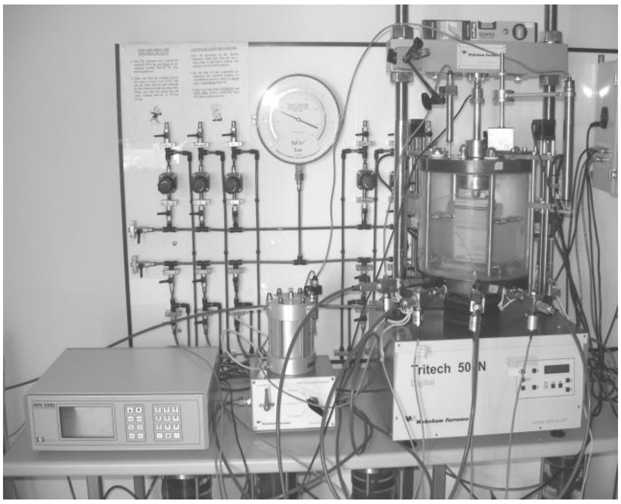

Figure 4. A view of the biaxial apparatus

In the biaxial test set-up, the rubber membrane was firs placed over the specimen with the aid of a sleeve stretcher. The rectangular porous plate was then placed on top of the specimen followed by the top assembly and the high air-entry disc (HAED). The rubber membrane was next slipped over the porous plate, the top assembly and the HAED and secured by the use of a set of O-rings and rectangular perspex clamp. The specimen, together with the porous plate and the top assembly were then placed over the pedestal of the plane strain compression apparatus. The rubber membrane was next slipped over the pedestal and secured by the use of a set of O-rings and clamp set. Two rigid perspex plates were then placed and secured by the use of clamp set.

Testing Procedure

Two types of specimens of IB (biaxial) and IT (triaxial) were tested under net normal stress of 0 and maximum matric suction of 500 kPa and matric suction of 0 and maximum net normal stress of 800 kPa. Specimen was firstly saturated until they reached the B-value of 0.95-0.98, followed by matric suction applied and loading compression processed.

To provide an initial net normal stress of 0 and matric suction of 10, 600 kPa cell pressure, 590 kPa back pressure and 600 kPa pore pressure were applied to the specimen. Once the changes in the soil and water volumes had ceased, the test specimen was presumed to have fully consolidated under a matric suction of 10 kPa. The matric suction was next increased to 20 kPa by reducing the back pressure to 580 kPa. The corresponding changes in the soil skeleton and water volumes were monitored continuously until they had ceased, at which stage the corresponding void ratio *e* and the water content of the test specimen were computed from the cumulative changes in soil skeleton and water volumes. The entire procedure, that is from increasing the matric suction to the desired value up to flushing out the air bubbles, was repeated for matric suctions of 50, 100, 200, 300, and 500 kPa respectively, which were applied by reducing the back pressure accordingly.

Similarly as before, another test apparatus was set up, except that the head was replaced with a porous disc. A cell pressure of 110 kPa, back-pressure of 100 kPa and pore-air pressure of 100 kPa were then applied to the specimen to provide an initial net normal stress of 10 kPa and matric suction of 0. The changes in soil skeleton and water volumes were then monitored continuously and when these changes had ceased, the total changes in soil and water volumes were noted. The net normal stress was first increased to 20 kPa by increasing the cell pressure to 120 kPa. Thereafter, the entire above procedure, starting from applying the net normal stress up to when the changes in soil and water volumes ceased, was repeated for net normal stresses of 50, 100, 200, 300, 500 and 800 kPa.

Specimen was then compressed at a constant velocity of 0.08 mm/m with the drainage line closed at matric suction of 0 and net normal stress of 800 kPa. This loading rate was deduced based on the permeability of adopted kaolin clay suggested by Bishop and Henkel (1962). The data were recorded at 3 minute interval test and it was terminated at the axial strain of about 20 % or sooner. In the analysis of the behaviour of the brittle unsaturated clay, the pore pressure parameter would be required in order to the determined the pore pressure increments and the matric suction. The pore pressure parameters were deduced from the volumetric deformation coefficient. This procedure was proposed by Fredlund and Rahardjo (1993) and adapted to plane strain condition (Lo et al., 2005).

RESULT AND DISCUSSION

As stated in foregoing sub sequent, a total of four specimens under plane strain as well as triaxial test set up have been performed on unsaturated kaolin clay under drained loading condition. Laboratory test results and discussion are presented in the following discourse.

The volume change response of the specimen tested under biaxial test set up and triaxial condition correspond to the void ratio are depicted in Figure 5 and Figure 6 respectively. The gradient of best straight line of the graph, that is the linear portions of the constitutive surfaces, would be the C_m and C_t. The slope of the intersection curves are the volume change index C_m for the case that net normal stress set to zero, and C_t for the case of net normal stress set to zero.

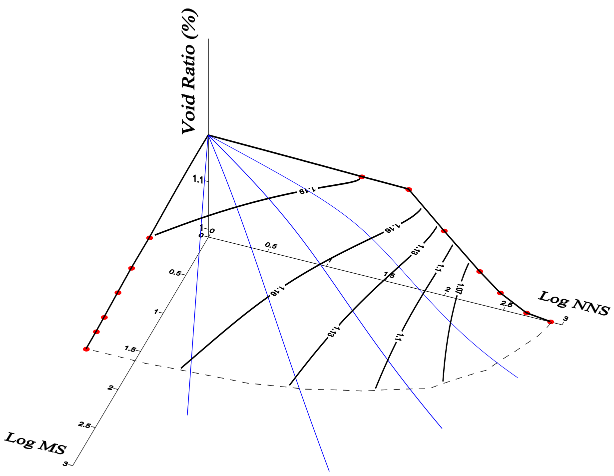

Figure 5. A-three dimensional constitutive surface of void ratio of IB specimen (biaxial test).

It can be seen from the graphs that the curves went down with the increasing of either matric suction or net normal stress. The higher the matric suction and net normal stress, the lower void ratio and water content. It is also shown that the slope of consolidation curve C_t is greater than the slope of the shrinkage curve $C_{m.}$ The constitutive surface of void ratio is defined by the volume change index C_t corresponding to the net normal stress. C_t is the slope of the consolidation curve and is equal to the compressive index of a saturated soil. The constitutive surface of void ratio defined by the volume change index C_m corresponding to the matric suction. It is equal to the slope of the shrinkage curve of a saturated soil. The slope of consolidation curve C_t is greater than the slope of the shrinkage curve $C_{m.}$ This is consistent with the theory presented by previous researchers (Fredlund et al., 2000; Fredlund and Rahardjo, 1993).

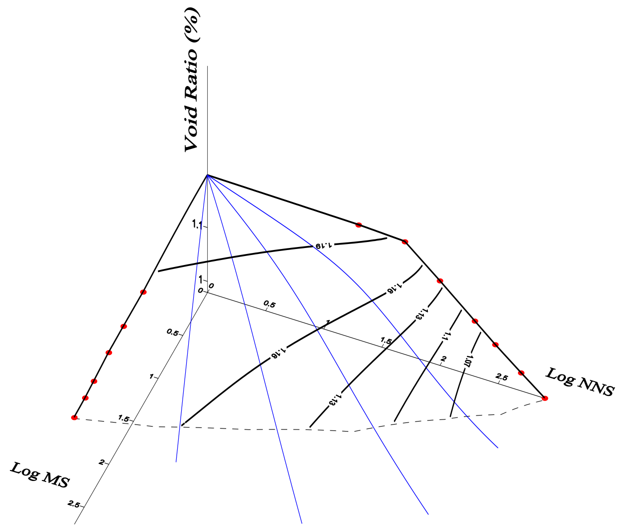

Figure 6. A-three dimensional constitutive surface of void ratio versus net normal stress and matric suction of IT specimen (triaxial test).

The volume change relationships of the kaolin clay specimens correspond to the void ratio is summarised in Table 1. It clearly shown from the table that either shrinkage curve slope, C_m or consolidation curve slope C_t of the specimen tested under biaxial biaxial condition exhibits a higher compressive strength than that the specimen tested under triaxial test set up.

Table 1. Volume change index of the specimen correspond to void ratio

Specimen Type	Matric suction	Net normal stress
	Cm	Ct
Biaxial (IB)	0.0115	0.2186
Triaxial (IT)	0.0173	0.2318

Similarly, the water content of the specimen with varying matric suction and net normal stress were obtained at different loading stages of the experiments. The results is summarised and tabulated in Table 2. The value of compressive index D_m obtained by determining the gradient of the linear portion of the curve of the water content against the log of matric suction. The constitutive surface of water content is defined by the water content index D_m corresponding to the matric suction. The value of water content index D_t obtained by determining the gradient of the linear portion of the curve of the water content against log net normal stress and is equal to the shrinkage of a saturated soil.

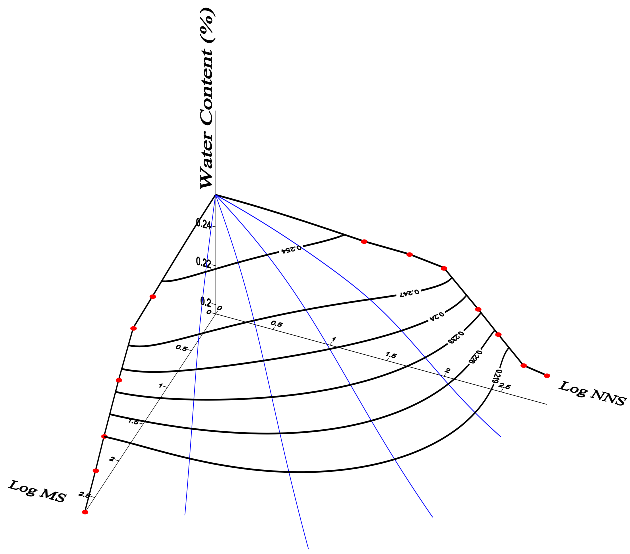

Figure 7. A-three dimensional constitutive surface of water content versus net normal stress and matric suction of IB specimen (biaxial test).

The constitutive surfaces of water content against log net normal stress and log matric suction of the specimen were plotted in Figure 7 and Figure 8. The estimation of the volume change constitutive surfaces for unsaturated soil for the case of monotonic loading was studied by Fredlund et al. (2000). The results of these studies seem to be in well agreement with the theory postulated by Fredlund et al (2000) presented in foregoing Figure 1 and Figure 2 and the work published by Fredlund and Rahardjo (1993).

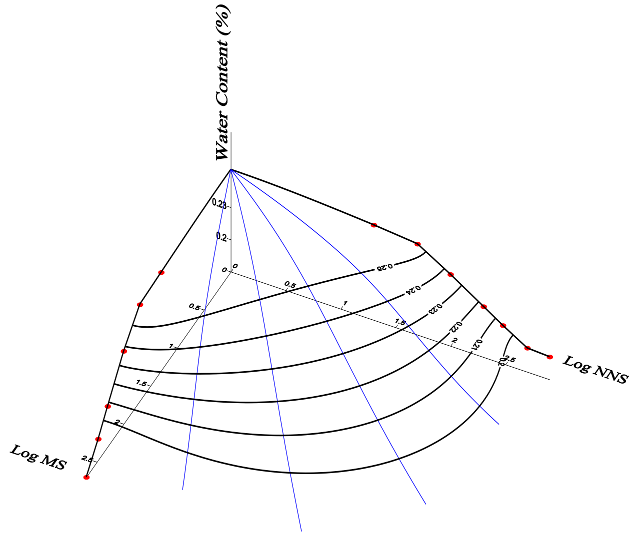

Figure 8. A-three dimensional constitutive surface of water content versus net normal stress and matric suction of IT specimen (triaxial test).

The volume change relationships of the kaolin clay specimens correspond to water content is summarised in Table 2. It can be seen that the specimen tested under triaxial test set up of IT had greater compressive index than that of specimen tested under biaxial condition. This is in well agreement with the founding of Mochizuki et al. (1993), who found that when soil is tested under plane strain conditions, it, in general, exhibits a higher compressive strength and lower axial strain.

Table 2. Volume change index of the specimen correspond to water content

Specimen Type	Matric suction	Net normal stress
	Dm	Dt
Biaxial (IB)	0.0548	0.0560
Triaxial (IT)	0.0899	0.0623

The deviatoric stress against the axial strain curves of specimens presented in Figure 9 showed that the curves increased monotonically with the increasing of vertical strain until they reach peak stresses followed by strain softening behaviour. It is clearly shown from the graphs that the stress strain respond of the specimens are exhibit elastic behaviour. According to Lo et al. (2005) this is the typical phenomenon of specimen of brittle, hard unsaturated soil specimen and demonstrated elastic failure only behaviour. It is also shown from the graph that under the same matric suction and net normal stress, specimen tested under biaxial tes set up exhibit a higher deviatoric stress than that the specimen tested under triaxial test set up. This is also consistent whit founding of Mochizuki et al. (1993).

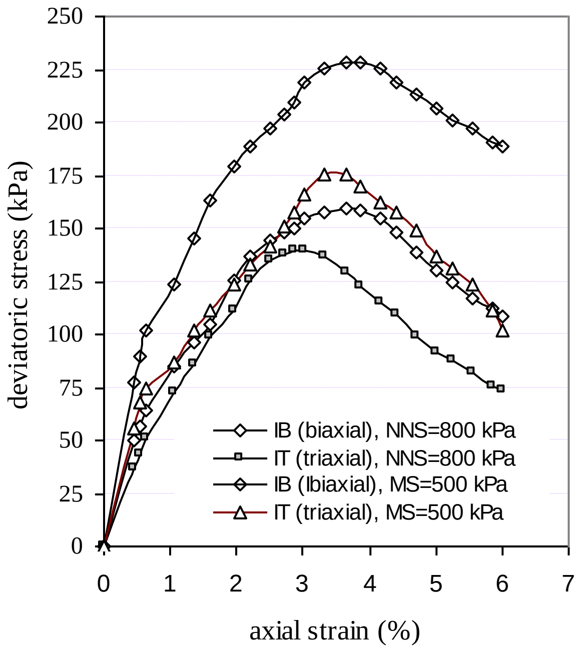

Figure 9. Stress strain relationship of the specimen

CONCLUSIONS

Biaxial test have been performed on specimens of unsaturated brittle clay to observe their volume change characteristics corresponding to the matric suction and net normal stress. The experimental results revealed that volume change relationship of the specimen corresponding to the void ratio and water content of the tested specimen were influenced by matric suction and net normal stress applied to the specimen. The higher the matric suction and net normal stress, the lower void ratio and water content. The result of shear strength curves indicated that the specimens were the typical of brittle and exhibit elastic only failure. A pronounced failure and greater shear strength as well as compressive strength were shown by specimen under biaxial testing than that of specimen tested under triaxial condition. In general it can be concluded that the experimental results seem to be accordance with known soil behaviour from previous research.

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PHYSICAL PROPERTIES BEHAVIOR OF CRACK GIRDER DUE TO DYNAMIC LOADING

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ABSTRACT

This paper deals the behavior of crack girder in terms of the physical properties such as deflection, strains (ε_x, ε_y and ε_p) and stresses (σ_x, σ_y, σ_p and σ_I) due to dynamic loading. The dynamic load analysis was performed based on the finite element software where damping force was neglected. The harmonic loading system was applied during the dynamic analysis and its response was implemented by applying a cyclic force (harmonic) that varies with a sine function at the mid span of the girder. The excitation frequency of the force 400 KN was varied from 1 - 100 Hz. The numerical analysis stated that the physical properties are changed at the bottom surface of crack girder which is very high with respect to the change of the crack depth upon dynamic load action on the girder for example, the value of σ_x for the 190 mm crack depth is 15 MPa which is 20 times lower than the value, 155 MPa for 120 mm crack depth. Similarly, it is seen that the σ_y value for the 190 mm crack depth is 64 MPa and for the 120 mm crack depth is 7.2 MPa; the value of σ_p for 190 mm crack depth is 5.7 MPa and for 120 mm crack depth is 150 MPa which is 26 times higher than the σ_p value of the 190 mm crack depth girder. It is observed that the resisting capacity in terms of stresses such as σ_x, σ_y, σ_p and σ_I, at the bottom surface of the crack girder due to dynamic loading is abnormally reduced with increased the crack depth. Similarly, in the case of the strains, the same variation of the strain result is also observed.

Keywords: *physical properties, crack girder and dynamic loading*

INTRODUCTION

Crack is one of the most familiar defects in bridge structure that may result in adverse effects on the behavior and ill performance of that structure, which can ultimately lead to their collapse. In general, when a structural component is subjected to cracks, its stiffness is reduced, thereby reducing its whole lifetime due to own its one component's stiffness dropping (Ariaei et al., 2009). Moreover, the crack is propagated or increased in time depending loading conditions and vibration amplitude (Chondros et al., 2001). The time dependent loading is called as a dynamic loading or dynamic force. The dynamic analysis has been studied by many researchers during last decade. Chondros et al. (1998) developed a continuous cracked beam vibration theory for the lateral vibration of cracked Euler Bernoulli beams with single or double-edge cracks. This continuous cracked beam vibration theory is used for the prediction of the dynamic response of a simply supported beam with open surface cracks. Chu and Shen (1992) presented an approximate analytical technique to predict the super-harmonic components resulting from low-frequency excitation of an undamped bilinear oscillator. Shen and Chu (1992) investigated the existence of fatigue cracks by exciting the structures at different frequencies and using a numerical study for the response analysis.

It is due to the fact that estimates of the natural frequencies can be obtained from measurement of the vibration at only one point on the structure (Dimarogonas, 1996). The drawback, that escaped the attention of most investigators, is that the change of natural frequency due to the crack is proportional to the square of the relative crack depth or for redundant systems but it does not give any additional information about the physical properties such as deflection, strain, stress of the structure which is very important for estimation of the life duration of the bridge structure. To determine the physical properties of the bridge structure, the dynamic analysis base on the harmonic load is needed to consider in the fracture analysis of structural component of bridge. To know this properties change, the finite element analysis of 3D girder base on the harmonic load is well thought-out in this paper and finally, it is compared the damage state properties (such as deflection, strain and stress) of the two type of damaged or crack girder.

DYNAMIC LOADING SYSTEM

The dynamic loading system is one of the most important loading systems, which is applied during the dynamic analysis. Any structure that is excited by a time varying force is subject to vibrations. The vibration of a structure is normally classified as free or forced. In the case of free vibration, the only forces acting on the body are those owing to the inertia forces developed as a result of its distribution of mass. A dynamic load is characterized as such if its magnitude, direction, or point of application varies with time. A formal definition of dynamic loads or dynamic action is an assembly of concentrated or distributed time varying force acting on the structure and an indirect dynamic action is caused by imposed or constrained motions in the structure due to excitations of its supports. All type of dynamic actions which act upon the bridge structure during their lifetimes stem from two sources. The first type includes environmental forces such as wind, earthquake, impact due to wave action or floating of ice etc and the second source originates from society´s, technological and industrial activities. From the mathematical point of view, these excitations can be divided into deterministic and random actions (Fertis, 1973). If an action is a known function of time, it is denoted as prescribed or deterministic. If the time variation of an action can only be described in a statistical sense, the action is called random or stochastic. A useful classification of dynamic loading system according to their special features is shown in Figure 1. The purpose of the dynamic analysis is the evaluation of displacements, strains and stresses due to the dynamic action on the bridge structure.

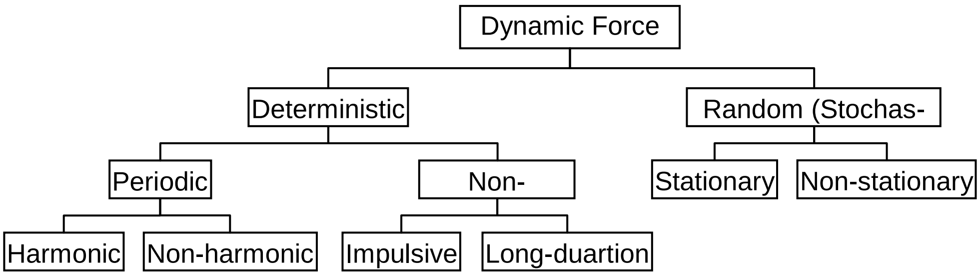

Figure 1. Classification of the dynamic load excitation

HARMONIC LOAD APPLICATION

When an applied load varies as a sine function, it is also called harmonic loading. In this study, notch edge crack of rectangular cross section girder is considered (Figure 3), which is subjected to the harmonic force (i.e. cyclic load).

$$F(t) = F \sin \omega_f t \qquad \text{..........................(1)}$$

Where F is the amplitude or maximum value of the force and its frequency, ω_f is called the exciting frequency or forcing frequency unit of radians per second; $T = 2\pi / \omega_f$ is the exciting period or forcing period and $f = 1/T$ is the frequency of force unit of Hz i.e. cycle per minute.

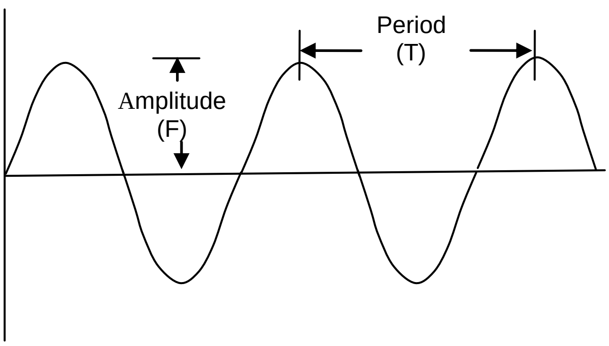

Figure 2. Harmonic loading system

If the impressed force $F(t)$ is acting on the of mass, m and its damping force is neglected i.e. $c\dot{y} = 0$, the differential equations of motion for undamped forced vibration under harmonic excitation is to obtain as

$$m\ddot{y} + ky = F \sin \omega_f t \quad \text{......(2)}$$

Where, m is the mass, $\ddot{y}$ is the acceleration of the mass, k is the stiffness and y is the displacement of the mass. The Eq. 2 is to be solved for the displacement or deformation y subjected to the initial conditions

$$y = y_o \text{ and } \dot{y} = \dot{y}_o \quad \text{......(3)}$$

Where y_o and $\dot{y}_o$ are the displacement and velocity at the time instant the force is applied. The complete solution of the Eq. 2 is sum of the complementary and particular solutions is

$$Y(t) = y_c(t) + y_p(t) \quad \text{......(4}$$

Where $y_c(t)$ is the complementary solution that satisfies the homogeneous part of the Eq. 2 and $y_p(t)$ is the particular solution based on the forcing function and it satisfies Eq. 2. The complementary solution, $y_c(t)$ of Eq. 2 (see details in Eq.1-50, page:17, Fertis, D.G.) is

$$y_c(t) = C_1 \cos \omega_f t + C_2 \sin \omega_f t \quad \text{......(5)}$$

Where, C_1 & C_2 are the constant. Since the complete solution of the Eq. 2 is sum of the complementary and particular solutions, the solution of the Eq. 2 is

$$y(t) = C_1 \cos \omega t + C_2 \sin \omega t + \frac{F}{k} \frac{1}{\left[1 - \left(\omega_f / \omega\right)^2\right]} \sin \omega_f t \quad \text{......(6)}$$

$$\dot{y}(t) = -C_1 \omega \sin \omega t + C_2 \omega \cos \omega t + \frac{F\omega_f}{k} \frac{1}{\left[1 - \left(\omega_f / \omega\right)^2\right]} \cos \omega_f t \quad \text{......(7)}$$

The value of constants C_1 & C_2 are determined by imposing the initial conditions Eq. 3, is

$$C_1 = y_0$$

$$C_2 = \frac{\dot{y}_0}{\omega} - \frac{F\omega_f}{K\omega} \frac{1}{\left[1 - \left(\omega_f / \omega\right)^2\right]}$$

By substituting the value of C_1 and C_2 in the Eq. 6 and the Eq. 7, the final solution of the Eq. 2 is

$$y(t) = y_0 \cos \omega t + \left\{ \frac{\dot{y}_0}{\omega} - \frac{F\omega_f}{K\omega} \frac{1}{\left[1 - \left(\omega_f / \omega\right)^2\right]} \right\} \sin \omega t + \frac{F}{k} \frac{1}{\left[1 - \left(\omega_f / \omega\right)^2\right]} \sin \omega_f t \quad \text{......(8)}$$

The first two terms of the Eq. 8 and Eq. 9 illustrate the free vibration and the third term gives the steady state forced vibration.

CONSIDERATION FOR ANALYTICAL SOLUTION

In order to model the effects that the crack introduce to a structure, the crack of depth 90 mm and opening 0.6 mm (Fig. 3) is considered at the mid span of the girder whose length, height and width dimensions are 16 m x 1.2 m x 0.5 m respectively, which is well thought-out for numerical dynamic analysis. The material which is considered for this dynamic analysis of bridge girder is assumed as a homogeneous and isotropic and the behavior of this material was considered as linear elastic. For the numerical analysis using computer programming software, it is required input data for material properties such as elastic modulus (E), Poisson's ratio (v), density(ρ). In this analytical study, the young's modulus and density of the material is considered as 31200 MPa and 2400 Kg/m^3 respectively and the Poisson's ratio is set as 0.2 according to the bridge design specification. The whole model of the girder except the crack zone is discreatized for the finite element modeling by a triangular mesh size 0.1 m to obtain satisfactory results using the concrete element Solid-65. To discreatize the crack zone of the crack girder, the mesh size is considered as 0.05 m.

A harmonic forced response analysis is accomplished by applying a cyclic force (harmonic) at the mid span of the girder. The frequency of the force is varied from 1 - 100 Hz. The Figure 3 depicts the girder with the application of the force. ANSYS provides three methods for conducting a harmonic analysis. These three methods are the Full, Reduced and Modal Superposition methods. The Full Method uses the full system matrices to calculate the harmonic response (no matrix reduction). In this paper, the Full Method is applied because it is simple and easy to use as compared to the other two methods. However, this method makes the use of the full stiffness and mass matrices. The amplitude of the harmonic force, F= 400 KN is applied at the mid span of the girder which is also considered as a simply supported and meshed it by triangular element for numerical analysis.

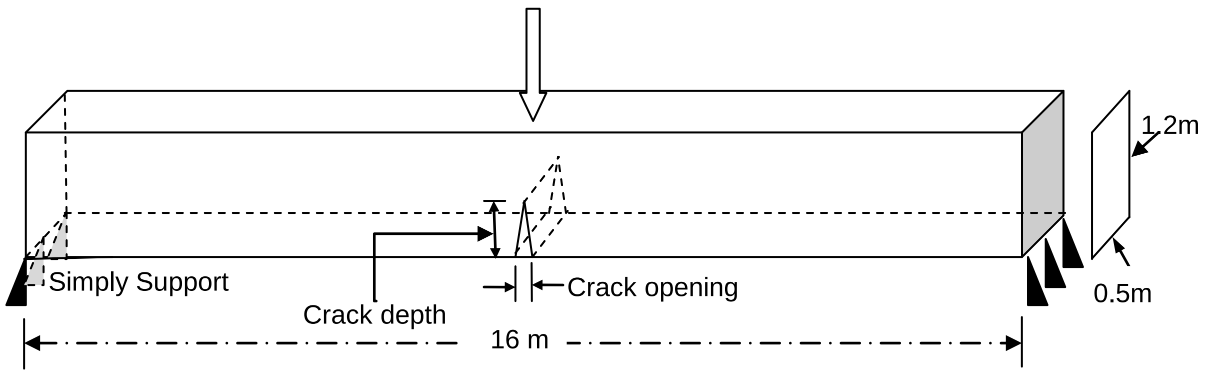

Figure 3. Application of harmonic loading on the mid span of the girder

RESULTS AND DISCUSSION

It is very important to know the behavior of the crack structure especially for the girder of the bridge when dynamic load is acting because most of the failures are occurred to dynamic load action such as wind load, earthquake, impact load and load owing to movement of heavy vehicle. The girder's failure is the more catastrophic than the other components of the bridge. In this study, the behavior in terms of physical properties such displacement, strain and stress of crack girder due to the dynamic load such harmonic load is pointed up.

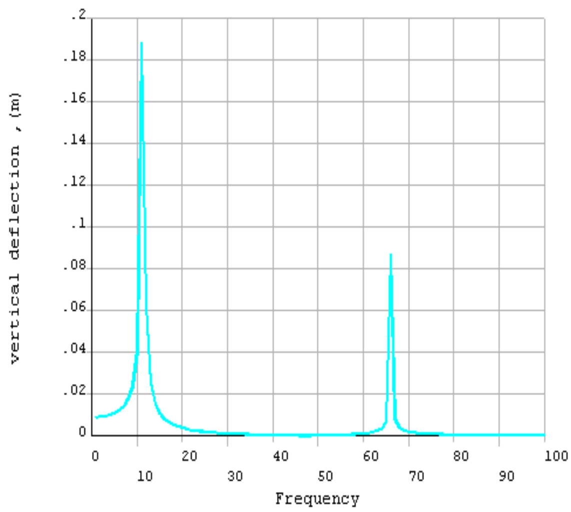

Figure 4(a). Deflection at mid span for 190mm crack depth

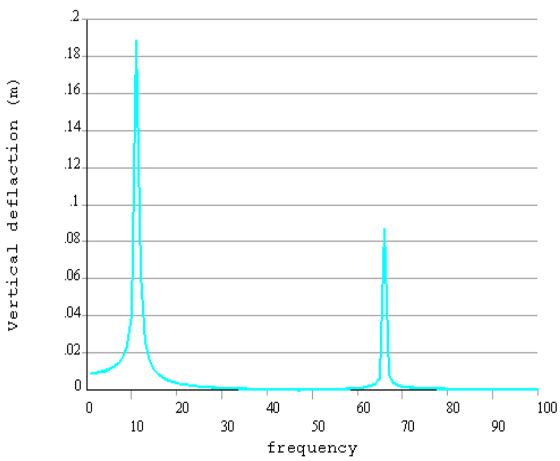

Figure 4(b). Deflection at mid span for 120mm crack depth

Deflection Behavior due to Dynamic Load

Deflection of any components of the structure is one of the most essential considerations in dynamic analysis of the fracture. From the analysis of the deflection for the different crack depth of girder due to dynamic loading, it is observed that the maximum deflection value for 190 mm crack depth is 0.180 m and for 120 mm crack depth is 0.185 m.

Strain Behavior due to Dynamic Load

The basic property of the fracture analysis of the structure is strains which completely recoverable on removal of stress are called elastic strains and its behavior depends on the loading and structural condition where it is subjected to dynamic loading or static loading because when a load is suddenly applied to a vibrating system, the stress and strains in the system are larger than in the case of a gradually applied load or static load. In this study, three types of strain are considered to evaluate the crack girder's behavior. The behavior of the strain's components such as x-component of elastic strain (ε_x), y-component of elastic strain (ε_y) and principal elastic strain (ε_p) owing to the dynamic loading is highlighted and which is shown in Figure 5(a) & (b), Figure 6 (a) & (b) and Figure 7 (a) & (b). From the Figure 5 (a) & (b), it is observed that the peak value of ε_x for 190 mm crack depth is around 28.4 $\mu\varepsilon$ which is lower than the value of ε_x for 120 mm crack depth, 4590 $\mu\varepsilon$. Similarly, it is seen from the Figure 6 (a) & (b) and Figure 7 (a) & (b) that the value of ε_y & ε_p for 190 mm crack depth is 31 $\mu\varepsilon$ & 60 $\mu\varepsilon$ which is lower than the value for the 120 mm crack depth as shown in above figure. From these results, it is concluded that the behavior of strain of the different crack girder due to the dynamic analysis is not singular because when the dynamic load is acting on the crack girder, the crack is propagated i.e. crack depth is increased. As a result, the strain at the bottom surface is reduced but strain at the crack tip is increased with increased the crack depth due to dynamic loading.

Stress Behavior due to Dynamic Load

The major property that is normally considered in the fracture analysis is stress which is defined as the intensity of internal reactive forces in a deformed body and associated unit changes of dimension, shape, or volume caused by externally applied forces. In general, stress is a measure of the internal reaction between elementary particles of a material in resisting separation, compaction, or sliding that tend to be induced by external forces. Total internal resisting forces are resultants of continuously applied forces that are of varying magnitude and direction and are acting on elementary areas forces.

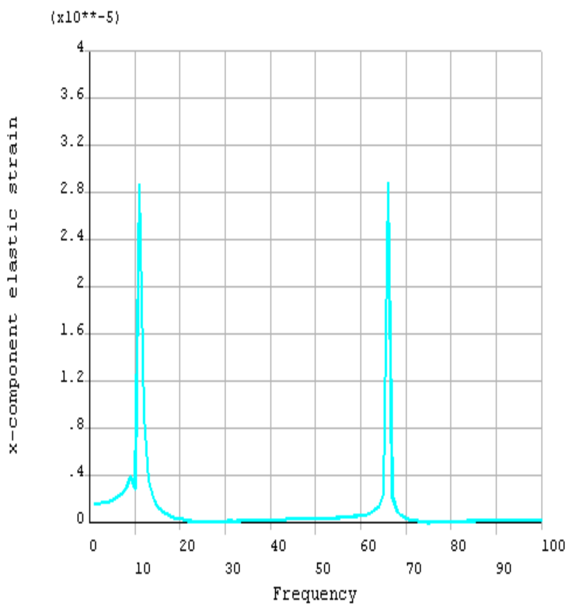

Figure 5(a). X-component strain at mid span for 190 mm crack depth

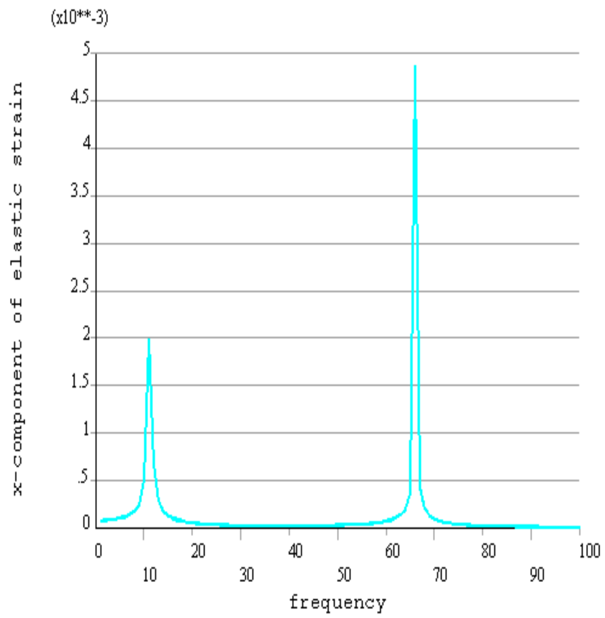

Figure 5(b). X-component strain at mid span for 120 mm crack depth

However, total internal resisting forces are resultants of continuously applied forces that are of varying magnitude and direction and are acting on elementary areas throughout the material. So, in this paper, the stress is well thought-out to evaluate the behavior of the crack girder due to dynamic load action. The stresses such as x-component of stress (σ_x), y-component of stress (σ_y), principal stress (σ_p) and stress intensity (σ_I) at the bottom surface of mid span of the crack girder caused by the dynamic loading is calculated and the all the values of the stresses that are considered in this paper are shown in the Figure 8(a) & (b), Figure 9(a) & (b), Figure 10(a) & (b) and Figure 11(a) & (b) respectively. It is observed from the Figure 8 (a) & (b) that the value of σ_x for the 190 mm crack depth is 15 MPa which is 20 times lower than the value,155 MPa for 120 mm crack depth. Similarly, from the Figure 9(a) & (b), it is viewed that the σ_y value for the 190 mm crack depth is 64 MPa & for the 120 mm crack depth is 7.2 MPa and Figure 10(a) & (b) show that the value of σ_p for 190 mm crack depth is 5.7 MPa and for 120 mm crack depth is 150 MPa which is 26 times higher than the σ_p value of the 190 mm crack depth girder and it is also seen from Figure 11(a) & (b)that the maximum σ_I value for the 190 mm crack is 68 MPa and for 120 mm crack is 157 MPa. From these analysis results, it is finally concluded that the resisting capacity in terms of stresses such as σ_x, σ_y , σ_p and σ_I at the bottom surface of the crack girder is abnormally reduced with increased the crack depth.

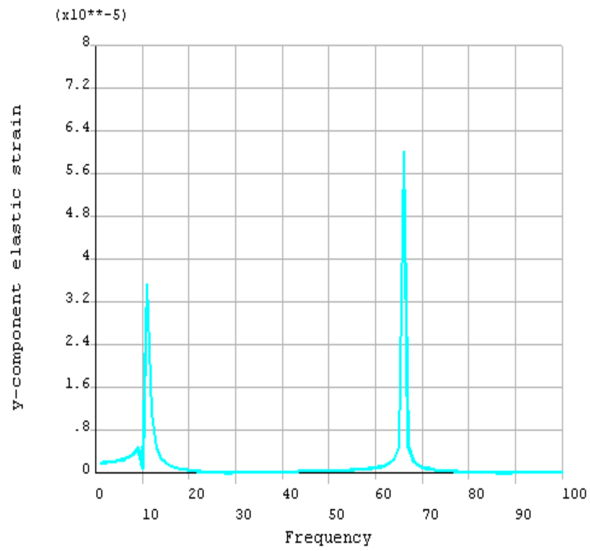

Figure 6(a). Y-component strain at mid span for 190 mm crack depth

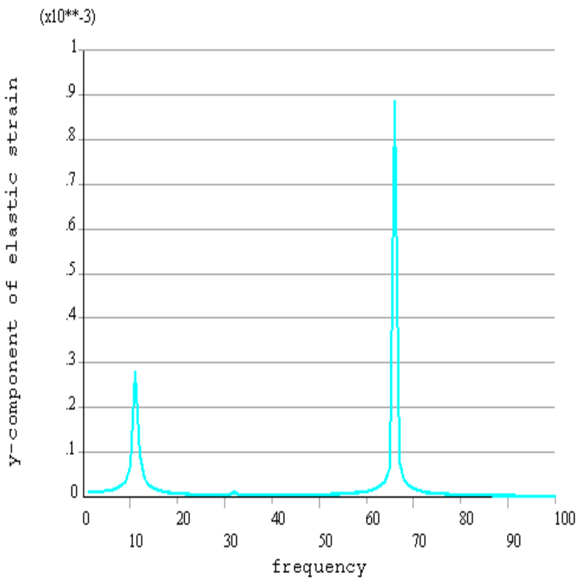

Figure 6(b). Y-component strain at mid span for 120 mm crack depth

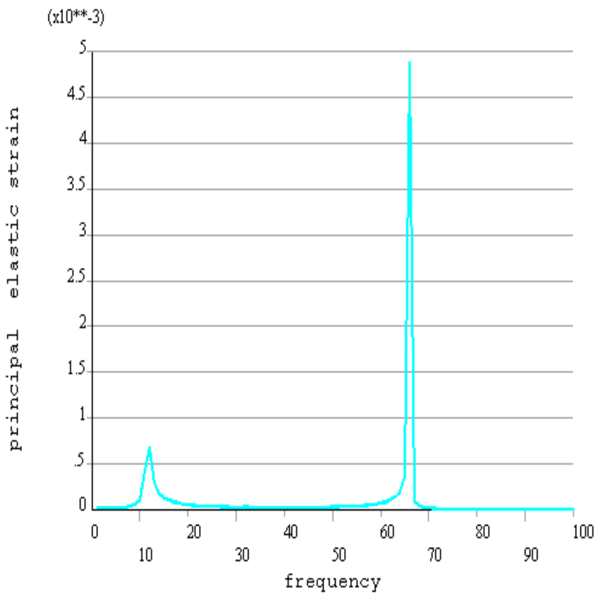

Figure 7(a). Principal strain at mid span for 190 mm crack depth

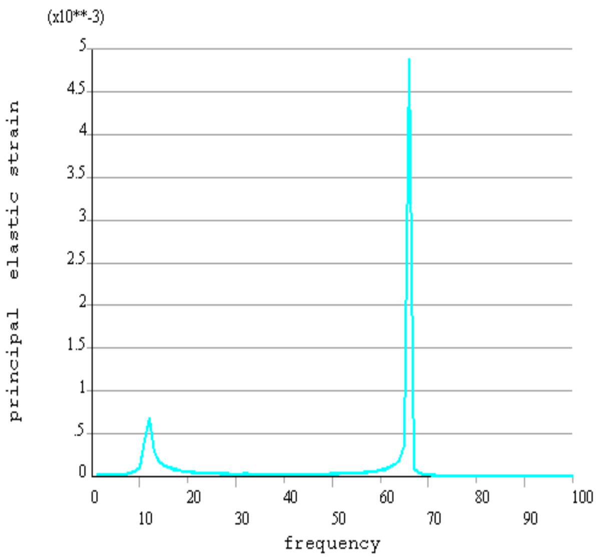

Figure 7(b). Principal strain at mid span for 120 mm crack depth

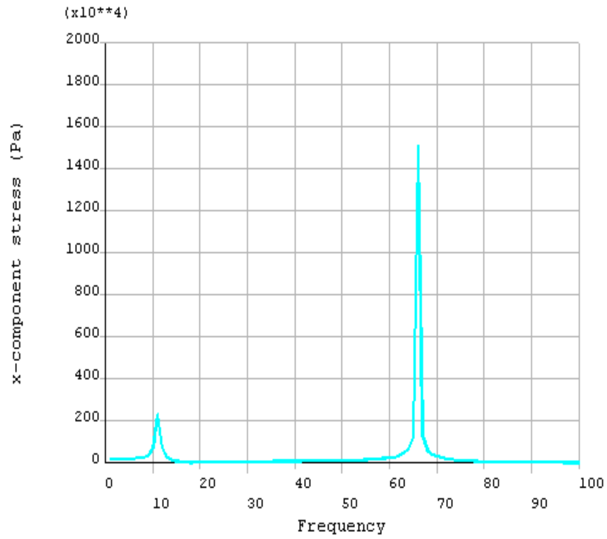

Figure 8(a). X-component stress at mid span for 190 mm crack depth

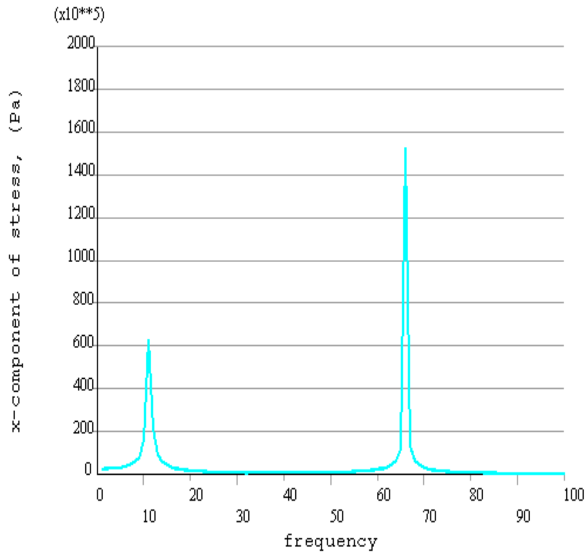

Figure 8(b). X-component stress at mid span for 120 mm crack depth

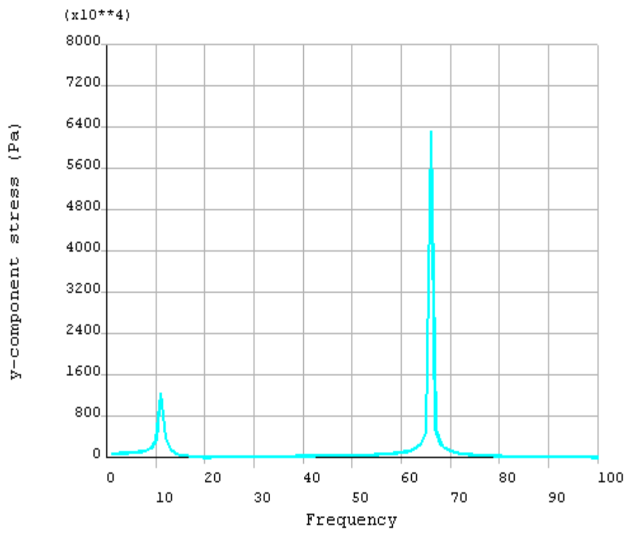

Figure 9(a). Y-component stress at mid span for 190 mm crack depth

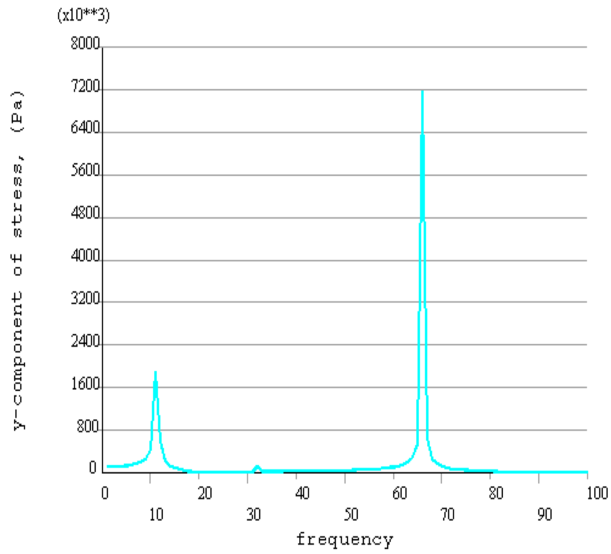

Figure 9(b). Y-component stress at mid span for 120 mm crack depth

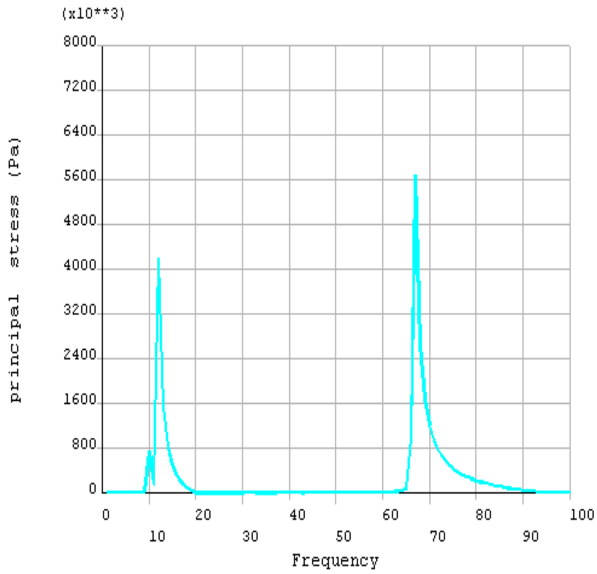

Figure 10(a). Principal stress at mid span for 190 mm crack depth

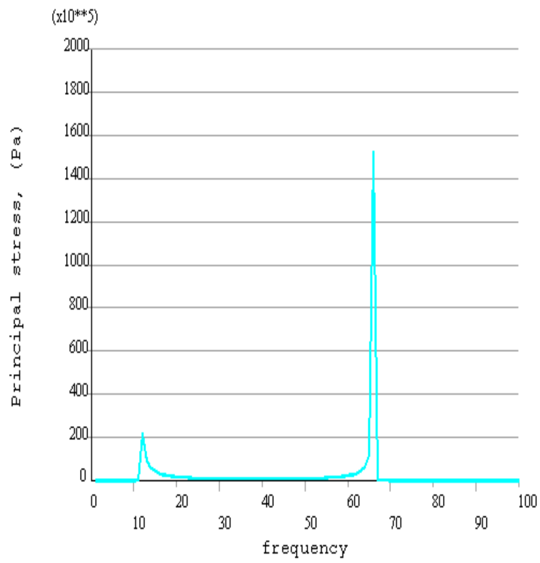

Figure 10(b). Principal stress at mid span for 120 mm crack depth

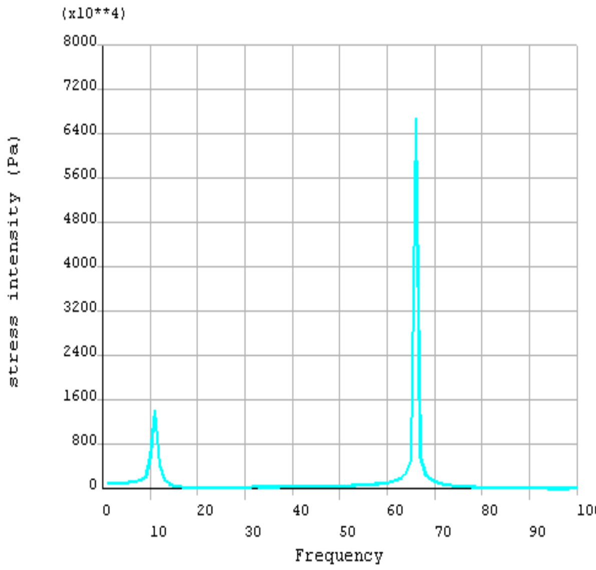

Figure 11(a). Stress intensity at mid span for 190 mm crack depth

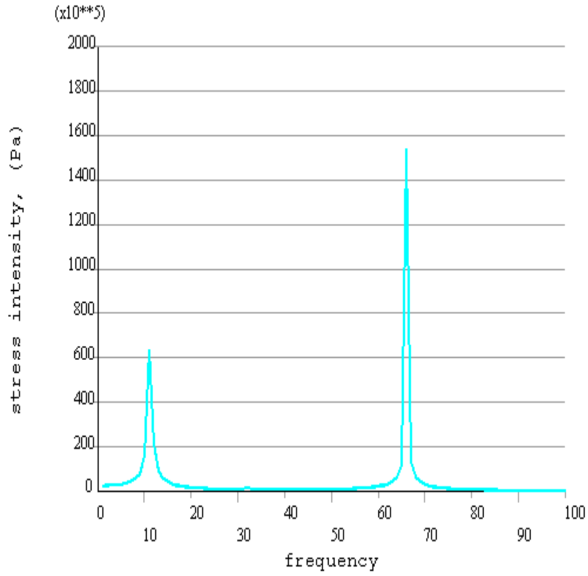

Figure 11(b). Stress intensity at mid span for 120 mm crack depth

CONCLUSIONS

Dynamic load in terms of harmonic load is considered to analysis the behaviors of crack girder based on the finite element software where damping force is neglected. It is found from the analysis data that the maximum deflection value for 190 mm crack depth is 0.180 m and for 120 mm crack depth is 0.185 m; the ε_x value for 190 mm crack depth is around 28.4 $\mu\varepsilon$ and for 120 mm crack depth is 4590 $\mu\varepsilon$, the value of ε_y & ε_p for 190 mm crack depth is 31 $\mu\varepsilon$ & 60 $\mu\varepsilon$ respectively which is lower than the value for the 120 mm crack depth and the σ_y value for the 190 mm crack depth is 64 MPa & for the 120 mm crack depth is 7.2 MP, the σ_p value for 190 mm crack depth is 5.7 MPa and for 120 mm crack depth is150 MPa & the σ_l value for the 190 mm crack is 68 MPa and for 120 mm crack is 157 MPa. From these analyzed data, it is seen that the change of the structural property such as deflection is not so high but the change of strains (ε_x, ε_y and ε_p) and stresses (σ_x, σ_y, σ_p and σ_l) values of the crack girder at the bottom surface is very high with change of crack depth when dynamic load is acting. It is, finally, concluded that it should be important to know the physical properties such as deflection, strains and stresses of the girder to avoid the failure of girder of the bridge due to dynamic action because the change of these properties due to dynamic load action are not identical of that static load action.

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PERFORMANCE IMPROVEMENT OF PROFILED STEEL SHEETING DRY BOARD FLOOR SYSTEM BY CONCRETE INFILL

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ABSTRACT

The Profiled Steel Sheeting Dry Board (PSSDB) system is a type of lightweight composite structure constructed from profiled steel sheeting and dry board connected by self-drilling and self-tapping screws. All these materials can be found in local market. The PSSDB system has been applied as flooring, walling and roofing panels in building. This paper exposes the method to enhance structural performances of the system by introducing concrete as infill material. In general, up to date, infill materials are assumed only as structural loading. Therefore, the influence of concrete in the PSSDB system was studied. The research work consists of full-scale bending tests of the PSSDB floor system were conducted to investigate the floor behavior, and to find out the improvement of the system. Based on the study conducted, it was proven that concrete as an infill material can increase the performance of the floor system compared to the system without any infill material. Result found that with the use of concrete infill, deflection at the mid-span of the PSSDB floor system has been reduced up to 19%. Although the research was conducted on specific proprietary profiled steel sheeting, board, connector and infill materials, the principles applied are completely general in nature and can be exploited to any PSSDB floor system of different combination by adjusting their properties.

Key words: Steel Sheeting, Dry Board, self-drilling and self-tapping screws, infill material, deflection,

INTRODUCTION

Studies on the behaviour of the Profiled Steel Sheeting Dry Board (PSSDB) system as floor panel system have been conducted and reported in earlier publications (Ahmed 2000, Harsoyo 2004, Mangesha, 1992, Wan Badaruzzaman 1994, 1998, 2001, 2003). Profiled Steel Sheeting Dry Board (PSSDB) composite panel system, i.e. profiled steel sheeting connected to dry board by means of mechanical connectors (see Figure 1), is a structural load bearing system and can be used for a variety of structural purposes such as flooring, roofing, and walling units. Most of the earlier reported work studied PSSDB floor panels without any infill materials. This paper deals with the effect of infilling the normally voided PSSDB floor panels with infill materials in the trough of the profiled steel sheeting, which formed a very rigid load bearing floor structure as expected. As load bearing floor, the system acts a membrane carrying the out-plane deformation and bending. The structural behaviour and strength of the PSSDB composite panel system depend to a large extent on the properties of the basic components forming the system, i.e. the steel sheeting and dry board, and the degree of interaction between them. The degree of interaction can be either full or partial interaction depending on the connector modulus and spacing. In a building, floor loading would induce on the PSSDB floor. Therefore, the floor should be strong enough to support the load without any damage and has an acceptable out-plane deformation, for example deflection less than 1/250 of the span.

OBJECTIVE

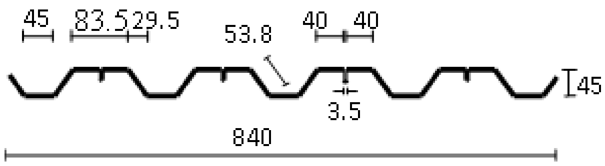
Since theoretically, the concrete tension is always assumed to be zero or ignored. It is nessacery to set the objective of this research is investigating the effect of the concrete as infill material in PSSDB experimentally.

RESEARCH COMPONENTS

Profiled Steel Sheet Dry Board composite panel system consists of three main components that are available as individual item.

Profiled Steel Sheeting

This study deals with profiled sheet, Peva 45 (1 mm thick) produced by Asia Roofing Sdn. Bhd. Malaysia. Figure 1 shows the cross-section of Peva 45 profiled sheeting. Table 1 shows the characteristics of Peva 45.



Note: All units are in mm

Figure 1. A cross-section showing Peva 45 of 1mm thickness

Table 1. Section properties/metre width

Nominal Thickness mm	Depth of Profile mm	Weight of Profile kg/m^2	Height to Neutral axis mm	Area of Steel mm^2/m	Moment of Inertia cm^4/m	Moment Capacity kNm/m
1.0	45	13.33	16.81	1422	7.07	4.4

Dry Board

Various types of boards are available in the market. For the present study, An 16 mm thick cement board, Cemboard, manufactured by Hume Cemboard Berhad Malaysia has been used. The materials properties for these boards were tested in the laboratory and tabulated in Table 2.

Table 2. Material Properties of Cemboard

Young's Modulus (MPa)		Bending Strength (MPa)	
Parallel to Grain	Perpendicular To Grain	Parallel to Grain	Perpendicular to Grain
5250	5250	8.4	8.4

Connectors

Horizontal shear at the interfaces between Peva 45 and Cemboard are being transferred by means of self-drilling and self-tapping screws as shown in Figure 2.

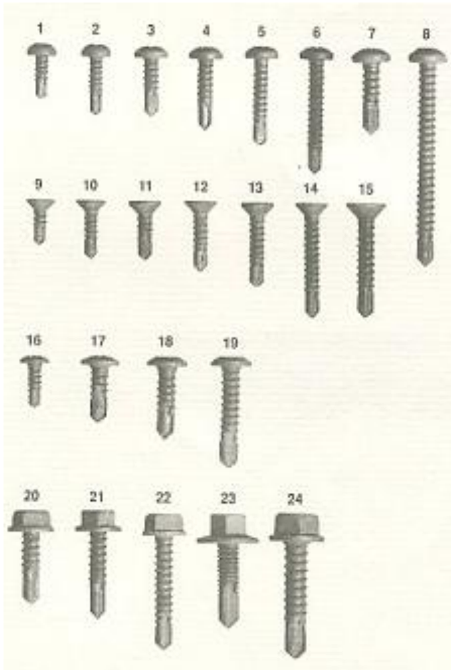


Figure 2. Types of Self Drilling and Self Tapping Screws

EXPERIMENTAL STUDY ON PSSDB FLOOR PANELS

In this section, experimental study conducted by the authors on PSSDB floor panels is described. The aim of the experimental work is to gain an understanding of the behaviour of PSSDB as floor panels, and to study the effect of introducing infill materials in the trough of the profiled steel sheet on the structural behaviour of the floor panels.

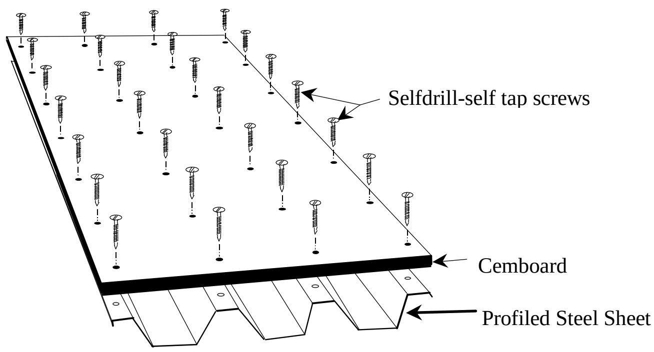


Figure 3. Typical PSSDB Floor Panel

PSSDB Test Specimens

Two kinds of specimens having rectangular dimensions were used in the experimental investigations. Peva 45 (a type of profiled steel sheeting manufactured by Asia Roofing Sdn. Bhd.) of 1 mm thick and Cemboard (types of cement board manufactured by Hume Cemboard Berhad) of 16 mm thick, and self-tapping, self-drilling screws were selected for this purpose. All specimens had the dimensions of 750 mm by 2000 mm, and were constructed as single-skin panels. Table 3 gives the samples specifications with cross-sectional illustrations of PSSDB without infill material as shown in Figures 4

Table 3. Sample Specifications

Kind of Sample	Description of Samples
Standard PSSDB Panel	Peva45 (1 mm thick) was used as the base material, whilst Cemboard (16 mm thick) was screwed on every rib on Peva45. No infill material was used in this sample. Please refer to Figure 4. The sample is tested almost immediately after preparation
Concrete Infilled PSSDB Panels	As same as the first kind sample, but the troughs were filled with concrete. The sample was tested after the age of concrete at least 28 days

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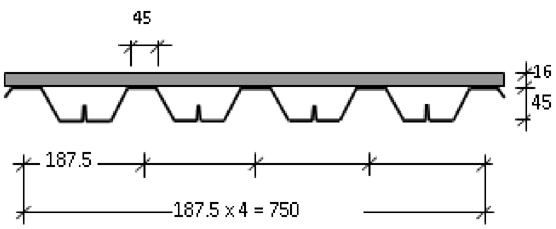

Figure 4. Cross Section of PSSDB

Loading System, Instrumentation, and Test Procedures

The loading was applied via using steel blocks. The weight of each block is 20 kg (200N). The load is placed on the panel manually. Transducers measuring lateral deflections of the test panels at various locations on either side of the centre point along both in the x and y directions were used to check for expected symmetrical behaviour of the panels as seen in Figure 5. The load cells and transducers were connected to a digital portable electronic data logger. The initial values for deflections and loads are zeroed on the measuring device once the panel, the loading system and the transducers had been assembled in position on the supporting and specimen frames. These conditions are then considered to represent the initial unloaded state of the panel. Loads are then applied incrementally. After a regular increase of loading, the loading values and the corresponding deflection values are recorded. The load and the corresponding deflection measurements taken from the test are then used to investigate the behaviour of the panels.

Figure 5. Loading State of The Test

RESULT AND DISCUSSION

Table 4 shows that the deflections of the specimens are relatively linear. It means that the panels still behave linearly under loading of 1.33 – 6.67 kN/m^2. These loads represent the live load of ordinary housing to industrial building (BS6399, 1996). Theoretically by assuming that infill marterial as tension concrete which is zero, the deflection of PSSDB with concrete infill will be greater than the standard one doe to the addition load of concrte infill. But the test shows that deflection of PSSDB with concrete infill is less as it indicates in figure 6. The diferrence of deflection in earlier test is about 11% then followed by 3 % and finally about 19%. The difference seams inconsistence, it may be because of the addaptation among materials of the panels.

Harsoyo (2004b) showed that in single Peva 45 trough, the slip resistance of concrete infill is about 1900 kN/mm. It means that concrete infill behaves as part of the structure as long as its slip is less than the resistance. So, by assuming that concrete infill has zero tension or no contribution to the structure except as addion load is not accurate. It shows that concrete infill has participation to improve the stiffness of PSSDB. The stiffness improvement of PSSDB with concrete infill is varying from 11% to 19 % compared to the standard one. However, the panels do not meet the requirement of the maximum deflection of 1/360 span that is 5.56 mm (0.00556 m) for the higher load, especially for the PSSDB standard. It implays that the panel without infill only suitable for building with live load less than 3 kN/m^2 and 4 kN/m^2 for panel with concrete infill as shown in figure 6.where d_s is diameter of transverse steel, ρ_{cc} is the ratio of area of longitudinal steel to area of core of section and s' is the clear spacing between spiral or hoop bars. Mander et al proposed equation for K_e for circular sections and the spiral-shaped transverse reinforcement (Eq 9). As K_e defined, it takes into account of the efficiency of the various possible arrangements of transverse reinforcement.

Table 4. Deflection at Mid Span

Load	PSSDB Standard	PSSDB with infill	Difference
kN/m²	(m)	(m)	(%)
1.33	0.00252	0.00222	11.90
2.67	0.00392	0.00380	3.06
4.00	0.00602	0.00517	14.12
5.33	0.00834	0.00679	18.59
6.67	0.01017	0.00820	19.37

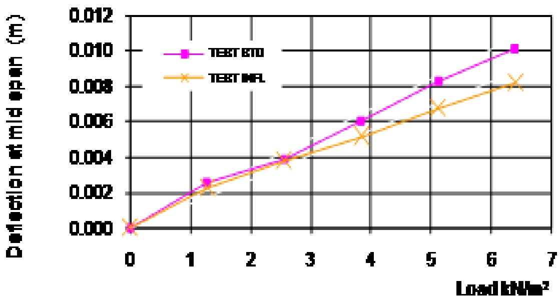

Figure 5. Deflection of Samples

CONCLUSION AND RECOMMENDATION

The test shows that the PSSDB with infill matrial of concrete improves the stiffness of the panel by 19 %. It means that infill material such as concrete contributes to the panel structure in improving the stiffness. Even though, the concrete is placed in troughs of the profiled steel sheeting which is in the tension part, as it is assumed theoretically that concrete tension is zero (it should be no contribution). To extend the understanding the behaviour of the infill material, it is recommended to study theoretically by taking account the present of the infill material, such as using finite element analysis and the others.

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HOUSE AMENDMENT PROCESS OF SASADUSAHU, HALMAHERA, NORTH MALUKU PROVINCE

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ABSTRACT

Urbanization process will impact on social change, economic and cultural community, and ultimately affects to homes and settlements. The process of change also applies to traditional homes, which can change shape, pattern, function and meaning in line with the dynamics of time due to the influence of urbanization. Sahu public manifestation of traditional houses (houses Sasadu) as a custom home is one of the architectural wealth of the archipelago, which contains the symbols of the agricultural community as a pillar of community life Sahu. Currently the house is undergoing the process Sasadu change because of urbanization that occurred in the process of division of administrative areas. This study examines the effect of changing the community culture sahu on traditional buildings, which, among others reflected on Sasadu homes and residential units. The aim of this study is to identify the influence of socioeconomic and cultural changes to housing and settlements, including the process of change in shape, building materials, functions and meanings of home Sasadu. The research method used was a qualitative method with case studies and comparative approach, which aimes to investigate intensively about the background of this phenomenon which occurs when the interaction of social change, economics and culture of the built environment in this case Sasadu home.

Keywords*: Houses Sasadu, Sahu, urbanization, cultural*

INTRODUCTION

Indonesia as one of the developing countries, an increase of uncontrolled urbanization. From the results of projections of urbanization, the rate showed a trend of increasing urbanization. Level of urbanization in 1990 is 28.69% increased to 36.46% in 2000. Level of urbanization is expected to increase to 44.48% in 2010 and became 52.20% in 2020.

Urbanization may be defined as urban development, city growth, city expansion, the displacement of population from rural to urban. Development of a region usually associated with economic development and population growth, and regional planning considerations are generally prepared with the development of economic activities in the region (Happy, 2000).

The regional government of north maluku was established in 1999 following the division of two districts in the northernmost province of maluku region, namely north maluku and north halmahera. New province formed from the division was overshadowed one city, two districts, 45 districts, 89 villages and 644 villages spread over an area of 33,321 km2 land area. In 2003, north maluku district separated into north maluku district, west halmahera, south halmahera and sula islands, while the district of central halmahera halmahera separated into east and city tidore islands.

The existence of splitting of the impact on the social, economic and cultural sahu has significant effect on physical and non physical changes sasadu house.

The purpose of this research is the traditional house sasadu examining changes due to urbanization sahu community. Identifying the goals of this study the influence of social change, economy and culture of form, layout, function, meaning sasadu custom homes and residential units.

THEORY BASIC

Understanding of urbanization (urbanization) basically have several meanings depending on the perspective used. Daldjoeni (1986) has shown many limitations of urbanization that has been proposed by de bruijine as follows:

1. Percentage growth of population residing in urban areas, either through modial, nationally and regionally.
2. Transfer of population into cities from rural areas.
3. The increase in non-agricultural population in rural bermatapencahariaan.
4. The growth of a settlement into the city.
5. Blossom or the expanding morphological structure of a settlement.
6. The broadening effect of the economic atmosphere of the city to the countryside.
7. Widespread social influence, psychology and the cultural to the countryside.

The process of urbanization, by golberg and chinloy (1984) are classified into three stages, namely: (i) the urbanization of agriculture (agrarian urbanization), (ii) urbanization of the metropolitan-based industries (industrial-based metropolitan urbanization) and (iii) counter urbanization not a post-industrial metropolitan (non-metropolitan non postindustrial urbanization). Each stage of the urbanization process was marked by several major changes at once is a central feature of every stage.

According to Rapoport (1983) based on the diagram (Fig. 1) below, alongside the cultural change will affect the environment that is built up. At the same time there are three elements can diinditifikasikan elements as central elements (social, cultural and physical), also around the less important elements in traditional environments, differences in these changes and showed signs of great help to predict future developments.

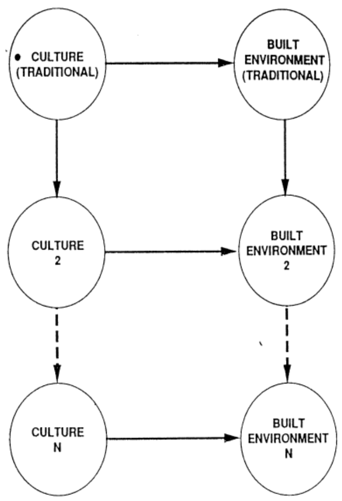

Figure 1. Built environment diagram

Changes in the traditional culture will also influence changes to the traditional built environment. The next traditional cultural change will also affect the ongoing rural areas as well.

Turner (1972) revealed that the house has a variety of functions and all functions that depend on the objectives to be achieved, different from one another depending on the place and time. Interaction between the houses with their inhabitants is what is given to the residents home and what the occupants of the house. From home is the most important impact on the lives of its residents and not the shape or physical standards.

Houses are not just shows a physical structure, but also shows a group of families who inhabit the home or family members. The appointment of the identification of families with home grouping in question, prove that the family system in Southeast Asia should generally be viewed as a community residents (house society), with three applied (Waterson, 1993).

Cognitive space, or cultural space is the space interpreted by certain groups, dipengaruh by past experiences, memories, and mental category groups. Imaginary space, describe the living arrangements that reflect a pattern and a certain regularity of diverse social groups, hierarchical and rule them (Rapoport, 1970).

RESEARCH METHODS

This study investigated the cultural changes that affect the built environment on public sahu due to the influence of urbanization. On the basis of the above research started by sahu community cultural studies contained in the custom house sasadu. given the ever-changing culture will always be found although some parts of which remain, it is necessary to study the cultural aspects of both fixed and changing the mempengauhi lingkunngan coachee.

To explore sahu culture associated with traditional house sasadu pattern changes that are influenced by regional development, the strategy used was qualitative research. according moleong (in 1997), "qualitative methodology" is defined as a procedure that produces the data descriptive study of the written word or spoken of those who observed.

Methodology to examine the cultural and environmental changes; fundamentally is historically, in terms of trying to establish a foothold line traditional environment (culture) and then, through the sequence of the built environment over time, to identify the core of the traditional elements remain, and that changes, missing , new elements were added. this method is trying to find something very special in that context, based on changing situations and time, so there are elements of what has changed, adapted, modified and still maintained, can give a clue where these elements are relatively important, and we can conclude why these elements are very important (Rapoport and Hardie, 1991).

Approach to examine the cultural changes in the wake environment, is fundamentally historical in the sense of trying to establish the authenticity of tradisonalnya environment, and with in line with the passage of time, is necessary to identify the elements that remain, change and disappear. According to Rapoport and Hardie (1991), almost always by definition, any approach which seeks to obtain such information (the process of cultural change and its relation to changes in the built environment), will be longitudinal or historical, but not implicitly.

However, a comparative approach dikemukan faqih was quoted Rapoport (2005), suggesting the analysis on the environment as a substitute for the existing continuum longitudinal approach. Basically this method assumes that the model of cultural change in unison with the built environment. Rapoport (1991), as shown in the Fig. 2, illustrates this analysis in detail, namely first define the traditional characteristics of the environment as the foundation line. then identify the existing environmental continuum, ranging from remote villages have changed little in moving towards a changing environment.

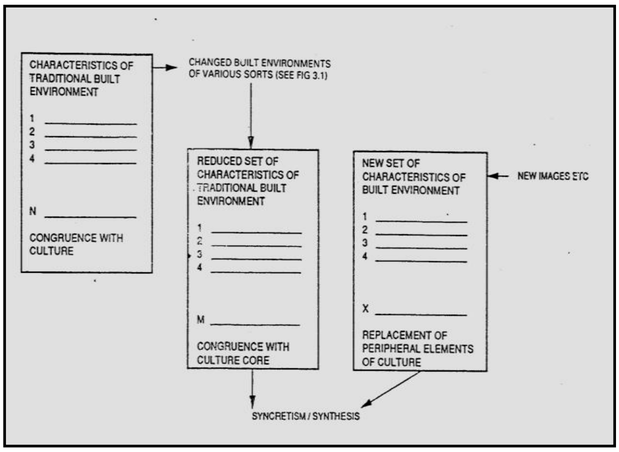

Figure 2. Identification of characteristics of cultural change with the artificial environment *source : Rapoport (1991)*

Based on the characteristics of those cultural changes, the location of the village were taken two or drawing, which represents the traditional (taraudu) and lingkungaan coachee has changed a lot (awer).

RESEARCH RESULTS AND DISCUSSION

Custom house, Sabua (Maluku Melayu language) or Sasadu (Sahu language) has important cultural significance. At the time sahu communities living in the middle of their garden, the community came together in the village is only at times of ceremonies are held only (Abdurahman, 1996).

Building Forms

In architecture, the impression that we will soon catch from sasadu building is, the rows and columns are drawn so gable extension to the 4 sides making the terms of the form 8. The gable is the most high-cap space at the same time indicated below. "The floor in the" building, the higher ± 30 45 cm - from ground level outside, to prevent entry of water, and to provide a clear frame boundary between inside and outside. There are two forms of structured roof, the roof of the steep, sloping roof and protrudes into the bottom side, eliminate the possibility of glare for people inside the buildings. Besides the low roof, so determine the scale of buildings Sasadu be perfectly proportioned. Conversely, a low roof makes every person that comes in, feels the need to slightly bowed his head. An act of homage that inevitably must be done accidentally.

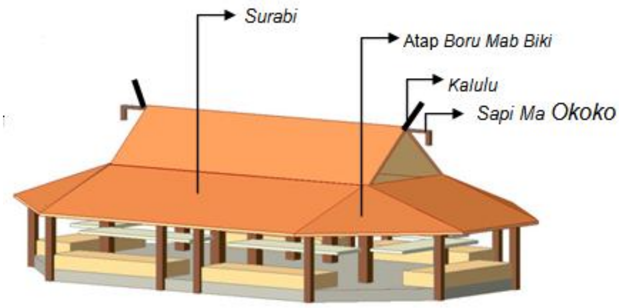

Figure 3. Perspectives of Sasadu
(source : personal sketches,2007)

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Building Structure

Like most other areas of traditional houses in Indonesia, building structure Sasadu, adopts a construction framework (skeleton) with the main elements of primary and secondary columns are mutually bound by primary and secondary beams are tied together by transverse beams, longitudinal and circular into one solid unity (rigid). All the columns are not planted into the ground dead, but standing on the foundation stone umpak intact (not cut stone) (Mursid, 1977).

Building Materials

Columns of the main pillars supporting the building material made of wood Sasadu gofasa and for many of the other main frame: cross beam and the roof frame. Bamboo material is a key ingredient in the battens and the roof truss usuk. Sago palm leaves as roofing material.

Earthen Floor as a Material Floor

Therefore, in essence the building is very easy to movable, if the community owner so demands. Houses Sasadu also easily treated, by replacing the elements or components are damaged or when obsolete. The relationship between the component elements that are not dead perfect, lets all do the things mentioned above.

Function Houses Sasadu

Place of execution ceremony. Sahu society is an agrarian society where the belief that relegius adopted at that time was primitive belief in animism is apparent in agriculture fields. In the field of agricultural fields have conducted ceremonies are customary Sa'ai mango'a the party after sowing rice seeds. Sa'ai means to cook, ngo'a means child. Ma Sa'i ngo'a not mean cooking the child, but rather indicates that the implementation of customary feast lasted three days and three nights. Custom party sa'ai ngo'a ma is a shindig. This party is held when rice is planted two or three weeks old. Sa'ai Lamo is customary thanksgiving feast that lasted seven to nine days. The party is done with his old customs must be odd ie 9,7,5 or adjusted by the amount Sasadu faras or roof.

Houses Spatial Sasadu

At the ceremony, which is only present in sasadu men and women who become clan-clan of the most prominent in the group Walasae, Ngowarepe, Walangatom and so forth, are also regarded as the landlords there. Their seating is arranged according to the membership in one of the clans through the male lineage (patrilineal), and according to the position of (position) in a hierarchical clan groups larger territorial (fencing) as walasae. In Sahu, the position of clan is always portrayed with demikan way, and someone who is supposed to represent their ancestors (omenge) occupied the first pew monyangnya grandmother. Sometimes the blades are above the roof sasadu seating (aoto) had representatives there are carvings lineage ancestors. The woman took the seat in accordance with the position of the husband or father. What is usually called a tradition or custom here is none other than the concepts of cosmological order in different parts of the culture Sahu (Visser, 1994).

Meaning House Sasadu

Sasadu house has four entrances located at the corner of the building, which is just below the roof of the triangle Boru Ma Biki, used as an entrance to the various levels of society including indigenous stakeholders, while the second entrance which is right in the middle of building a special door bypassed by Kolano / Kolano Ma Jiko and his deputy when the ceremony held in the house this sasadu. Triangle-shaped roof called 'Boru Ma Biki' (tail Bird), was designed with the intention to lower through the door must be bowed as a mark of respect. Rectangular-shaped roof called 'surabi' (porch). (Nukila, 2003).

Hierarchical system on the ship were also seen in buildings that contain the highest meaning of that section is occupied by Kolano / Kolano Ma Jiko but protected by the princes, while behind them is the community led by the head of each ancestral lands (see Figure 4).

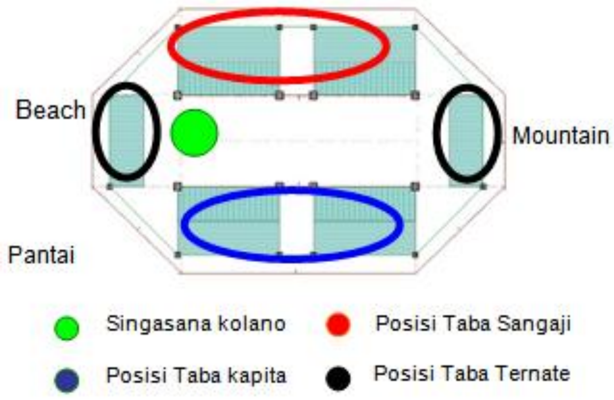

Figure 4. General plans of Sasadu

In this analysis, show changes sasadu house in two villages namely: Taraudu and Awer. In the previous chapter mentioned that the embryo of the seed of the existing tribes in Halmahera Sahu comes from Taraudu. It is almost in every village has a traditional house. But the pattern changes, the researchers took a closer comparison of the original (Taraudu Village) and that changed. Furthermore, these comparisons are presented in table form that can be seen in Table 1.5.

CONCLUSIONS

Urbanisasi in West Halmahera occur because development and urban expansion. It ultimately affect social change, economic and cultural community. The biggest changes occurred in the traditional house Sasadu, many things happened from the building structure, function and building materials.

Building structures that are clearly visible changes are: the replacement of the use of building materials made of thatched originally was replaced with zinc material (Taraudu), whereas in Awer still using fixed material (thatch).

Broadly speaking Sasadu fugsi house that still serves as a place of the customary activities of the rice harvest. In the village community activities Taraudu function is still found here: the place of the customary court (deciding a person's inheritance rights or other customary decision).

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WHY THE JAVANESE HOUSES HAVE FAILED IN THE 2006 JOGJAKARTA EARTHQUAKE

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ABSTRACT

The 2006 Indonesian earthquake stroke the most populated area of Java Island, Central Java, and became a deadly catastrophe since it was causing great range of fatalities. Many aspects varying from natural to social were counted in contributing to the high number of casualties. However, the most direct aspect related to the high number of victim was the failure of the houses; the Javanese house. This paper examines the reasons behind the question "Why the Javanese houses were easily collapsed during the quakes?" Initially, the natural and social background is studied to understand the pre-earthquake setting condition. The Javanese house typology is then assessed based on their level of vulnerability to earthquake. A comparison method is adopted to re-evaluate the structural properties of main type of Javanese houses in order to investigate housing safety level deal with earthquake.

Keywords: *Javanese houses, earthquake vulnerability*

INTRODUCTION

The 2006 Java earthquake resulted in a huge loss of life and destroyed thousands of buildings. Although the actual shaking only lasted 59 seconds with a magnitude of 5.9 on the Richter scale, over 6,060 people were killed and a further 63,305 injured (WHO, 2006). More than 300,000 houses were destroyed with minor damage to a further 200,000 houses. This left 1.6 million people homeless (UN-OCHA, 2006). Eight districts in the Jogjakarta and Central Java Provinces suffered extensive damage. The majority of the destroyed houses were mostly located in the area near the epicenter of the earthquake in the southern rural provinces of Jogjakarta and central Java.

Soon after the implementation of the emergency post disaster period, the Indonesian government, supported by various relief organizations, redeveloped the destroyed area with a reconstruction program. This program was highly successful and 279.000 houses were rebuilt and 253.000 were repaired and restored in a very short time - within a two year period (JRF, 2008). Within the reconstruction program, a large variety of new housing types were offered starting from the very simple to the strange and unusual. The purpose was to provide people with more quakeproof houses. As a result, the many types of new housing in the area ranges from simple to advanced construction systems.

JAVA AND EARTHQUAKE DISASTER

Natural disaster is not a global phenomenon; instead it's related to the local-regional condition. Earthquake in one place may be similar to earthquake in another in term of magnitude level and or epicenter distance, but earthquake disaster is definitely different from one and others. Casualties resulted also might be similar as well, in term of number, but the way people get hurt and how they react to the natural phenomenon is widely different. The level of disaster will depend on surrounding natural and social aspects, locality and history.

Since Indonesian territory is located among three edges of continental plate, long active tectonical line creates series of volcanic mountains spread along 5000 km trough western coast of Sumatera, Java Island, Nusa Tenggara, Maluku, and up to Sulawesi. In this area so called ring of fire laid 132 active volcanoes. This natural condition beside gives very vertile land also situates the people in high risk from tectonical disaster. This risk is worsted by high density population such as Java Island which is inhabited by 65% of 2,006,264,595 Indonesian populations.

In Java Island alone, found a series of active volcanoes starting from Krakatau which exploded in 1883 and created 40 m high tsunami. The Krakatau is one of the 10 most active volcanoes in the world which erupted in 1954, 1973, 1979, 1984, 1994 and 2006. The other following volcanoes like Semeru in Eastern Java exploded in 1978, 1979, and Galaunggung which erupted in 1982.

Besides affecting many volcanic explosions, tectonic activity also creates earthquakes. In Java Island recorded big earthquake as follows:

a. 1867 : 372 houses collapsed, 5 fatalities,
b. 1943 : 2.800 houses collapsed, 213 fatalities, 2.096 injured,
c. 1981 : no casualties,
d. 2006 : 6.234 fatalities, > 50.000 injured, >70.000 houses collapsed.

From the data above, the only significant earthquake before 2006 is 1943 earthquake when about 2.800 houses were collapsed. The 1943 earthquake is believed to be a great quake, however since the houses at that time were mostly constructed by light materials such as wood and bamboo, also the population was still low, the number of casualty was relatively less.

Since gaining independence by 1945 and then specially by 1980s when social economy of the people tends to increase, houses were started to be built by heavy 'expensive' materials such as brick and clay roof tiles which were rarely used before. Unfortunately, this development was done with some limitations both in budget and building technique. The massive construction using heavy materials such as bricks and clay tiles was done by improper construction technique. Confusion between old and new way to construct the houses resulted the mixed practice in building development and as a result causing the weakness of the building structure.

THE REASON OF HIGH FAILURE OF JAVANESE HOUSES IN THE 2006 EARTHQUAKE

Even though the magnitude of the 2006 Java earthquake is not high enough to be stated as a big earthquake, the result was more than enough to be a disaster. In fact, almost all type of the houses had been destructed in various levels including traditional and new houses. Some reasons behind the catastrophe are described as follows.

The Epicenter Was Relatively Very Close and Shallow to The Object of Javanese Houses

According to USGS, the magnitude was 6.2 Ritcher scale and the epicenter was at 7.96°S, 110.46°E with 10 km depth. The epicenter was located in the Opak river estuary around 20 km from Jogjakarta with shallow depth. It means that the source of the quake was on the site of the houses (Bantul district of Jogjakarta). The magnitude would have less meaning if the proximity to the epicenter is also less by means far away from the energy resource. Some other earthquakes actually stroke later such as the 7.0 SR West Java Province on September 2, 2009 with the epicenter distance 195 km from Jakarta and 46.2 km depth under the sea (USGS, 2009a). In this case, it was causing casualties 'only' 57 fatalities and 300 injured from about 10000 damaged houses. This earthquake was also felt from Jogjakarta and Central Java but it has no effect or little, if any, to the buildings there. The other earthquake happened in November 13th with 5.4 SR magnitude 360 km away from Jakarta and 41 km depth (USGS, 2009b). The last quake has no any casualties and building damage. In this matter, the MMI scale is more useful in measuring the effect earthquake to the buildings since it based on the impact in the area. If the 2006 Java earthquake has VIII-IX, while the September 2, 2009 west Java earthquake only VI-VII.

Geological Formation of The Sites Bolstered up The Effect to The Buildings

Instead of spreading to the surrounding site in radial way, the 2006 Java earthquake had different effect in some areas related to the local geological condition. Soft soil easily amplifies shear waves transfer from epicenter. As a result, buildings located near river line or wet land will be affected more. From the 2006 earthquake data, the nearer area of the epicetre, Gunung Kidul has less effect since the ground is more rigid constituted from limestone. In other hand, farer area as Klaten Regency with most wet agricultural soil has more collapsed houses. Unfortunately, as a consequence of agricultural land, Bantul and Klaten have sit on soft soil and will have more threat from earthquake disaster compared to surrounding areas. The wet areas stretched from Bantul to Klaten are also known as Opak vault.

The Affected Areas Have Very High Density of Houses

Java Island in general is the densest population in the world by 979/km². Among of them, Bantul district where collapsed houses were high is the densest area in Java with population of 831,955 living in 226,777 houses in 506.85 km² area or 1641.4/km² of inhabitants and 447.4 houses in every km² (DEPKES, 2007). When the 2006 earthquake stroke, 148,440 out of 218,345 houses (67.9%) in Bantul were non inhabitable or badly damaged and collapsed (BAPPENAS, 2006).

The Houses Structure Was Very Weak and Built Without Earthquake Consideration

According to Boen (2006), the houses collapsed from Java 2006 were mostly built by masonry either with or without reinforced concrete frame. The weak masonry was the main factor to collapse of the building while for the newer with reinforced concrete; improper connection is the most aspect of structural failures. Those structural failures were mainly because of lack in earthquake consideration since 1943 when big earthquake, for the last time, was causing high casualties before it happen again in 2006. The complete examination based on the main three types of Javanese houses will follows in this paper.

Lesson Learnt from The 2006 Java Earthquake

From the 2006 Java earthquake, only less than 3% was involving the failure of traditional houses in all affected areas (BAPPENAS, 2006). In the area of Kota Gede where many traditional houses were settled, from 150 of joglo 21 of them collapsed, 25 severe damaged, and 75 slight damaged (Sinar Harapan, 2007).

In other case, in Banguntapan village of Bantul, 30% of traditional houses were collapsed and damaged from 216 totals of the houses and miraculously only 6 were died from total of 3600 inhabitants (Koran Jakarta, 2009). This less casualty is believed as result of non-heavy materials used in the traditional houses.

The other significant figure involving the traditional wooden structures and masonry houses correlated to the number of victims can be discovered by using the statistical data of the most damaged areas in ten sub-districts of Bantul Jogjakarta (see Table 1). According to the data, the high percentage of victims related to the failure of the buildings was happened in town areas such as Bantul. Beside the area are relatively have higher population, masonry houses were also highly populated. While in village areas such as Piyungan, Pundong, and Sewon were relatively less. Houses so called "semi permanent" building which constructed mostly by wood were easily founded.

Table1. Statistical data of ten most affected areas in Bantul related to the buildings failure and victims

No	Sub-districts	Total Houses*	Total un inhabited buildings	Population	Total Victims***	% victim to population	%victim to uninhabited buildings
1	BAMBANG LIPURO	12394	9319	43,996	548	1.2	5.9
2	BANTUL	17364	12086	60.799	1312	2.2	10.9
3	IMOGIRI	16072	11017	58,482	401	0.7	3.6
4	PLERET	12349	10461	34,600	595	1.7	5.7
5	JETIS	14493	13727	51,083	366	0.7	2.7
6	KRETEK	9573	5746	31.704	869	2.7	15.1
7	PANDAK	13406	8071	49,996	247	0.5	3.1
8	PIYUNGAN	13882	10315	38,911	153	0.4	1.5
9	PUNDONG	10216	8696	32,561	120	0.4	1.4
10	SEWON	29366	16777	79,382	304	0.4	1.8

Note:

* Census data of 2003 PODES multiplied by 1.4 assumption of growth aspect

** uninhabited houses for collapsed and severe damaged houses

*** Victims considered as dead and bad injured

JAVANESE HOUSING DEVELOPMENTS AND ITS VULNERABILITY

In order define the Javanese houses vulnerability, some aspects related to the level of vulnerability should be examined such as dynamic, structure and material (Scawthorn, 2008) which can be related to building type, structural system, building form, and detailed construction on the building.

Building forms in Javanese houses are mainly based on five types of roof configuration, from the simplest to the most complex; *Panggangpe, Kampung, Limasan, Joglo* and *Tajug* (Ismunandar, 1993; Prijotomo, 1984; Dakung, 1981). From these five major types, at least 18 variants can be generated as result of their construction and dimension differences. However, the major three (*Kampung, Limasan* and *Joglo*) of these are the common types. The first one of the five roof configuration (*Panggang-Pe*) is mostly used for temporary construction and the final one (*Tajug*) is only for the important or religious buildings like mosque, temple and graves (Idham, 2006). In other hand, Javanese houses are also can be grouped according the time when the houses were mostly built which are; Pure Traditional, Old Culture, and New Culture.

Traditional Style

This style is purely own by Javanese which is previously known as *Joglo, Limasan*, and *Kampung*. All main structural system members are constructed using any kind of wood including hardwood, coconut palm tree, or bamboo. Wooden plank or woven bamboo is common material used for walls while wooden tiles or thatch was used for roof layer. Nowadays these are very rarely used. Houses are relatively big in size and composed from more than one unit depending on the wealth of the owner.

Figure 1. Original Javanese Joglo, Limasan, and Kampung types with clay roof tile and wooden materials from hard wood to bamboos

In case of dealing with the earthquake, this type of house is proven to be has the least number of casualty since the houses constructed in light weight materials. The changing in roof materials from wooden tiles or thatch to heavier materials such as clay roof tiles somehow decrease its capability to deal with earthquake shake since the center of gravitation of the houses moves upper. In many cases, the material used for wall is also changed with more massive substance such as brick wall. For the latter case called as 'old culture' house type where brick wall is a common to be constructed not only as partition of the rooms but also acting as bearing wall structure.

Old Culture Style

The old culture and new culture are terminologies used by Boen (2008) to distinguish between Dutch colonial era and post independence-modern technique in house construction in Indonesia. Old culture refers to the colonial era when houses mostly use thick bearing wall system and burned clay roof tiles for roofing. In traditional housing, this technique was adopted for constructing Javanese house by changing wooden wall and roof with masonry brick wall and clay roof tiles. However, in general, the forms used were still referring the three traditional house types mentioned above, excluding the houses built by the Dutch themselves.

Figure 2. Old Culture houses; Dutch high pyramidal roof, Javanese Limasan, Javanese Kampung with masonry bearing wall structure

Since these houses are using brick wall instead of wooden plank or woven bamboo, the principle of structure of the houses is then change. If before (in pure tradition houses) the main structure of the houses is flexible post and beam by wooden columns and beams, for old culture houses is somehow as a combination between post-beam and bearing wall structure. Boen (2008) explained that one of the main reasons for weakness of the houses is because of the use of the weak-porous masonry wall. However, the combined construction has made the house structure became complex. If earthquake strike, the proper reaction of the houses are also complicated between flexible and rigid constructions. It is also worsted by the low quality of masonry wall construction. As result, the houses and its parts were easy collapsed and the casualty was high.

Figure 3. Javanese old culture houses collapsed

New Culture Style

Figure 4. New culture types: gable roof with the reinforced concrete frame structure

New culture used for new houses built in recent time. Brick wall combined by reinforced concrete frame structure is the main structural system for the houses. Ceramic roof tiles and floor tiles are common materials used for roof and floor. The size of the houses are mostly smaller than two types before since the trend of big house is decreasing by younger generation which prefer to stay as a single family. The form is also simpler as well.

Unlike the old houses, the new culture has completely different form and structure with the traditional houses. The use of reinforced concrete frame became important although it is not applied correctly or completely for some houses. For many cases, the application of this heavy rigid frame is still done as a wood material e.g. in structural members connection. As result of weak connection between structural members and heavy material used, any shake from earthquake can easily destruct the houses.

Figure 5. Javanese new culture house collapsed

Figure 6. Comparation between still standing combined structure and purely brick wall house

STRUCTURAL ASPECTS

In order to understand the deference between Javanese house types, below is examination from structural point of view. Three Javanese houses Joglo, Limasan, and Kampung are analyzed regarding their strength related to earthquake shakes.

Material Properties and Mechanical Characterization of The Structural Elements

Originally the main material used is wooden post and beams. The main columns in the middle are the most important structure which is called *saka guru*. The saka constitute of four, six, eight of columns depends on the type and the size of the house. The analysis will include the following:

Joglo type:

Four main columns in the middle with most rigid in the top (more horizontal beams).

Limasan type:

Eight main columns in the middle with medium rigid in the top less horizontal beam.

Kampong type:

Eight main columns in the middle with less rigid in the top one horizontal beam.

In this examination the three types will have the same material and the same cross section because the spans are approximately the same, then the comparison between the original construction with the substitute ones (the completely rigid reinforced concrete structural system) will be done.

Wall System

Wall, originally constructed from wooden plank or woven bamboo, but lately changed by brick wall, this was the most suspected one as the main cause for collapse of the houses when the quake stroke. Some of them just fill the brick between the wooden columns, and the rest were just completely remove wooden columns and changed with bearing wall system. The quality of the brick bearing walls is mostly low since the limitations on budget and economical conditions.

The comparison will be done considering the Original wooden wall or woven bamboo in the wooden frame with the Brick wall between the wooden frame, and the Completely bearing wall brick without wooden frame.

Mechanical Characterization

There are essentially three features which influence the mechanical behavior of the timber frames and which have to be evaluated correctly: the connections, the strength of timber and the type of filling.

The behavior of the connections can be considered as a function of the quality of their execution, the material properties and the degree of deterioration. Moreover, the connections introduce a fundamental aspect in terms of the building's seismic behavior, i.e. ductility that acts as a safety valve for the building as it enables dissipation of energy.

The state of deterioration, on the other hand, like the inevitable presence of cracking and strain, is particularly indicative of the degree of uncertainty in any attempt to determine the real behavior of the joints analyzed on a sample timber frame.

Moreover, two factors that depend exclusively on the analyzed methods can also have a considerable influence on the outcomes of the analysis, i.e.

1. the rate of application of the load and the duration of loading;
2. the loading frequency and alternation, if any.

Finally, although it is not part of the load-bearing structure, the filling plays a fundamental role in the global behavior of the building. It is influencing the structural behavior by means of its position, stiffness and strength. Its mechanical characterization proved particularly difficult, however, for at least two reasons, i.e. because its strength and stiffness could not be reliably determined and because it was impossible to schematically reproduce the filling and conditions of constraint between filling and the other structural elements with a sufficient degree of realism.

The stiffness and strength of the three types of wooden frames in withstanding seismic actions depend on the capacity of the filling to brace the structure and on the mechanical and technological features of its internal connections and their ability to assure a plastic, energy dissipating behavior.

Quantifying the lateral stiffness is somewhat complicated, however, because the values being sought depend largely on four fundamental characteristics:

1. The frequency and regularity of the building's internal connections;

2. The repetition of vertical elements in the vertical structures;
3. The presence of filling in the load-bearing wooden frame.
4. The presence of horizontal elements (beams) between the vertical structural elements (columns)

During an earthquake, the filling can collapse while the wooden frame remains standing; deformations and overstrain of weaker parts are not transmitted to the load-bearing structure.

The elements of the building structure can become independently deformed while simultaneously collaborating.

In this study in order to understand the behavior of the three forms, the analysis has been carried out in support of four different forms, which can be characterized as follow:

1. The complete architectural form of the three types without enclosed wall.
2. The complete architectural forms with support walls.
3. The complete architectural forms without the wooden frame; only enclosed walls.
4. The complete architectural forms with concrete frame and enclosed brick walls.

ANALYSIS AND INTERPRETATION OF THE ANALYSIS RESULTS

By using structural computer software the three type forms have been completely analyzed considering all the cases mentioned above, the stress distribution as well as the stability of the forms for each case can be discussed as follow.

The results confirmed the predictions concerning the behavior of the models under seismic action.

Considering the wooden frame without any bracing walls, and by comparing Joglo type with other 2 types it demonstrated greater strength but no change in ductility, because more horizontal beams (most rigid in the top between the central columns).

The filling plays a fundamental role in the global behavior of the three types building, by increasing the strength of the form to resist seismic action, but it decrease the ductility.

By repeating the analysis considering the complete architectural forms including only enclosed walls without the wooden frame. It shows less ductile behavior of the masonry wall than of the enclosed wall with the wooden frame, the buildings behavior was completely brittle (less ductility).

Considering the complete architectural forms with concrete frame and enclosed brick walls. It demonstrated greater strength but change in ductility, in this case the roof system was considered as the traditional one consist of light material (concrete is only the material of the frame).

By considering the results of all cases, it can be shown that the presence of horizontal elements (beams) between the vertical structural elements (columns) plays a fundamental role in the global behavior of the building. It is influencing the structural behavior by means of its position, stiffness and strength.

Focusing on the case with enclosed wall the results indicate that the architectural form can stand against the external seismic loads, by increasing the strength of the form, but it decrease the ductility which means increasing the strength but brittle collapse.

CONCLUDING REMARKS

The factors affecting Javanese houses were easily collapsed in the 2006 earthquake are varying from natural condition, social-economy of the people, and structural-construction technique of the houses. Changing in social-economy means changing in the way people construct their houses. Unfortunately, in the case of Javanese house, introducing new building techniques and building materials are not automatically increase the quality of the houses since the application of the new aspects did not followed correctly. Mixed application between old and new both in housing principle and technique has complicated the houses. As result, the Javanese houses comprised from some types which are different each other related to ability to stand with the quake.

Since the fact that Javanese sites are laid in the earthquake prone area, the only way to save the people is to decrease the vulnerability of the houses. By understanding what houses they have and which one is really fulfill their need is useful in order to avoid the similar disaster in the future.

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THE LOCAL WISDOM EVOCATION AS AN EFFORT OF DISASTER MITIGATION THROUGH STRUCTURAL RELIABILITY OF *JINENG* TRADITIONAL BUILDING IN BALI

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ABSTRACT

Indonesia's location on the edges of the Pacific, Eurasian, and Australian tectonic plates makes it the site of numerous volcanoes and frequent earthquakes. Across its many islands, Indonesia consists of ethnic and culture diversity through differ districts. Cultural difference and local wisdom of every district generates various vernacular building characteristic. Jineng is one of the vernacular Balinese buildings. Its main function as a place to store agricultural products especially rice paddy. In addition, the social function of social status Jineng shows the state of society, both economically and their livelihoods. At present, the system shifts the main livelihood of the agricultural sector to the industrial sector, trade, and others contribute to the transformation of the Jineng main function. The growth of tourism in Bali has become transforming Jineng as a commercial building. Jineng most structural components made of wood/bamboo. In general, wood material density is lighter than concrete or steel structures, tend to be more earthquake proof than the others. The principles of the structure in which one of the ways to reduce the influence of earthquake loads on a structure is to reduce the mass of the structure. However, these conditions tend to contrast to the behavior of structures when viewed against the other lateral load which is wind load. The mass of traditional building structures tend to influence mild effect of wind loads on structures. Assessing the behavior of Jineng structures can be done by various methods including the method of testing full scale building structural model which is made according to the actual size and then performed load testing. Another method that can be used to analyze the numerical simulation by using the software or program structure analysis. Analysis of the structure behavior by numerical simulation methods tend to be more efficient because the time needed is shorter with a cheaper cost. Based on these considerations, the process of behavior analysis performed Jineng structure with numerical analysis methods.

Keywords *: reliability, structure, Jineng, disaster mitigation.*

JINENG TRADITIONAL BUILDING

Jineng is part of the traditional Balinese architecture. Physically functioned as a place to store agricultural products (rice, tuber, chili, etc). In addition, social functions Jineng indicate social status of Balinese society, both economic circumstances and livelihoods. Nowaday, the globalization era gives great influence on the change of principal livelihood system from the agricultural sector into industry, commerce, and others. So that is very influential on core functions. This is also supported by population growth, and the transformation of spaces that used to be where a Jineng function established into commercial buildings.

When Jineng been unable to function optimally as its original function, due to advances in other sectors of agriculture and when the mindset of society which increasingly tends to switch to other sectors, the community is expected to think wisely to the existence of Jineng. The wisdom, in this case is considered that Jineng as an invaluable cultural heritage, and should be maintained, and developed into something more useful and beneficial.

The principal livelihood system changes from agriculture to industry, commerce, etc.; changing storage system from the savings of food materials agricultural products, such as: rice, pulses, cattle, etc into the form of money (banking), are very influential against Jineng principal function, from place to store grains to other functions. The rapid population growth will be followed by the development which is also increase the privacy space requirement while the land has not increased. Its forced the community to utilize where the Jineng space in one dwelling unit established to the other residential buildings. While in urban areas/tourism, land has high economic value, have transform the Jineng space in one dwelling unit to other leasing building. Even with its architectural style, Jineng has a high commercial value as a new residential building as shown Figure 1.

Figure 1. Jineng building in Bali

Jineng Structural Characteristics

Jineng is one of the cultural heritage of Balinese society in the form of a traditional building which originally functioned as a storage of agricultural products of society. However, over the current era of development, utilization Jineng not limited to the functions of storage of agricultural products, but has explored as a residential building.

The Jineng functional changes brings its own impact on Jineng structure characteristics. It is influenced by the changes in assumptions, especially on the loading of building construction upstairs Jineng. However, changes in assumptions loading occurs, does not affect the existing building structure system. Pattern of connections between the pillars and beams of the original pattern is maintained as property. While cross-sectional dimensions of the structure and the type of wood used is adjusted to the needs of building functions to obtain the level of effectiveness and efficiency of the building.

Globally, Jineng have the same structural system characteristics such as the construction of wooden buildings in general. The use of wood as a material of construction material thus has its own characteristics compared to the use of concrete or steel materials. Some characteristics of structures owned by a traditional wood construction, especially Jineng include pedestal structure in which the behavior of columns (pillars) were placed in such a way on the holder (the joints) that causes the behavior of the joint placement on edge part of the column. In addition to placement behavior of joints in the plinth structure, other structural characteristics of Jineng is a pattern of connections between columns with beams. The specific connection patterns that occur between the beams and columns structure raises the clamp on the behavior of beam-column connection. But the behavior that occurs in connection clamp beams and columns of this structure are limited. It is influenced by the behavior of wood that has a low level of elasticity so that when there is deformation caused by loading the structure, the ability of structures return to the initial shape before the deformation is an insignificant factor.

Based on these assumptions, the behavior of structural connections is defined as a limited joint-flops. In addition to placement and behavioral patterns beam-column connection, other structural characteristics of Jineng roof structure (upper structure) which is likely to have a proportion of excess weight compared to the sub structure of the building. Besides the proportion of structures that tend to be heavy, the connection between roof frame with girders (secondary beams) Jineng structure behaves as a joint. Connection pattern in which the roof frame placed above the secondary beams without making a more rigid pattern of connections that led to the join can not accept the influence of moment that happened, so that the joint condition is defined as the connection joints.

TRADITIONAL BUILDING AND ITS STRUCTURAL REALIBILTY

Traditional vernacular building in every district in Indonesia is made by considering strength aspect of building structure that is often called as structure reliability. Structure reliability of the building would give endurance to the lateral load influence such as earthquake load and also wind load. Those aspects become important because Indonesia lies between the Ring of Fire and windy tropical climate which is need correct disaster mitigation effort. In general, earthquake vibrations will affect the building, such as: the force of inertia, which is where the acceleration of land masses caused by the earthquake below the structure/building that caused the building vibrating; bolster building force caused by differences in the rigidity center of mass of the central structure of the earthquake loading.

As the main sanctuary of a traditional society, the existence of traditional building structures must meet the reliability requirements. Reliability of traditional building structures depend on construction system, but also by the use/selection of appropriate building materials. Traditionally, indigenous people in Indonesia tend to use a lightweight structural material such as the use of wood materials as the main frame construction and bamboo as a building roof truss. Thus, material selection has its own benefits related with earthquake-resistant construction. This way construction try to adapt the seismic resistant structural engineering in order to reduce the mass of the structure.

Wood as a Construction Material

Wood is one of the natural structure material that is not homogeneous. That characteristic is influenced by the pattern of growth and environmental conditions that are not often the same growth (Awaludin, 2009). Physical properties and mechanical properties of wood tend to differ in the direction of longitudinal, radial, and tangential. Differences in physical and mechanical properties of wood caused it classified as construction materials those are Ortho-tropics which mean the strength behavior of wood is not the same on each side of the section.

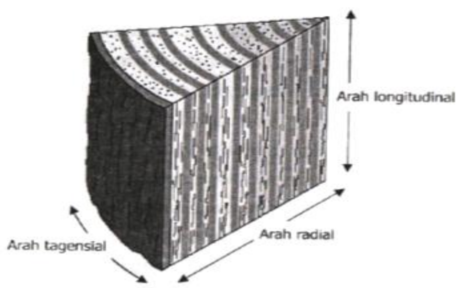

Figure 2. Longitudinal, radial, and tangential direction of the wood

Generally, wood has a low elasticity values compared to concrete or steel material. Its represented by the behavior of large deflection of wood. Under certain conditions, the effect of deflection behavior of wood as a construction material can be limited by adjusting the dimensions of wood.

Bamboo as a Construction Material

Like a wood, bamboo is also a construction material which is not homogeneous. The strength of the wood is not same on each side of the cross section. Bamboo strength to withstand tensile load differs between the inner and outer parts of the stems, whereas the compressive strength of bamboo is different on each segment.

Bamboo is an elastic material, therefore, deflections on a bamboo structure elements tend to be higher (l/20) compared to other construction materials where the deflection occurs not exceed l/300 which "l" is the length of the span. In a study conducted by Morisco in 1994-1999, found that the tensile strength of original bamboo reaches 500 MPa exceeds the yield stress of steel (Morisco, 2006).

SEISMIC LOAD

Earthquake is an incident when the earth release energy where that energy is spread randomly in all directions through the rocks of earth in the form of invicible waves. Activity due to release of energy causes a strong vibration wave on the surface of the earth. This can lead to lateral and vertical load effects on a building structure. The amount of seismic energy received by a building structure is influenced by the distance of the epicenter building (hypocentrum) and its magnitude earthquake that occurred at the location of the epicenter.

Generally, earthquake load acting on the center of mass of a structure, so that the heavier mass of such structures, the influence of earthquake loading will be greater. In traditional building construction, using wood as a structural material provides its own benefits against the effect of seismic load because the weight of a light kind of wood compared to concrete or steel, so the effect of earthquake loads will be smaller as well. In addition to the use of lightweight materials, the impact of the earthquake energy that can also be minimized. One of them by giving freedom of the heavy dots moving in a limited field for the horizontal direction. Behavior of joints that occurs between the surface of the soil column with traditional building structures are expected to provide energy dissipation effects due to earthquake load on the structure so that the effect of seismic load on the structure can be reduced.

In the implementation of numerical simulation using the software, which used an input earthquake load is adjusted to the provisions in ISO-03-1726-2002 on Earthquake Resistance of Planning Procedures For Building. Based on seismic mapping of the area of SNI-03-1726-2002, Indonesia is divided based on six regional seismicity, where the seismic zone I is an earthquake risk area with the lowest while the seismic zone VI is the area with a large earthquake risk. Based on its location, Jineng are in the seismic zone V (Bali Province).

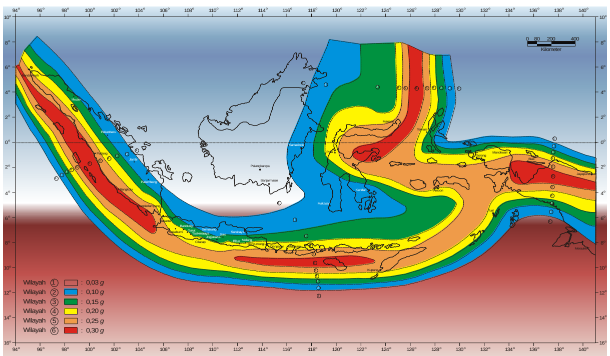

Figure 3. Map of Earthquake Prone Areas in Indonesia

ANALYSIS PROCEDURE

The structure analysis carried out on existing Jineng model using the software. The analysis process begins with designing a model of Jineng structure being analyzed and observed before. The model structure is created in order to form three-dimensional space (3D).

In the process of numerical analysis, Jineng building floor structure elements were analyzed as a unified whole building structure.

The process of structural analysis done by not defining the floor plate as a structural element in the model of Jineng. This is to avoid the behavior that occurs when modeling clamp plate (area) on the beam element structure. For loading behavior that occurs on the floor of the structure of the building is defined as the load is distributed evenly to the floor beam support structure, where previously the definition of loading is done manually by referring to the imposition of Indonesia for the Building Regulations (PPIUG) in 1983.

Furthermore, structural models were analyzed with analysis of spectral response in the form of three-dimensional (3D), where the behavior occurred loading axis is also defined in three dimensions. The analysis process is selected with the intention of getting the structure of behavior and behavior that is more real loading conditions approaching real structural behavior. Results of structural analysis of the forces in will be calculated manually to determine the level of structural stability.

In general, the analysis steps shown in flowchart form as in Figure 4.

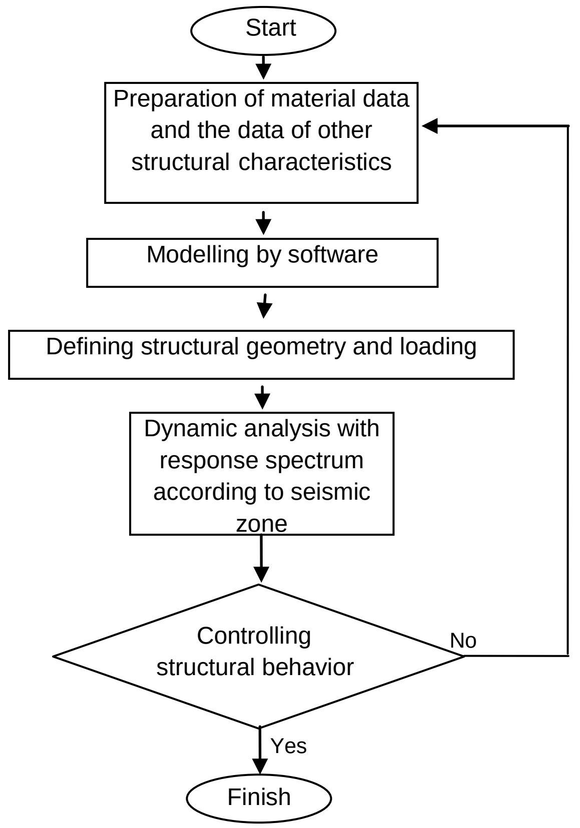

Figure 4. Structural Reliability Analysis Flow Chart

STRUCTURAL LOADING

In the process of structural analysis, the expenses incurred should be considered as ultimate load to include some combination of loading. Here are some of the loading behavior that occurred in the structure Jineng model:

1. Own weight structure

   Own heavy burden incurred structure defined by software to enable automatic self-wights multiplier feature. Own weight the structure is strongly influenced by wood density and dimensions of structural elements used.

2. Live load structure.
   Defining the structure of living expenses necessary to model a multilevel structure by taking assumptions based costing Indonesia Regulation Fees For Building (PPIUG) in 1983. In this analysis process, the live load is assumed as a simple load of residential buildings for which value is taken 125 kg/m².
3. Wind load
   Wind loads that occur in the structure of loading taken under the provisions set forth in Rule Imposition of Indonesia for the Building (PPIUG) in 1983, which incurred a minimum wind load of 25 kg/m².
4. Earthquake load.
   Earthquake load used is the dynamic seismic force response spectrum under the provisions of SNI 03-1726-2002 on Earthquake Resistance of Planning Procedures for Building Construction. In the process of data input seismic load plan, the value of the response spectrum which occurs multiplied by a correction factor of I / R where I is the primacy factor whose value is taken first building to function as a residential building, while the reduction factor R is the representative structure whose value is taken 2.4 to partially ductile structure.

In this numerical simulation process, the jineng building located at seismic zone V. In the process of analysis, which analyzed the structure model is assumed to be at medium soil conditions, so the equation of seismic response spectrum is $c = 0{,}5/T$ for buildings located in seismic zone V. Where C is the seismic design response spectrum and T is the period of seismic design whose value is taken from 0 to 3 seconds with a time interval of 0.1 seconds.

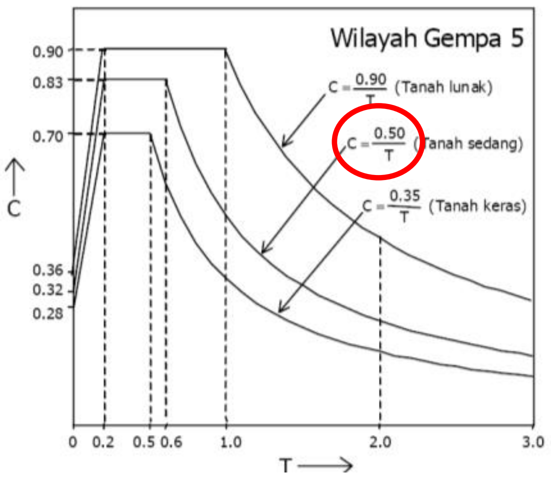

Figure 5. Region V's Earthquake Response Spectrum Equations

Based on the ISO (2002) concerning Planning Procedures Indonesian Wood Construction, the calculation of the forces that occur based on various combinations of loading. Loading combinations that occurred in the wood structure, among others:

1. 1.4 D
2. 1.2 D + 1.6 L + 0.5(La or H)
3. 1.2 D + 1.6 (La or H) + (0.5 L or 0.8 W)
4. 1.2 D + 1.3 W + 0.5 L + 0.5 (La or H)
5. 1.2 D ± 1.0 E + 0.5 L
6. 0.9 D ± (1.3 W or 1.0 E)

which is:

- D : Dead load
- L : Live load
- La : Live load on roof
- H : Rain water load
- W : Wind load
- E : Seismic load

JINENG STRUCTURAL ANALYSIS

The analysis of each model structure by three dimensional analysis where the model was created as a portal frame structure of space. Structural models of dynamic earthquake loading was analyzed by the response spectrum of earthquake region V in accordance with SNI 03-1726-2002. In the process of structural modeling, defining the behavior of the structure and behavior that occurred loading is required. It is intended to obtain the simulation result which approximates the real behavior of such structures.

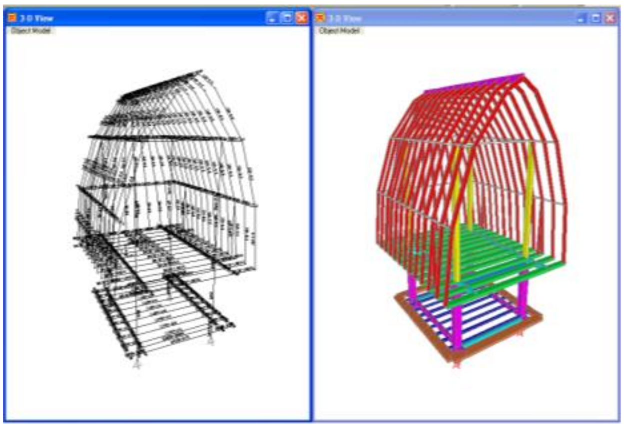

Figure 6. Jineng Building Modeling

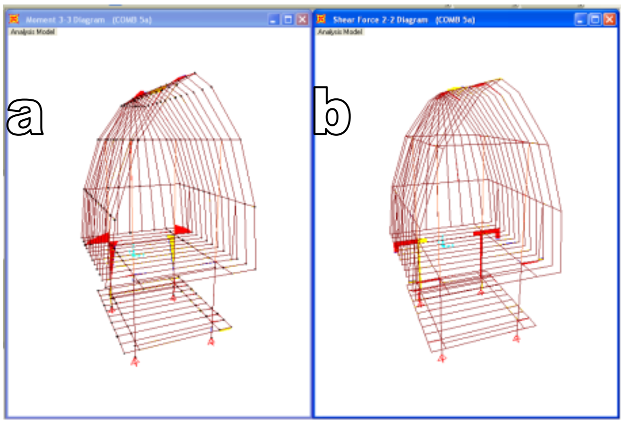

Figure 7. (a). Moment Force caused by the combination of seismic loading.
(b). Slide Force caused by a combination of seismic loading.

Jineng Structural Behavior Definition

In the process of modeling the structure, there are several behavioral models manually defined structures associated structural connection behavior occurs. Several joint behavior that occurs among others:

1. All the joint between the beams and columns (pillars) is defined as a modification of the default joint moment ratio reaches 0.2 release. It is intended that the beam joint connection with the column behaves as a limited-flops joint.
2. All the joint between the secondary beam and roof frame is defined as a joint release by modifying the ratio of joint moment to be 0. Under these conditions, it is expected the joint is only capable of receiving the vertical and horizontal styles without being able to receive the load rotation.
3. The lower deck of Jineng is not defined as an area on the model structure is created, but rather calculated manually as dead weight on the beam structure Jineng. It is intended to avoid the occurrence of the behavior of each joint-flops joint on beam area.
4. Pedestal (restrain) columns (pillars) made as a joint.

Forces Behavior in Jineng Structure

After the entire process of defining the structure and behavior that occurred in Jineng loading, the next stage of analysis performed with the idealization of the structure of DOF's Frame. From the structural analysis process, obtained by the behavior of forces in the structure as shown in Figure 7 and 8.

Based on the results of structural analysis carried out, resulted in several behavioral parameters of the structure to a combination of dynamic loading occurs. The maximum moment of the force structure on elements of the beam structure where the moments that happen secondary beam reached 5.136 kgcm due to a combination of loading 2. The maximum shear force occurred on the same structural elements with shear force reached 162.57 kg. The maximum shear force caused by gravitational loading combination COMBO 2. For maximum axial force occurs at the bottom of the pillars of structural elements with a axial load reached 1222.85 kg caused by a combination of gravity load (dead load and live load).

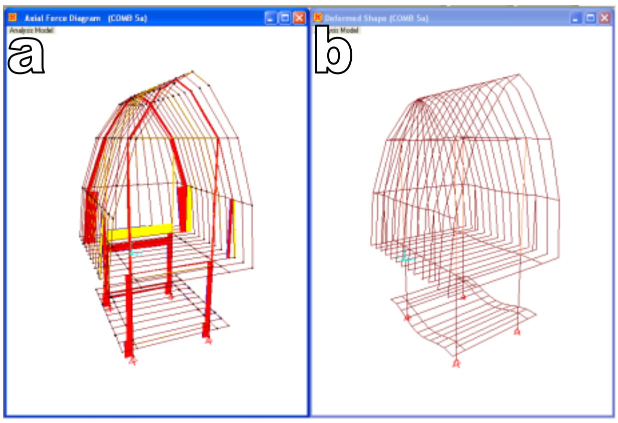

Figure 8. (a). Axial force caused by the combination of seismic loading.
(b). Structural deformation caused by a combination of seismic loading.

Stability Control of Jineng Structural Element

The stability of the structure to the working load can be detected by comparing the behavior of the structure due to the costs incurred in the capacity of the structure itself. Behavior of structures that can be used as a parameter, among other styles and joint displacement in the structure.

On Jineng structural analysis, internal forces caused by controlled loading capacity of timber in accordance with the provisions of the Indonesian National Standard (SNI) in 2002 on the Procedures of the Indonesian Wood Construction Planning.

For structural elements where there is a combination of column bending moments and axial loading press, the stability of structural elements shall be in accordance with the following provisions:

$$\left(\frac{Pu}{\lambda\phi_c p'}\right)^2 + \frac{M_{mx}}{\lambda\phi_b M'_x} + \frac{M_{my}}{\lambda\phi_b M'_y} \leq 1{,}00 \qquad (1)$$

Description:

- Pu : axial force due to loading incurred
- P' : Resistance press corrected for weak axis bending value which is influenced by a column Stability Factor (Cp).
- M_m : Factored moment second-order effect.
- M' : Flexural resistance corrected with a correction factor pivot broad cross section of structural elements C_L.
- ϕ_c : Correction factor, value 0.90
- ϕ_b : Bending correction factor, value 0.85

Secondary beam structural elements are structural experience bending, and therefore control the stability of the structure element is being made by the following equation:

$$M_u \leq \lambda\phi_b M' \qquad (2)$$

Description:

- Mu : Force moments due to occured loading.
- λ : The time factor, its value as 1.
- M' : Flexural resistance corrected with a correction factor pivot broad cross section of structural elements C_L.
- ϕ_b : Bending correction factor, value 0.85.

Jineng shear stability of structural elements is determined according the following equation:

$$V_u \leq \lambda\phi_v V' \qquad (3)$$

Description:

- Vu : Shear force due to dynamic loading occurs.
- λ : The time factor, its value as 1.
- V' : Corrected shear resistance obtained from the shear capacity parallel to grain of wood.
- ϕ_v : Shear correction factor, value 0.75

In addition to the calculation of stability against the forces in that case, the stability of the structure is also reviewed to permit the deflection occurred. Where the control surface deflection that occurred refers to provisions to permit deflection bending rod components in the sheltered construction as follows:

$$\Delta \leq \frac{L}{300} \qquad (4)$$

Description:

- Δ : The maximum deflection occured.
- L : Length of net span reviewed.

Based on the calculation of the stability of structural elements, shows that all Jineng structure elements has a fairly high degree of stability against the influence of loading combinations that occurred, including a combination of seismic loading area V where the structure is located.

CONCLUSIONS

Jineng structural reliability analyzed by a combination of seismic lateral loads that have been determined in the Indonesian National Standard (SNI) on Procedures Wood Construction Planning, obtained results that the model structure Jineng have a fairly high degree of stability to resist earthquake that occurred in the seismic zone V. This is reflected in the calculation of the value of cross resistance of structural elements that are smaller than 1.

This proves that the traditional building with its local wisdom since time immemorial been designed to be able to adapt to the lateral loads that can be experienced as a result of its location in the earthquake prone areas.

Hopefully, next to many more efforts to analyze the reliability of traditional buildings through different aspects.

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TRANSMISSION LOSS (TL) VALUES OF WALL PANEL CONSTRUCTED FROM PADDY-STRAWS

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ABSTRACT

A series of experimental study has been conducted to seek possibility in using paddy-straws - disposed materials of paddy plants - to be constructed as wall panels. The panel is aimed to improve sound insulation of building vertical elements regarding traffic noise issues in Indonesia. Paddy-straw is chosen as main materials to construct wall panels caused by its affluence and consideration of green materials. A pre-research has been carried out to seek suitable straw types and the most effective process of lamination. Earlier research has also reported that the panels complied with compression strength test.
The study that will be reported here is regarding its acoustic qualification to perform as sound insulation elements. The Transmission Loss (TL) test was carried out in standardized testing chambers in National University of Singapore. However, as difficulty arises in transporting panels of 10,25 mm2 as is required by the standard, a testing method known as composite wall method was conducted. The investigation and calculation showed that paddy-straws panels may provide TL of minimum 9,2 dB refers to centre band frequency of 500 Hz and varies accordingly to 1/3 octave band frequencies. This value is regarded as significant in order to provide quieter indoor environment.

Keywords: *paddy-straws, wall-panels, composite wall, transmission loss*

INTRODUCTION

Environmental noise pollution which predominantly caused by aggravation of traffic noise has placed building inhabitants as 'noise victims'. This is experienced by inhabitants of buildings in Indonesian busy cities. In this case, the use of high quality building materials entitling of sound insulation capability is of importance. However, lack of knowledge on noise impact on life and low revenue, put most Indonesians to employ ordinary building materials with poor sound insulation.

The wall panels constructed from paddy-straws that have gone through a series of preliminary studies is aimed to improve insulation values of building elements ordinarily used. Compared to floor and ceiling/roof, wall is a building element that is readily exposed to noise. In the case when walls having poor insulation values, attachment of additional wall panels that may increase the insulation values is substantial. In Indonesia, ordinary wall constructed from red-bricks (less dense compared to those used in developed country) offers insulation of approximately 30 to 40 dB only (Mediastika, 2000). This is considered insufficient compared to the surrounding noise which could reach up to 80 dB (Mediastika, 2000). There is a vast array of wall panels available in the market, but normally they are of high quality acoustic panels which correlate to the price. These types of panels assure sufficient insulation values, but not affordable to low-cost building. Hence, the availability of low price wall panels in the market becoming significant.

Paddy-straws, waste materials of paddy plants, are considered very potential raw materials. The potency is in the aired hollow within the straws, which naturally creates air gaps when go through lamination as a panel (Mediastika, 2007). This is match to the theory of wave-refraction, whereby sound intrusion is lowered when refraction is maximized. In ordinary walling construction, this is complied by air gap formed between two or more material layers (refer to Fig 1).

In Indonesian villages, as waste product, paddy-straws are commonly used for cattle food-supply or during incineration process of red-brick making. In fact, in developed countries, straws have been utilized for building materials. However, concerning climatic issues of warm humid, it is considered rather impossible to use paddy-straws as it is, since the climate will easily decompose them to turn into non-durable materials. Fortunately, this is not the case of temperate climates, where straws can be readily constructed as straw bales (Lacinsky and Bergeron, 2000).

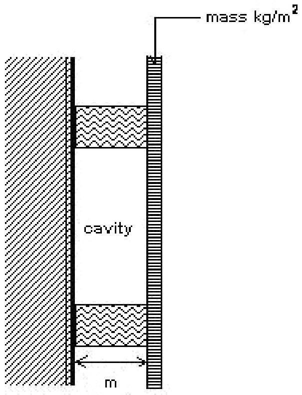

Figure 1. Ordinary wall panel attached to main wall with air gap to gain better sound insulation

Another challenge in using paddy-straws is limitation of information and technology among most Indonesian, which lead them in to questioning the strength, durability and performance of this waste. In this early stage, the panels will only be constructed as for non-structural wall which is attached to the main wall. The attachment is aimed to improve insulation values of ordinary wall, which in Indonesia is mostly formed by grey bricks (less dense concretes) and red bricks (less dense compared to red bricks utilized in developed countries). Beside consideration of cost and potency, the use of paddy-straws may also as one solution toward green building issues by reuse and recycling waste materials.

THEORETICAL APPROACH

An ideal insulator must comply with aspect of mass/density, thickness, and homogeneity (Freeborn and Turner, 1988/1989). The more mass/density of materials, the thicker the materials, and the more homogeny with no holes and crack of the materials, the better insulation will be provided. Aspect of material thickness is not always gained by the material it self, but can be substitute by the presence of air gap between two or more material layers. Many research concluded that air gap between layers will increase sound insulation capability of materials than the thickness of material itself (Templeton and Saunders, 1987). This is caused by effect of refraction, i.e. bending of sound wave motion while entering materials with different densities (refer to Fig 2). The more bending on sound wave motion, the more energy of sound is reduced, thus less energy to be transmitted over the materials. Air gap which naturally found within paddy- straws is the main aspect while considering straws as raw materials for acoustic wall-panels.

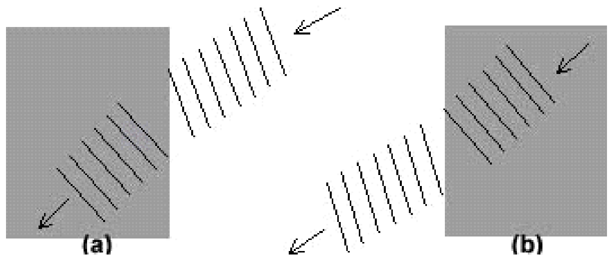

Figure 2. Sound wave refraction, bending downward while entering more dense material (a) and bending upward while entering less dense material (b). Air gaps within layers will maximise wave refraction.

METHODS

Pre-experiment on Straw Characteristics

Prior to the main experiment, a series of pre-experiment has been conducted, i.e. experiment to seek the most suitable straw characteristic to go into panel lamination and experiment to seek effective proportion of adhesive substance for panel lamination. The experiments use trial and error approach.

There is a vast variety of paddy plants. Referring to the origin, it is grouped into two-main, i.e. local paddy and cross-fertilization paddy. According to field conditions, it is also grouped into two-main, i.e. planted in more watering field and less watering field. Whilst according to rice characteristics, it is grouped into two-main, i.e. non-sticky rice and sticky rice (AKK, 1990). All these types of paddy-straws went into pre-lamination process and mixed with adhesive substances. This process reported that local paddy-straw is too soft, thus losing air gaps while being pressed during lamination. Whilst, cross-fertilization paddy-straw is capable to maintain the air gap and thus resulting panels as expected. The less watering paddy is too hard to be laminated thus resulting untidy and fragile panels. This is also the case of sticky rice straws. This pre-experiment concluded that cross-fertilization paddy-straws (which is in coincidence also more watering and non sticky rice), performed better as raw material to construct wall panels compared to the rest types of paddy-straws (Mediastika, 2006). Prior to lamination process, the straws have to be cleaned by water and then dry under the sunlight in order to kill germ and fungus.

Pre-experiment on Laminationn Process

At second stage, pre-experiment for lamination process was carried out. In response to climatic issue and ease of utilization, paddy-straws are not being used as it is, but be bounded together with adhesive substances and formed into a panel shape. This process is defined as lamination. There is vast variety of adhesive substance in the market, grouped as natural and synthetic adhesive, but whilst the aim of composing paddy-straw panels is to provide low-price materials, the use of high cost adhesive will be neglected. A moderate price adhesive substance for building construction that is widely available is cement powder and gypsum powder. Since both of them are powdered adhesive, a proportion of water has to be added carefully prior to mixing process (Mediastika, 2006).

Beforehand, critical characteristic of paddy-straw was scrutinized. This leads to conclusion on the best characteristic of each element to perform the best mixture for lamination, i.e. straws should be slightly moisturized, adhesive powder should also be in the exact ratio to the straws, which then be sprayed on to the moisturized straws. The best volume ratio between water: adhesive: straws is 1,5: 1: 3. When the three are mixed evenly, it then goes to lamination tray for 2x 24 hours and dry out of direct sunlight for approximately 14 days to be fully dry and ready for use. The fully dryness of panels is significant to minimize the presence of fungus that will decompose straws and decrease panel performance. Drying the panel out of direct sunlight is also important to avoid sudden drying that will cause panels to become fragile.

Compression Strength Test

There is no definite standard of compression strength (CS) when the panel is not aimed to be structural component as is panel of this study. However, CS test was once conducted to see capability of the panels to carry and maintain its own weight, i.e. for packaging and transporting, toward application as a construction material. Standard of General Regulation of Concrete Construction in Indonesia (*Peraturan Umum Beton Indonesia tahun* 1982) is use merely as a comparison. The test showed that laminated paddy straws have CS value of approximately 15 N/mm2 as the maximum, when the best mixture ratio is applied (Mediastika, 2006).

TL TEST AND DISCUSSION

Since the panels are aimed to improve insulation values of ordinarily employed walls, acoustic test regarding its insulation values is substantial. The insulation test or transmission loss test (TL test) was carried out in National University of Singapore, which is located within Department of Buildings, Faculty of School of Design and Environment. The rooms are standardized (ASTM E90-04 and ISO 140-3). According to ISO (ISO 140-3 part. 5.2.1) the specimen to be tested should be in 10 m^2 dimension with the shorter edge length not less than 2.3 m. The panel is to be installed between two testing chambers. However, there was problem arises in transporting such panel of 10 m^2 from Indonesia to Singapore. Besides, the panels itself is not designed as a structural ones that can be erected solely. A testing and calculation method known as composite wall is then utilized. At first, a double-layer gypsum panels filled with rock wool was tested for its TL values (refer to ASTM E90-04). It is known as filler wall. The values gained from the test are presented in Table 1.

Table1. TL values of the filler wall (two layer gypsum panels)

Freq (Hz)	TL_f values (dB)
100	25.9
125	34.6
160	37.4
200	41.2
250	41.8
315	44.5
400	48.7
500	52.0
630	54.2
800	57.3
1000	59.6
1250	60.5
1600	57.8
2000	54.2
2500	55.5
3150	58.5
4000	58.6
5000	58.1

The gypsum panels were then drilled in to dimension of 300 mm x 400 mm to put the paddy panels within. This is specific to the size of the prepared paddy panels (refer to Figure 3a).

Two layers of paddy-straws panels (each of 30 mm thickness) are put side by side in the hole to match exactly with the thickness of the rock wool filling. Once the paddy-panels were placed, the tiny leakage forming along side was filled with rock wool floss (refer to Figure 3b). The paddy-panel is known as specimen wall.

Figure 3a. Hole of dimension of 400 mm x 300mm was made on the existing filler wall (i.e. gypsum walls)

Figure 3b. Two layers of paddy-straws panels was put side by side, the tiny cavity gap between panels and wall were filled with rock wool floss to sealed it

Figure 3c. Perspective view of the composite wall with the specimen within

Paddy panels that stays within gypsum panels forming a composite walls. The composite walls was then measured for its TL values (refer to ASTM E90-04).

Table 2. TL values of the composite wall

Freq (Hz)	TL_c values (dB)
100	26.8
125	28.7
160	28.9
200	31.7
250	31.0
315	31.9
400	29.8
500	28.5
630	29.3
800	29.7
1000	30.2
1250	31.0
1600	32.9
2000	34.4
2500	36.3
3150	38.8
4000	41.6
5000	45.4

From TL values found for both filler and composite wall, TL value of the specimen (i.e. paddy-panels) then can be calculated using formula as follows (after ASTM E90-04):

$$\tau_c = \frac{\tau_f S_f + \tau_s S_s}{S_f + S_s} \quad (1)$$

where $$TL_c = 10 \log \frac{1}{\tau_c} \quad (2)$$

and where:

τ_c *is sound transmission coefficient of composite wall*

τ_f *is sound transmission coefficient of filler wall (i.e. gypsum wall),*

τ_s *is sound transmission coefficient of test specimen (i.e. paddy-panel),*

S_f *is area of filler wall (after test specimen is attached, i.e. 10,25 m^2-0,12 m^2=10,13 m^2,*

S_s *is area of test specimen (i.e. paddy-panel of 0,12 m^2),*

TL_c *is transmission loss of composite wall.*

To calculate TL_s of specimen, first we need to calculate τ_s, which is done by the following steps. For instance, calculate a τ_f value referring to 500 Hz sound frequency on Table 1:

$$TL_f = 10 \log \frac{1}{\tau_f} \quad (3)$$

$$52 = 10\log\frac{1}{\tau_f}$$

$$\tau_f = 6.3\times10^{-6}$$

Then, referring to 500 Hz sound frequency on Table 3, calculate τ_C as follows:

$$TL_c = 10\log\frac{1}{\tau_c} \tag{4}$$

$$28.5 = 10\log\frac{1}{\tau_c}$$

$$\tau_c = 1.4\times10^{-3}$$

Using the above result, τ_S (specimen) can be calculated as follows:

$$\tau_c = \frac{\tau_f S_f + \tau_s S_s}{S_f + S_s} \tag{5}$$

$$1.4\times10^{-3} = \frac{(6.3\times10^{-6}\times10.13) + (\tau_s\times0.12)}{10.13+0.12}$$

$$\tau_s = 0.120$$

Thus, TL_s is found by the following:

$$TL_s = 10\log\frac{1}{\tau_s} \tag{6}$$

$$TL_s = 10\log\frac{1}{0.120}$$

$$TL_s = 9.2\ (refer\ \ to\ \ 500\ Hz)$$

By using similar steps, TL values of the specimen for 1/3 octave band frequency may also be calculated, which is presented in Table 3
.

Table 3. Compilation of TL values of the filler wall and composite wall to calculate TL of paddy-straws panel

Freq (Hz)	TL_f (dB)	TL_c (dB)	τ_f	τ_c	τ_s	TL_s (dB)
100	25.9	26.8	0.00257	0.00209	-0.02889	-
125	34.6	28.7	0.00035	0.00135	0.064466	11.90673
160	37.4	28.9	0.00018	0.00129	0.094677	10.23756
200	41.2	31.7	7.6E-05	0.00068	0.051345	12.89502
250	41.8	31.0	6.6E-05	0.00079	0.062272	12.05707
315	44.5	31.9	3.5E-05	0.00065	0.052154	12.82712
400	48.7	29.8	1.3E-05	0.00105	0.088303	10.47268
500	52.0	28.5	6.3E-06	0.00141	0.120122	9.192383
630	54.2	29.3	3.8E-06	0.00117	0.100035	10.00272

Table 3. (Continued)

Freq (Hz)	TL_f (dB)	TL_c (dB)	τ_f	τ_c	τ_s	TL_s (dB)
800	57.3	29.7	1.9E-06	0.00107	0.091368	10.39074
1000	59.6	30.2	1.1E-06	0.00095	0.081480	10.90734
1250	60.5	31.0	8.9E-07	0.00079	0.067774	11.70830
1600	57.8	32.9	1.7E-06	0.00051	0.043667	13.60887
2000	54.2	34.4	3.8E-06	0.00036	0.030692	15.12155
2500	55.5	36.3	2.8E-06	0.00023	0.019786	17.06730
3150	58.5	38.8	1.4E-06	0.00013	0.011141	19.54514
4000	58.6	41.6	1.4E-06	6.9E-05	0.005793	22.29608
5000	58.1	45.4	1.5E-06	2.9E-05	0.002333	26.32085

From the value of τ_S presented in Table 3, referring to ASTM standard test method for laboratory measurement of airborne sound Transmission Loss (TL) of Building Partitions and Elements (E90-04) some corrections must be made when there is particular difference of log ($\tau_c S_c$) − 10 log ($\tau_f S_f$), as follows:

1. when the difference is more than 15 dB, calculate τ_S from Eq 1 ignoring the term $\tau_f S_f$,
2. when the difference is between 6 and 15 dB, calculate τ_S using Eq 1. This corrects for transmission through the filler wall (i.e.gypsum wall),
3. when the difference is less than 6 dB, reliable corrections cannot be made. Calculate τ_S from Eq 1 ignoring the term $\tau_f S_f$. Multiply the values obtained by 0.75 and then use Eq 2 to calculate a lower limit for the transmission loss of the test specimen. (This is equivalent to limiting the difference to 6 dB).

For the values presented in Table 3, some correction has been made according to the above guidelines, and the TL values of the paddy-panel which are shown have referred to the guidelines.

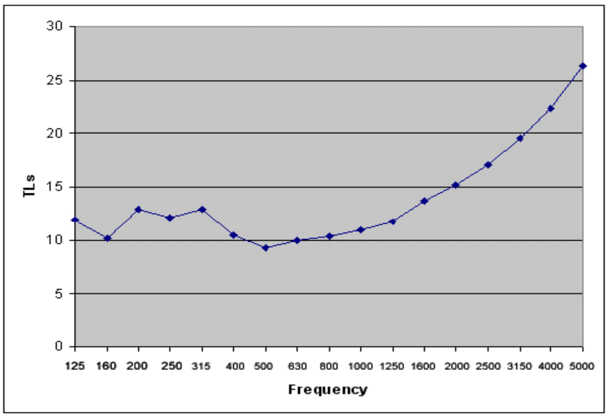

Figure 4. TL values of paddy-straws panel to frequency respectively

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

From Table 3 and Figure 4, we learn that paddy-panels offer higher TL values for high sound frequency and reach it maximum at centered band frequency of 5000 Hz. In opposite, TL value is lowest at frequency of 500 Hz, and remains similarly of 10 to 12 dB for frequency of 125 Hz to 1250 Hz. If the specimens have the same behavior when used in field, then attachment of this specimen to the main wall may increase TL value by approximately 10 dB (in general). The increase in 10 dB will provide quieter indoor environment (Mediastika, 2000).

The indirect calculation method of composite wall to calculate TL value of research specimen is widely used and is assumed to be valid. However, it will be ideal if this research can also proved the validity, i.e. by testing another layer of the specimen (added to those of the previous two layers that have been tested). If by putting this third layer we can achieve approximately 4 to 6 dB improvements, then we can more or less confirm the validity and accuracy of this method.

Unfortunately, within limited time and resources, it is considered impossible to do more testing and calculations at this moment of research. Therefore, it is recommendation for further research to carry on this task.

ACKNOWLEDGEMENT

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ESTIMATING GROUND SETTLEMENT POST-LIQUEFACTION USING CPT

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ABSTRACT

The Universitas Muhammadiyah Yogyakarta (UMY) campus is constructed on 28 hectares which are mostly rested on a sand deposit layer and the ground water table was shallow relatively. During earthquake on May 27, 2006, a magnitude of 6.3 struck the Special Province of Yogyakarta resulted in a number of seismic damages were reported. The damages were identified because of liquefaction phenomena during the ground vibration. Reconnaissance study after the earthquake was found some sand boiling sites near the mosque and library buildings. This paper presents liquefaction evaluation and estimation of liquefaction-induced settlement at those buildings. The liquefaction analysis was based upon force equilibrium concept using cone penetration test (CPT) method. The ground settlement is calculated from CPT data which were collected from 9 testing sites at those studied area. The computation showed that the ground accelerations affected more than 50% of top sand layer liquefied at the Library Building. In general, the estimated ground settlement ranged from 2.5 cm to 13.5 cm in hazard area. The results imply that ground improvement should be applied to reduce the effect of liquefaction-induced ground settlement. After three days of lime-column intallation, the settlement is lower that the tolerable settlement.

Keywords: *earthquake, liquefaction, sand, settlement, CPT*

INTRODUCTION

The Universitas Muhammadiyah Yogyakarta (UMY) campus was constructed on 28 hectare which mostly rested on a sand deposit layer and the ground water table was shallow relatively. Theoretically, the site was susceptible to liquefaction during ground-shaking. During earthquake on May 27, 2006, a magnitude M_w 6.3 struck the provinces of Yogyakarta, among those number of seismic damages were reported. The damages were identified because of liquefaction phenomena during the ground vibration. Reconnaissance study after the earthquake was found some sand boiling sites near the Masjid and Library building. This paper presents liquefaction evaluation and estimation of liquefaction-induced settlement at those building.

Liquefaction-induced ground settlements are essentially vertical deformations of surficial soil layers caused by the densification and compaction of loose granular soils following earthquake loading. Several methods have been proposed to calculate liquefaction-induced ground deformations (Tokimatsu and Seed, 1987; Zhang et al., 2002; Ishihara and Yosemine, 1992). This paper present an estimated liquefaction-induces ground settlement by using the method proposed by Zhang et al. (2002). Ground improvement technique by using lime-column (LC) is also introduced to reduce settlement. Trial-field test of LC is presented in this paper.

METHOD OF ANALYSIS

Site Characteristics

Based on the CPT site investigation report, the campus of UMY is covered by 8 m to 10 m thick sandy soil layers. Loose sand layer generally appears at the depth from 3 m to 10 m. The ground water table is at the depth of 0.5 m to 1.0 m. The particle size distribution curves of sites are presented in Figure 1. The average particle diameter D_{50} of the soil samples range of D_{50} was between 0.057 mm – 0.841 mm (the mean and variance value was 0.57 mm and 0.054 mm, respectively). Comparing the particle size distribution with the other case histories, it can be concluded from Figure 1 that the studied site is susceptible to liquefaction.

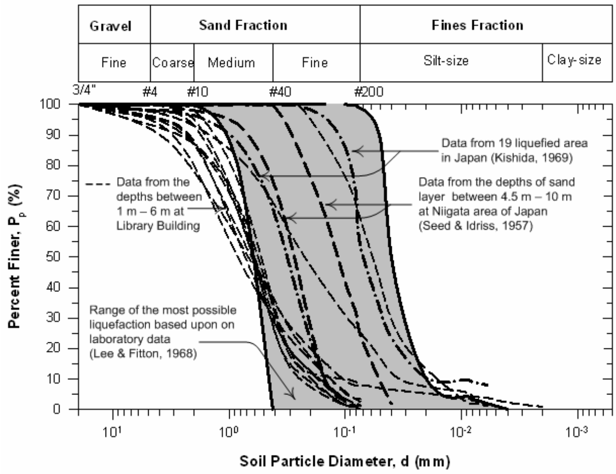

Figure 1. Particle size distribution at the hazard area

Based on the previous investigation carried out by Muntohar (2009), the critical accelerations ranges from 0.34g to 0.69g will generate liquefactions in all depth of loose sand layers in hazard areas.

Liquefaction Analysis

Calculation, or estimation, of two variables is required for evaluation of liquefaction resistance of soils: (1) the seismic demand on a soil layer, expressed in terms of cyclic stress ratio (CSR) to generate liquefaction; and (2) the capacity of the soil to resist liquefaction, expressed in terms of cyclic resistance ratio (CRR). The approach requires an estimate of the CSR profile caused by a design earthquake. A simplified method to estimate CSR was also developed by Seed and Idriss (1971) based on the peak ground surface acceleration (a_{max}) at the site. This simplified approach can be summarized as follows:

$$CSR = \frac{\tau_{av}}{\sigma'_{vo}} = 0,65\left(\frac{a_{\max}}{g}\right)\cdot\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right)\cdot r_d \quad .0\text{-}9\text{-}1 \qquad (1)$$

where τ_{av} is the average cyclic shear stress; $a_{\max}$ is the maximum horizontal acceleration at the ground surface; g = 9.81 m/s^2 is the acceleration due to gravity; σ_{vo} and σ'_{vo} are the total and effective vertical overburden stresses, respectively; and r_d is a stress-reduction factor which is dependent on depth. The factor r_d can be estimating using the following bi-linear function, which provides a good fit to the average of the suggested range in r_d originally proposed by Seed and Idriss [2], that is

$$r_d = \begin{cases} 1-0,00765z & ;\text{ if } z < 9,15\text{ m} \\ 1,174-0,0267z & ;\text{ if } 9,15 \le z \le 23\text{ m} \end{cases} \qquad (2)$$

By using the CPT data, the estimated CRR was calculated from Robertson and Campanella (1985). The flow chart for calculation is shown in Figure 1. The factor of safely against liquefaction (FS_L) is defined as:

$$FS_L = \frac{CRR_{7.5}}{CSR}\cdot MSF \qquad (3)$$

where MSF is the Magnitude Scaling Factor to convert the $CRR_{7.5}$ for M = 7.5 to the equivalent CRR for the design earthquake. The recommended MSF is given by:

$$MSF = \frac{174}{M_w^{2.56}} \qquad (4)$$

The equation (4) is based on the NCEER Workshop in 1996 (Youd et al., 2001).

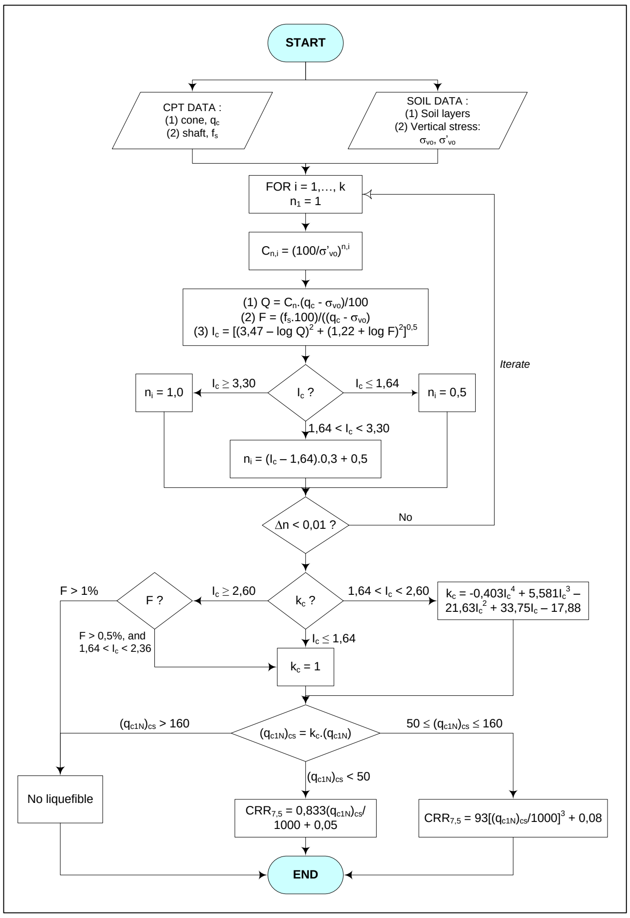

Figure 2. CRR estimation from CPT (Modified after Robertson and Campanella, 1983)

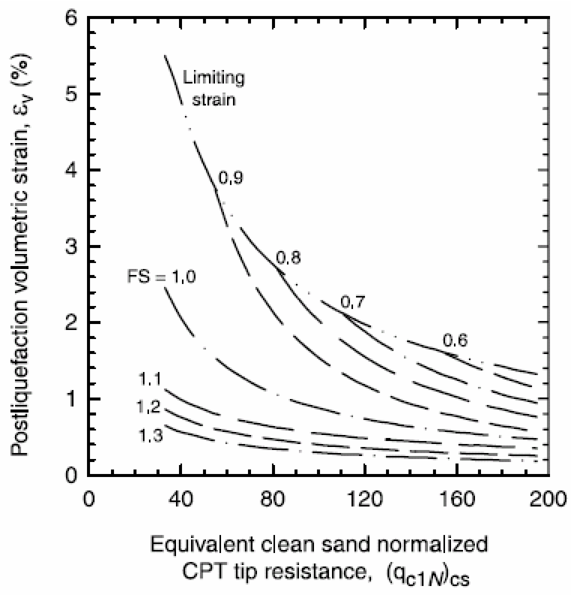

Figure 3. Relationship between postliquefaction volumetric strain and equivalent normalized CPT tip resistance for different factors of safety (Zhang et al., 2002)

Ground Settlement Estimation

The ground settlement for level ground can be estimated by using the following equation:

$$S = \sum_{i=1}^{j} \varepsilon_{v_i} \Delta z_i \qquad (5)$$

where S is the calculated liquefaction-induced ground settlement at the CPT location; ε_{vi} is the postliquefaction volumetric strain for the soil sublayer i; Δz_i is the thickness of the sublayer i; and j is the number of soil sublayers.

The post-liquefaction volumetric strain is estimated by semi empirical equation. The equation correlates $(q_{c1N})_{cs}$ and postliquefaction volumetric strain (ε_v) for different FS_L. The correlation is shown graphically in Figure 3.

RESULTS AND DISCUSSION

The liquefaction analysis is based upon force equilibrium concept using Robertson and Campanella (1985) method. The ground settlement is calculated from cone penetration test data which is collected from 9 testing sites at library buiding. The result of the calculated settlement, for the instance at SB1 point of Library area, is shown in Figure 4. The varation of the estimated ground settlement is shown in Figure 5. For each tested sites, the maximum settlement at ground surface is presented in detail in Table 1.

Table 1 Estimated ground settlement

Location	SB1	SB2	SB3	SB4	SB5
a_{max} (g)	0.43	0.57	0.56	0.27	0.43
S (cm)	2.5	10.5	2.7	11.4	12.2
Location	SB6	SB7	SB8	SB9	
a_{max} (g)	0.54	0.39	0.42	0.53	
S (cm)	4.6	4.7	7.1	13.5	

Note: the a_{max} used in this study is the average value at each tested CPT location

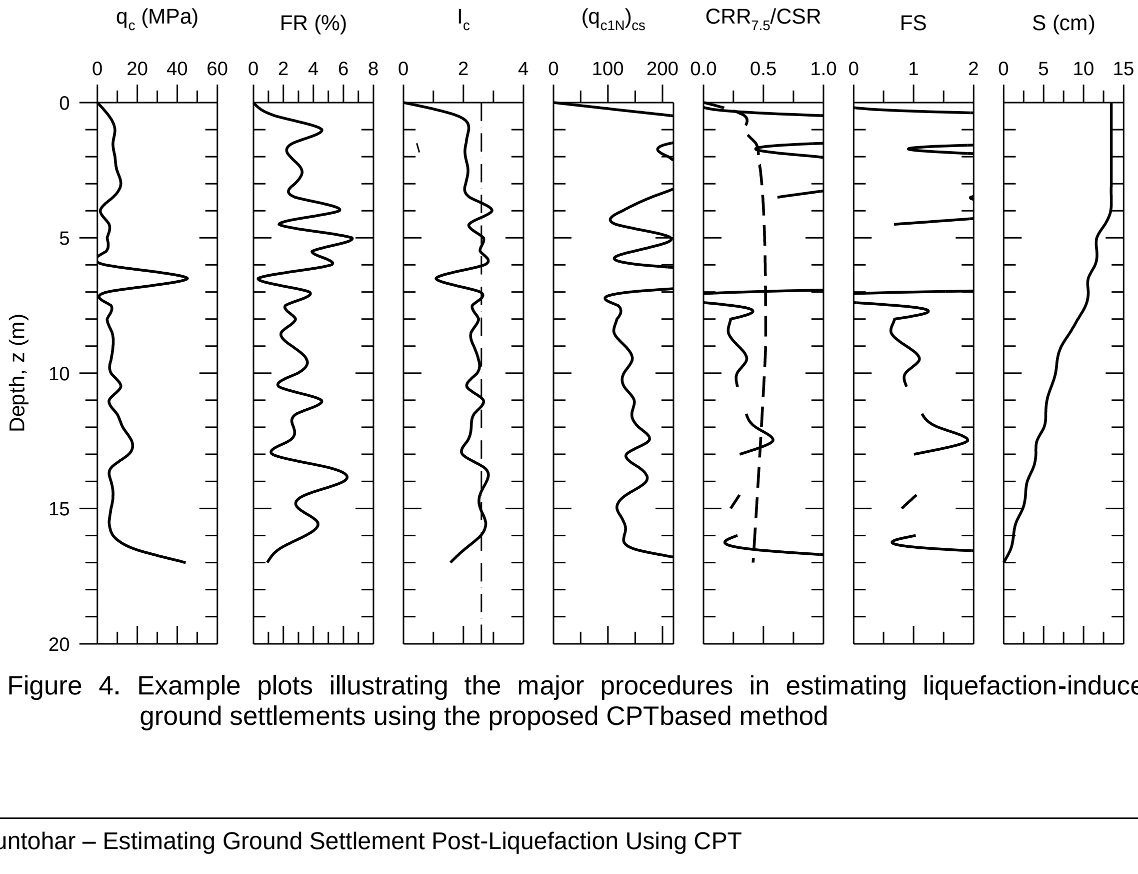

Figure 4. Example plots illustrating the major procedures in estimating liquefaction-induced ground settlements using the proposed CPTbased method

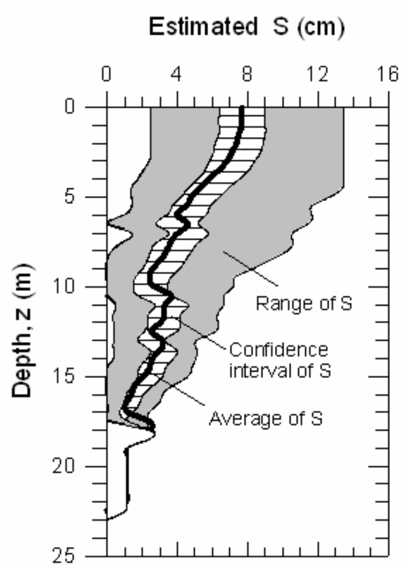

Figure 5. Variation of estimated ground settlement with depth.

In general, the estimated ground settlement ranges from 2.5 cm to 13.5 cm. The maximum settlement occurs at the surface up to 3 m of sub surface (see Figure 5). According tothe criteria of Terzaghi et al. (1996), the allowable settlement of foundation is 2 cm for diffential settlement and 2.5 cm for total settlement. The results imply that ground improvement should be applied to reduce the effect of liquefaction-induced ground settlement.

A lime-column method was applied for trial-test at the field. The diameter and length of column was designed to 6 inch and 2 m respectively. After installation of the lime column, the ground settlement at the trial-test point is estimated to diminish. The estimated ground settlement is shown in Figure 6.

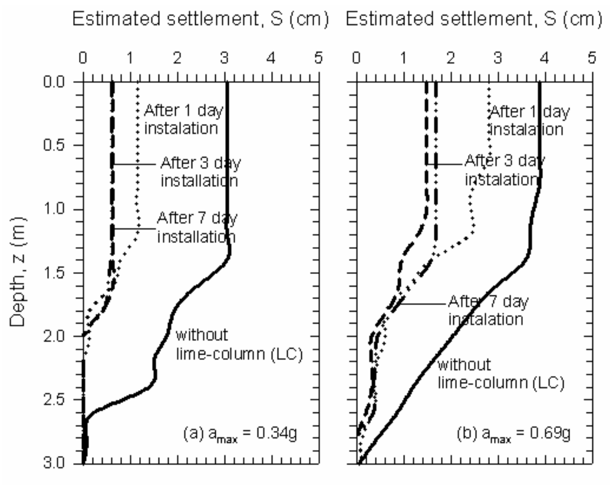

Figure 6. Estimated ground settlement before and after LC intallation (a) a_{max} = 0.34g, (b) a_{max} = 0.69g

Calculation results in Figure 6 show that installation of lime column reduces significantly the ground settlement. The settlement is observed, from Figure 6, to decrease in associated with the age of lime column. After one day of installation, the ground settlement decrease to about 1 cm and 2.8 cm for a_{max} = 0.34 g and 0.69 g respectively. In general, after three days of intallation the settlement is lower that the tolerable settlement. This result indicates that lime-column technique play a significant role to reduce liquefaction-induced ground settlement.

CONCLUDING REMARKS

The computation shows that the ground accelerations will make more than 50% of top sand layer liquefied at Library building. In general, the estimated ground settlement ranges from 2.5 cm to 13.5 cm at the hazard area. The results imply that ground improvement should be applied to reduce the effect of liquefaction-induced ground settlement. After three days of intallation the settlement is lower that the tolerable settlement. This result indicates that lime-column technique play a significant role to reduce liquefaction-induced ground settlement.

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NONLINEAR RESPONSE OF SOIL-STRUCTURE-INTERACTION DUE TO CYCLIC LOADING

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ABSTRACT

It has been proven in previous studies that soil is actually nonlinear. Numerous studies have previously been performed experimentally and numerically. Development of a nonlinear model for static soil conditions to cyclic nonlinear soil model plus the implementation for Gravity structure are included in this study. This study explains and develops a model for the influence of the nonlinear soil characteristic towards soil-foundation-structure interaction system in Gravity structure. Gravity soil structure interaction model simulation shows that soil nonlinear behavior has a significant effect to horizontal foundation response.

Keywords: *soil structure interaction due to cyclic loading, nonlinear soil behavior effect*

INTRODUCTION

It was many studies conducted by researchers, both experimental and numerically. However, these studies were still limited to static loading conditions.

This study investigates the development of constitutive law of the nonlinear soil under static load incorporated into the constitutive law of the nonlinear soil under cyclic load.

Response of soil-structure interaction system, where the soil has nonlinear behavior under cyclic loading, was carried out numerically by incremental Newmark method, whereas problem solving of nonlinear soil was done by modification of Newton-Raphson method.

BACKGROUND

Soil Strucutre Interaction System

The equation of motion system foundation soil structure interaction (FSSI) for continuous structure of Nataraja and Kirk (1977) is the equation of motion in matrix form with lumped parameter idealization as,

$$[M]\{\ddot{q}\} + [C]\{\dot{q}\} + [K]\{q\} = \{P(t)\} \quad (1)$$

where $[M]$, $[C]$ and $[K]$ denotes the system mass, equivalent viscous damping, and stiffness matrices respectively and $\{q\}$ represents the generalized coordinates in vertical plane parallel to the direction of the dynamic load $\{P(t)\}$. Although this is not rigorous but is is quite accurate.

The structure–foundation dynamic model is illustrated in Figure 1.

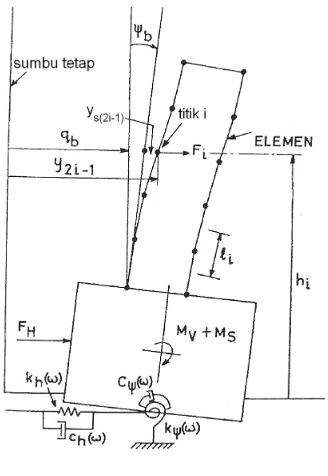


Figure 1. Structure-foundation dynamic model (Nataraja, at.al., 1977)

The equation was derived by considering that the total deformations y are a combination of the elastic deflections and rotations, y_s of upper structure relative to the foundation, and the rigid body motion of, q_b and ψ_b of the foundation. The total deflections are given by the following equation (see Figure 1)

$$y(i-1) = y_s(i-1) + q_b + h_i\psi_b \quad \textit{for translation, and}$$
$$y(i) = y_s(i) + \psi_b \quad \textit{for rotation} \qquad (2)$$

By combining the equation of motion for upper structure and the equation of equilibrium for base translation and rotation, Nataraja at. al. (1977) have derived

$$[M] = \left[\begin{array}{c|cc} [M_s] & 0 & 0 \\ \hline 0 & m_b & m_b\dfrac{h_b}{2} \\ 0 & m_b\dfrac{h_b}{2} & I_b \end{array}\right] \qquad (3)$$

where $[M_s]$ is upper structure mass, m_b and I_b are foundation mass and moment of inertia of foundation about base of foundation.

$$[K] = \left[\begin{array}{c|cc} [K_s] & -[K_s]\{1\} & -[K_s]\{h\} \\ \hline -\{1\}^T[K_s] & k_h + \{1\}^T[K_s]\{1\} & \{1\}^T[K_s]\{h\} \\ -\{h\}^T[K_s] & \{1\}^T[K_s]\{h\} & k_h + \{h\}^T[K_s]\{h\} \end{array}\right] \qquad (4)$$

where $[K_s]$ is upper structure stiffness,

$$\{1\} = [1 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0 \quad \ldots]^T$$
$$\{h\} = [h_1 \quad 1 \quad h_2 \quad 1 \quad h_3 \quad 1 \quad \ldots]^T \qquad (5)$$

k_h and k_ψ are translational and rotational soil stiffness coefficient. The damping matrix $[C]$ is similar to the stiffness matrix $[K]$ by changing k to c in equation 4.

The equivalent displacement vector $\{q\}$ is

$$\{q\} = \{y(t) \; \vdots \; q_b \quad \psi_b\}^T \qquad (6)$$

and the vector displacement is given by

$$\{Q(t)\} = \{F(t) \; \vdots \; F_H(t) \quad F_M(t)\}^T \qquad (7)$$

Soil under Cyclic Load

Modeling of soil behavior in response to dynamic loads has received is a have long attracted geotechnics. Given the complexity of the real nature of the soil, it is not easy to formulate a simple theoretical model.

Nogami at al (2003) outline classifies studies experts about the dynamic stiffness of soil in shallow foundation into several categories. The first classification is the study who obtained the dynamic stiffness of the soil derived from analytical solutions of the wave equation formulation for continuum of media (eg, research by Awojobi (1972), Luco (1976), Park and Gobert (1991)). The second classification method based on descretized or semi- descretized continuum media (as is done by Kausel and Roesset (1975), Lysmer at al (1976), Tassoulas (1981), Banerjee and Sen (1987), Beskos (1987), Dominguez (1993) and Banerjee (1994)). The third form of classification method based on simplification of the physical condition of continuum media (ie, studies pioneered by Novak at al (1972), Nogami at al (1985-2003). The last, is an empirical method based on the curve fitting. This method is developed by Gazetas dkk (1985-1991).

Formulas and charts provided by Gazetas (1991) is the sum of the previous Gazetas's for each case the dynamic motion of vertical, horizontal and rocking direction. Especially for dynamic motion in horizontal direction, the proposed formula and chart represent a systematic parametric study using boundary element formulation for arbitrary shape embedded in the soil or that are not embedded in the soil, while for dynamic motion in the direction of rocking, the proposed formulas and charts is based on the renewed understanding of the physical condition of the problem, for which the input for the results of parametric studies are done in a careful and wide using boundary element method. Although the Gazetas's formula is simple, yet has been proven by experimental results by Stokoe. Testing of formulas and charts presented in Gazetas's comparative study between formulas and charts to experimental study conducted by Gazetas and Gazetas dan Stokoe (1991).

Because of Gazetas's formulas quite easy in its aplication, it was possible to be developed into nonlinear soil case studies that will be discussed.

Soil Nonlinearity

There are many constitutive laws to represent the nonlinear behavior of soil. Desai (1984) group the models as: elastic, hypoelastic, Quasilinear and plastic models. Hypoelastic concept constitutes a generalzed incremental law in which the behavior of soil can be simulated from the increment to increment rather than for the entire load or stress at a time. Application of this constitutive law into a numerical model, need a special attention, because the obtained matrix is generally not symmetrical, so it takes a relatively long calculation. Quasilinier model based on piecewise linear behavior of the soil. For each piece (Figure 2), the material parameters, say *G* and *K* or *E* and ν , are revised by making them functions of the state of stress (strain).

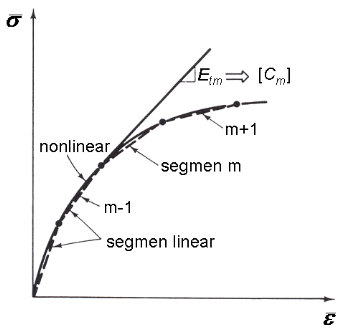


Figure 2. Piecewise linear or quasilinear approximation (Desai, 1984)

where *E* and ν are Young's modulus and Poisson's ratio of the soil, *G* and *K* are shear and bulk modulus of soil. The tangent of each segmen m denotes Young's modulus of the soil with strain ε_m . Hyperbolic and Ramberg-Osgood models are quasilinear. Although hyperbolic model is simpler than Ramberg-Osgood model, but it still gives a satisfactory result.

By performing direct shear experiment for several value of normal stress, Clough and Duncan (1971) proved that relationship of the shear stress on structure-soil boundary with shear displacement *u* can be approximated by a hyperbolic function according to the following equation

$$\tau = \frac{u}{a' + b'u} \tag{8}$$

The last is the plastic model in which the plastic deformation and volume change during load are included in this model. Drucker-Prager, Cap, Cam-Clay, Lade's and HiSS models are included in this constitutive law (Sengara-1992). However, the application of the plastic model is not simple, so it is difficult to develop to nonlinear soil stiffness in soil structure interaction due to cyclic loading in this study.

Soil Stiffness and Damping

As previously discussed that the given formulas and charts that provided by Gazetas (1991a) are quite simple but still accurate, make it possible to be developed as a spring stiffness in the horizontal direction that is use in equation 4 by considering the nonlinear behavior of the soil. The soil stiffness as the spring on the horizontal direction on the Gazetas's formulas is,

$$k_h = \frac{2GR}{(2-\upsilon)}\left(2 + 2.5\chi^{0.85}\right).k_h(\varpi) \tag{9}$$

where R and χ are radius and shape function of foundation, $k_h(\varpi)$ is obtained from the chart in Figure 3.

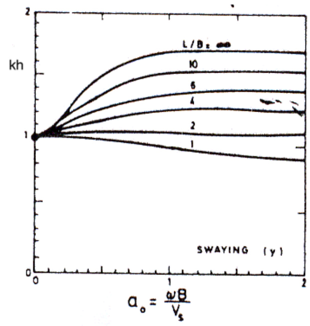


Figure 3. The Dimensionless Chart for Obtained $k_h(\varpi)$ coefficient of the Surface Foundation (Gazetas-1991a)

where $a_0 = \frac{\varpi R}{V_s}$, V_s is shear wave velocity of the soil and ϖ is the natural frequency of as a vibrator of the soil. In other words, soil stiffness depends on the natural frequency of the structure. However, as it is known that the dominant response of the system is determined by the mode shape with the natural frequency closest to the wave natural frequency as the load of the structure. The soil stiffness on the rocking for the surface foundation is,

$$k_\psi = \frac{3.2G}{1-\upsilon} I_f^{0.75}.k_r(\varpi) \tag{10}$$

where $k_r(\varpi) = 1 - 0.26a_0$

I_f is moment of inertia of cross section.

Gazetas's formulas for damping on horizontal and rocking directions are,

$$c_h = (\rho V_s A_b).\bar{c}_h \quad \text{and} \quad c_\psi = (\rho V_{La} I_f).\bar{c}_r$$

$$\text{where } V_{la} = \frac{3.4}{\pi(1-\upsilon)} V_s \tag{11}$$

$\bar{c}_h$ and $\bar{c}_r$ are obtained from the charts on Figures 4 and 5.

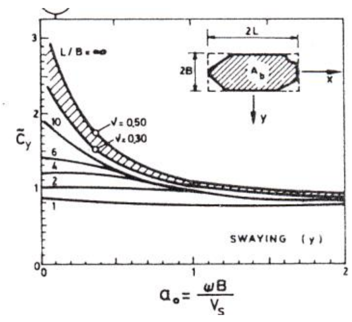


Figure 4. The Dimensionless Chart for Obtained $\bar{c}_h$ coefficient of the Surface Foundation (Gazetas-1991a)

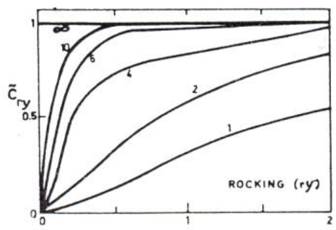
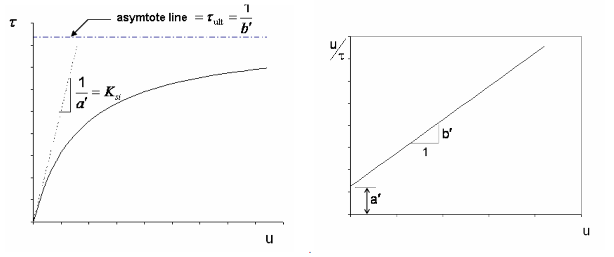


Figure 5. The Dimensionless Chart for Obtained $\bar{c}_r$ coefficient of the Surface Foundation (Gazetas-1991a)

STIFFNESS FUNCTION DEVELOPMENT

Effect of Nonlinear Behavior on Soil Stiffness

Following the study of Kondner (1963-1965), Clough and Duncan (1971) obtained for surface shear stress. General description of the relationship between shear stress τ and displacement *u* according to equation 8 showed in Figure 5. From equation 8, mathematically the shear stress-displacement curve will be asymptotic to the value of ultimate shear stress ($\tau_u = 1/b'$) at the value of displacement $u \approx \infty$. And $1/a'$ is the initial slope of curve.



(a) (b)

Figure 5. (a) Hyperbolic curve of shear stress - displacement,
(b) Hyperbolic transform curve of shear stress-displacement

The coeficient *a'* and *b'* would be more easily determined by using the vertical axis transformation proposed by Kondner (1963-1965) in Duncan (1970) according to equation

$$\frac{u}{\tau} = a' + b'u \qquad (12)$$

The first derivative of equation 12 yields the shear stress of the surface, ie

$$K_s = \frac{a'}{(a' + b'u)^2} \qquad (13)$$

Shear stiffness of the surface at u = 0 is the intial shear stiffness (K_{si}) and from equation 13 can be obtained the value of $K_{si} = 1/a'$.

For each of the different normal stresses used will give different hyperbolic curves, so that it will be obtained several sets of coefficient *a'* and *b'* accordance with the normal stresses used.

The problem of coefficient *a'* can be solved by using the research conducted by Janbu (1963), where the initial shear stiffness (K_{si}) is a function of normal stress (σ_n) according to the following equation,

$$K_{si} = K_I \gamma_w \left(\frac{\sigma_n}{p_a} \right)^n \qquad (14)$$

The problem of coefficient *b'* can be solved by finding the relationship of ultimate shear stress (τ_{ult}) with the shear stress at failure condition (τ_f) according to Mohr-Coulomb. Similar to that used by Duncan and Chang (1970), Clough and Duncan (1971) proposed a relationship of ultimate shear stress (τ_{ult}) with the failure shear stress (τ_f) as,

$$\tau_f = R_f \tau_{ult} \quad \textit{where} \quad \tau_{ult} = c + \sigma_n \tan \delta \qquad (15)$$

and R_f is the ratio of failure stress which range between 0.82 to 0.95.

Study conducted by Desai at al (1984a) in Desai at al (2005) about the behavior of the shear surface by numerical approach to the measurement of the experiment, showed that the shear modulus *G* can be approximate as,

$$G = K_s t_b \qquad (16)$$

where t_b is the thickness of the shear surface. Desai at al (1984a) in Desai at al (2005) found that the ratio between the thickness of the shear surface with the surface diameter or length range from 0.01 to 0.10.

Thus, based on the equation 16 and 13, then the shear modulus G that would be used for determining the stiffness in the equation 9 is the shear modulus as a function of horizontal displacement u (in other word the nonlinearity of the soil is considered).

By replacing the coefficient *a'* with $1/K_{si}$ according to the equation 14 and the coefficient *b'* with $1/\tau_{ult}$ according to the equation 15, yield the equation of shear modulus G as a function of displacement u, ie

$$G = \frac{K_I \gamma_w \left(\frac{\sigma_n}{p_a}\right)^n (c + \sigma_n \tan\delta)^2}{\left((c + \sigma_n \tan\delta) + R_f K_I \gamma_w \left(\frac{\sigma_n}{p_a}\right)^n u\right)^2} . t_b \qquad (17)$$

Then the soil stiffness in the horizontal direction is,

$$k_h(\omega) = \frac{2R}{(2-\upsilon)}(1 + 2.5\chi^{0.85}) k_h(\omega) \times \frac{K_I \gamma_w \left(\frac{\sigma_n}{p_a}\right)^n (c + \sigma_n \tan\delta)^2}{\left((c + \sigma_n \tan\delta) + R_f K_I \gamma_w \left(\frac{\sigma_n}{p_a}\right)^n u\right)^2} . t_b \qquad (18)$$

Horizontal Stiffness Spring Force Function

The stiffness equation in equation (9) can be written as,

$$k_h = k_{hst} . k_h(\omega) \qquad \text{where}$$

$$k_{hst} = \frac{2GR}{(2-\upsilon)}(1 + 2.5\chi^{0.85}) \qquad (19)$$

where k_{hst} is the horizontal spring stiffness that not related to the frequency and a function of shear modulus G of the soil that is a nonlinear function of displacement u, so the horizontal spring stiffness k_{hst} also a nonlinear function of horizontal displacement u.

Horizontal shear force that gives the horizontal displacement spring u can be determined by integrating equation 19 to u, i.e.

$$P_h = \int k_{hst}(u)\, du \qquad (20)$$

Next, be obtained the horizontal stiffness force, as

$$P_h(u) = \frac{2R}{(2-\upsilon)}(1 + 2.5\chi^{0.85}) k_h(\omega) \times \left[\frac{u}{\frac{1}{K_I \gamma_w \left(\frac{\sigma}{p_a}\right)^n} + \frac{R_f}{(c + \sigma_n \tan\delta)} u}\right] t_b \qquad (21)$$

Completion of this study was conducted numerically by using the fortran program.

Testing of the program subroutine to determine the horizontal stiffness spring force function was carried out by using soil parameters, K_I =7500; cohesion and soil friction angle respectively c = 0.4 kN/m^2 and δ= 34^o ; failure coefficient of the soil R_f =0.73; mass density and Poisson's ratio respectively ρ = 20 kN/ m^3 and υ = 0.33; the surface shear thickness t_b =4.5 m, and normal stress at shear surface respectively $\sigma_n = 5000$ kN/m^2 and $\sigma_n = 10000$ kN/m^2 yield the curve in Figure 6.

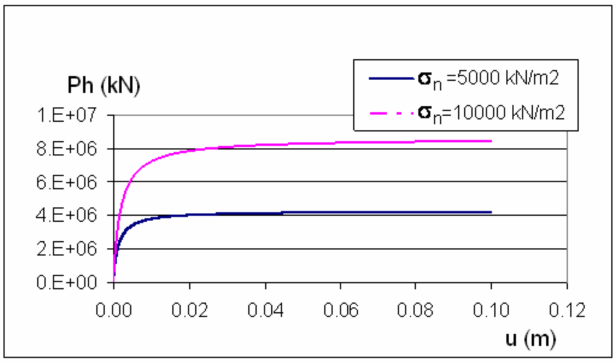


Figure 6. Horizontal Spring Force Function Curve

Rocking Spring Force Function

Given there is still no research that can present the nonlinear model of soil on rocking direction to support this study, it was assumed the soil behaves linearly in this direction.

NUMERICAL DETERMINATION OF THE SYSTEM

Response of soil-structure interaction system where the soil has the nonlinear behavior under cyclic loading, was carried out numerically, where the natural frequencies of the system was determined by using Stodola-Vianelo method, where by using this method is not carried out simultaneously making it suitable for the research problem.

Determination of system response was done by incremental Newmark method, whereas problem solving of nonlinear soil was done by modification of Newton-Raphson method.

CASE STUDY

Case study was done on the gravity structure system due to wave load, with a structure that has a uniform mass with a round hollow section; outside diameter 20 m and inner diameter 19,1 m; the modulus of elasticity, mass density and poisson's ratio of the structural material, respectively E = 2.45x 10^7 kN/ m^2 ; ρ = 25 kN/m^3 and υ = 0.25 ; the high of structure is 115 m, atmosphere pressure = 101.4 kN/m^2 ; mass density of fluid ρ_w= 10.25 kN/m^3 and the diameter and height of the foundation respectively R = 45 m and h_p= 60 m. The soil parameters: K_I =7500; cohesion and soil friction angle respectively c = 0.4 kN/m^2 and δ= 34^o; failure coefficient of the soil R_f =0.73; mass density and Poisson's ratio respectively ρ = 20 kN/ m^3 and υ = 0.33; the ratio of thickness to the length of surface shear $t_b/2R$ = 0.05.

From simulation for wave height 30 m and wave period respectively T = 17 sec and 15 sec, yield the horizontal responses of the foundation as shown in Figure 7.

Simulation for the wave height 1 m and the similar wave period, yield the horizontal responses of the foundation as shown in Figure 8.

Figure 7 and 8 show that the response of the foundation on the soil which was assumed to behave linearly behavior, different from the response of foundation on the soil that was assumed to behave nonlinear behavior.

By considering the nonlinear soil behavior both figures showed that the foundation moved permanently while doing periodic motion following the movement of wave, whereas if the soil was considered to be linear, the foundation will remain in it position while doing periodic motion following the pattern of wave motion.

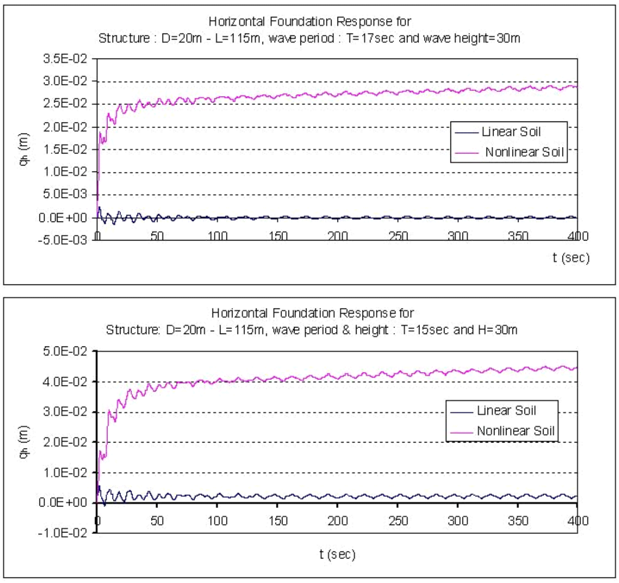


Figure 7. Horizontal Foundation Response due to wave height 30 m and wave period respectively T = 17 sec and 15 sec.

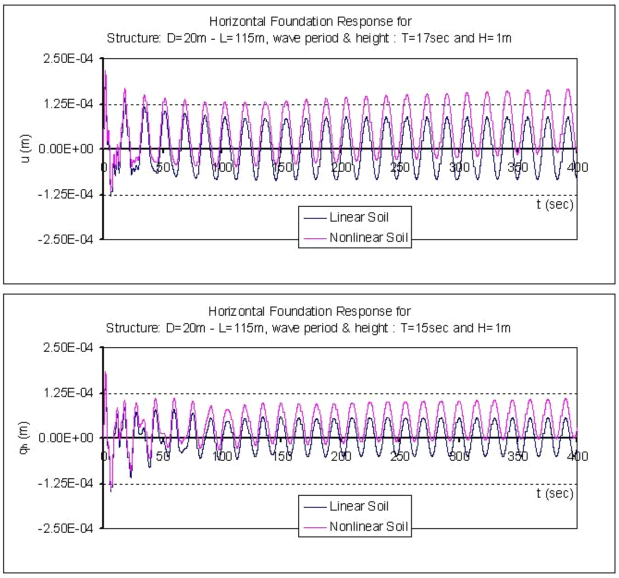


Figure 7. Horizontal Foundation Response due to wave height 1 m and wave period respectively T = 17 sec and 15 sec.

CONCLUSIONS

1. This study developed a constitutive law of the soil-structure interaction system in the nonlinear soil subject to cyclic loading.
2. Nonlinear soil properties on the system that interact with the soil at cyclic loading, only having an effect on the movement of his own foundation, while the upper structure no effect because the effect was very small.

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ENVELOPE RESPONSIVE DESIGN AS A PASSIVE COOLING STRATEGY IN TROPICAL BUILDING FOR CLIMATE CHANGE MITIGATION

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ABSTRACT

The impact of climate change in urban area has increased the temperature of urban area. It become a major thermal comfort problem, especially in warm humid region. Johor Bahru city which is situated within warm humid area also indicates similar increase phenomena of increasing temperature. The use of passive cooling strategy in tropical buildings and architecture can reduce appliance of air conditioning. This paper studies the envelope responsive design as one passive cooling strategy in comfortable housing in Johor Bahru, Malaysia. The specific case study of tropical house that initiate not permit good passive cooling for thermal comfort for the whole day. This is illustrated by the indoor temperature above the neutral temperature experienced during the day time. In this research, the proposed envelope responsive design has been suggested by adopting tropical design principle as alternative techniques for achieving passive cooling. The comfortable indoor environment achieved by using envelope responsive design of buildings and in this case by modification of wall and window design. The thermal environment study in this research involved the use of field measurement and computer simulation using Ecotect software. The result of the proposed envelope responsive design illustrated that the house model increased thermal environment performance by reducing air temperature up to 3.5°C. This effect is significant toward improving the comfort of indoor environment of typical tropical house also as a basic method for climate change mitigation.

Keywords: *climate change, envelope responsive design, tropical house*

INTRODUCTION

Climate is the average atmospheric conditions over an extended period of time over a large region. Small-scale patterns of climate, resulting from the influence of topography, soil structure, and ground and urban forms, are known as microclimates. Temperature, solar radiation, humidity and wind are the principal parameters that define the local climate. Given that the world is becoming more and more urbanized, specific attention must be given to the urban climate. The thermal balance in the urban environment differs substantially from that of rural areas. More thermal gains are added such as high anthropogenic heat released by cars and combustion systems, higher amounts of stored solar radiation, and blockage of the emitted infrared radiation by urban canyons. Thus, the global thermal balance becomes more positive and this contributes to the warming of the environment. As a consequence of heat balance, air temperatures in densely built urban areas are higher than the temperatures of the surrounding rural country. This phenomenon of heat island has an adverse impact on the energy consumption of buildings for cooling.

In tropical climates, buildings are overheated during the day due to solar heat gain through the building envelope and solar penetration through windows (Rajapaksha, 2002). From a thermal comfort point of view, it requires lowering of indoor daytime temperature below the outdoor temperature using building elements and by passive or active cooling. There are different problems associated with the use of air conditioning for active cooling. Apart from the serious increase of the absolute energy consumption of buildings, other important impacts include: the increase of the peak electricity load; environmental problems associated with the ozone depletion and global warming. The main environmental problems of air conditioning are associated with emissions from refrigerants used in air conditioning which impact ozone levels and global climate. Refrigeration and air conditioning related emissions represent almost 64% of all CFC's and HCFC's produced (AFEAS, 2001). Addressing successful solutions to reduce environmental effects of air conditioning is a strong requirement for the future.

Passive cooling techniques involving microclimate improvements, heat and solar protection, heat modulation and dissipation methods and systems can greatly contribute to buildings' cooling load reduction and increase thermal comfort. Results of Santamouris (1997), showed improved knowledge on this specific topic and develop design tools, advanced techniques to better implement natural cooling techniques and new techniques to characterize the performance of passive cooling components have been developed as an aid to designers. Passive cooling techniques in buildings have proven to be extremely effective and can greatly contribute in decreasing the cooling load of buildings. Efficient passive systems and techniques have been designed and tested. Passive cooling has also been proved to provide excellent thermal comfort and indoor air quality, together with a very low energy consumption. Techniques for such thermal modification have been widely addressed in tropical design principle. Tropical design principle utilized the environmental challenges and responds to achieve comfortable indoor environments. Thermal performance of housing has been a matter of concern in many countries. Some research have been performed by Givoni (1993), Kru¨ger and Givoni (2004) and Cheng et al. (2005) to evaluate the influence of thermal mass and the effect of envelope on thermal performance.

The research was carried out at the Tropika House located in Johor Bahru, Malaysia which was designed emplacing tropical design strategies. However, there is no evidence to justify the performance of this building in term of its actual indoor climate and comfort condition that an be compared to establish thermal comfort condition as suggested by many researchers such as Rajeh (1989) and Abdul Malek and Young (1993). Evaluation of actual performance through this research can provide further improvements in the advancement of knowledge and design appropriate within tropical climate. This research will scientifically prove the hypothesis. The actual performance of the house can then provide new concepts or principles of passive design and helps in the advancement of knowledge and design that is appropriate for tropical climate.

METHOD

This research is divided into several stages. First is the indoor measurement of existing tropical house; second, ecotect simulation and validation; and last, development of proposed envelope responsive design. In order to achieve the research objectives, the following steps are used: climate data and site measurement, Ecotect software validation, modification of tropical house envelope (wall and window) and analysis of indoor temperature performance. The effect of proposed envelope responsive design for thermal temperature is to be investigated using computer simulations for both the climate data and buildings elements. The Ecotect is the instrument that is used to model the tropical house thermal environment. Ecotect validation is done by comparing between field study and Ecotect simulation. The existing low cost house and the modification of wall and window element is built to a scale of 1:1 in simulation model. The testing of the models is divided into several parts to ease the comparison between various modifications of thermal environment performances.

The indoor temperature studies conducted on the existing tropical house not only provided valuable insights on its thermal performance but made it possible to compare the results from the computer model in which the dynamic thermal performance of the building was simulated against the real performance recorded. The building was occupied or heated during this period. Actual temperature measurements collected by data loggers for a one month period was compared with the computer predictions for the same period. Graphs displaying both the real and calculated data can be used to judge accuracy of the simulations and if discrepancy occurs the relevant parameters can be adjusted. When the weather data for the given region is available, simulations can be done for different times of the year. Thus it is possible to evaluate the effect of building elements and climatic factors on thermal temperature inside a given building. Other parametric studies related to wall form and material, window size, type and orientation can also be performed. The basic field study model is a typical room configuration with overall size of 3m width x 3m length x 3m high. This size is to represent a living room on field study. A model created for thermal analysis is geometrically simplified since the relevant attributes here are the thermo-physical properties (such as U-values and thermal admittance values) of the building envelope and fenestrations.

The analytical method of evaluating the comfort zone for tropical climate have been studied by several authors (Rajeh, 1989; Abdul Malek and Young, 1993; Abdul Rahman and Kannan, 1997; Azni Zain Ahmed et al.,2002), using the "Neutrality Temperature". In various studies, neutrality temperature is defined as the temperature that gives a thermal experience neither warm nor cool, which is a state of "neutral" or "comfortable". It is the mid point of the comfort zone, as an average value for many experimental subjects. According to Auliciems and Szokolay (1997) with the range of the comfort zone is taken as 5°C, thermal comfort temperatures extends approximately about 2.5°C above and below the neutral temperature. Szokolay (1998) recommended the use of the annual mean temperature (AMT) for applied Auliciems's equation for Malaysia's data. The comfort temperature or neutrality temperature can be predicted from the linier equation for naturally ventilated building as cited in Nugroho et al. (2007):

$$Tn = 17.6 + 0.31 \times Tamt$$

Where, Tn = neutral temperature with+/- 2°K range, Tamt = annual mean air temperature of the month. The comparative comfort zone, using above equations and the annual mean air temperature of the month worked out from the climatic data for Johor Bahru weather data. This will give a general picture of the range of comfort zone for Johor Bahru.

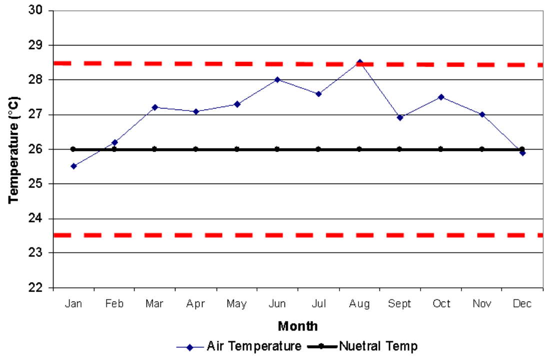

Figure 1. Neutral temperature range on the Johor Bahru Climate Condition

According to the figure 1, the neutral temperature of 26°C in free running building, the upper and lower limits of the comfort zone would then be 28.5°C and 23.5°C respectively. This neutral temperature is for conditions without air movement.

RESULT

The Neutral Temperature Condition of Existing House

A typical diurnal variation of the mean indoor temperature against the outdoor temperature is illustrated in figure 2. It can be observed that the tropical house indoor temperatures were significantly below the outdoor at 09:00h until 14.00h. The peak ambient temperature (indoor temperature) was 31.79°C at 15:00h. Figure 2 showed the outdoor humidity was generally lower than the humidity inside the house. The relative humidity for outdoor and indoor showed similar patterns as both illustrated a decreasing patterns starting from 09:00h until 18:00h.

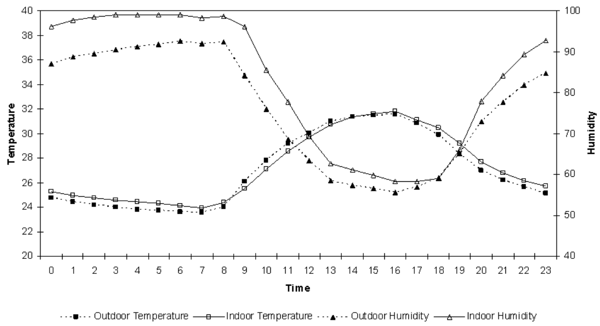

Figure 2. The average temperature and humidity measurement for indoor and outdoor

The indoor temperature was generally slightly higher than the outdoor temperature during the afternoon and night. Indoor temperature started to increase at 14:00h and peak at 18:00h. The indoor humidity decreased but still considered high from 08:00h until 16:00h. The temperature reduction occurred at 10:00h until 12:00h. Generally, the temperature difference in mid day was 0.01°C-0.72°C when compared for both outdoor and indoor. The maximum indoor temperature (31.5°C) was above the neutral temperature. A typical diurnal variation of the mean indoor temperature against the ambient temperature is illustrated in figure 2. It can be observed that the indoor temperatures were significantly below the ambient. This is representative of the pattern for all the tests undertaken. Typical values of peak indoor temperatures were between 25°C and 30°C compared with peak outdoor temperatures of 26°C-30.5°C. Corresponding average indoor temperature elevations ranged between 1°C and 0.5°C below outdoor temperature at 09:00h until 14:00h. Further, the incorporation of a combined envelope element designs can increase temperature reduction in the single room to a neutral temperature (26°C). Figure 2 illustrates that the upper target neutral temperature (28.5°C) was obtained during one day average indoor temperature measurement and simulations except at 12:00h until 19:00h. The neutral temperature performance was achieved with modification of tropical building design principle being studied. Better performance was obtained further with a maximum temperature reduction within the single space room. These present results are similar to previous results where they indicated that the increase of roof solar shaded area will decrease the indoor temperature as discussed by Bouchlaghem (2000) and Corrado (2004). Bouchlaghem (2000) presented a computer model, which simulate the thermal performance of the building taking into account design variables related to the building envelope and optimize window-shading devices with optimization programs. According to Corrado (2004) the appropriate external shading devices can control the amount of solar radiation admitted into the room, which could largely reduce cooling loads and improve indoor thermal comfort. Finally, it is in our opinion that tropical design principle seems to be feasible and viable and the opportunity to further develop the appropriate principle of design for tropical climate.

The Validation of Ecotect Simulation

Validation of the program was also performed by comparing the measurement of field study. Figure 3 shows the comparison of measurement and simulation result. It shows that the agreement between the measurement and simulation is generally good.

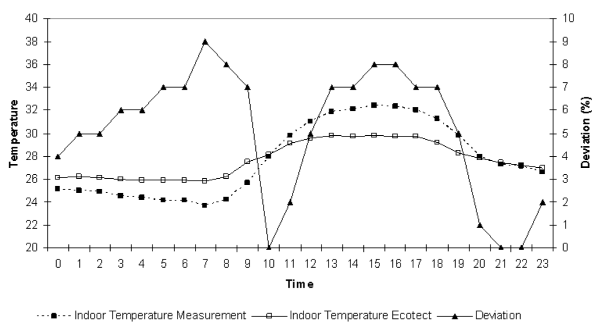

Figure 3. Comparing field measurement with Ecotect simulation of the field study

The average difference between the measurement and simulation for ambient temperature was 5%; the maximum difference was 9% at 07:00h for indoor temperature. This gives confidence in using the computer code to study the indoor temperature.

The results obtained from the measurement of tropical house has illustrated that employment of proper tropical design principle can maintain indoor temperatures consistently below the outdoor temperature in the morning. The maximum indoor temperature on the measurement and simulation was achieved at 16:00h. The indoor temperature profile also indicated similar trend against the outdoor temperature. This means that the indoor temperature close to outdoor temperature can be achieved by modification building envelope based on tropical design principle.

Modification of Window Responsive Design for Passive Cooling

Modification of tropical opening design had been undertaken on selected climate condition within same ambient conditions. It was simplifed to make easier comparison between field study and the different design configuration due to similar climatic conditions used. In the field study, the window opening of the tropical house is used as a ventilation controller. A combined opening modification between full opening (100% open), no opening (close) and small louvers (0.05m) should be employed and tested for same field study design elements. Figure 4 shows the indoor temperature and outdoor temperature of the tropical house with different sizes of opening. Generally, decrease of the opening size will decrease the indoor temperature.

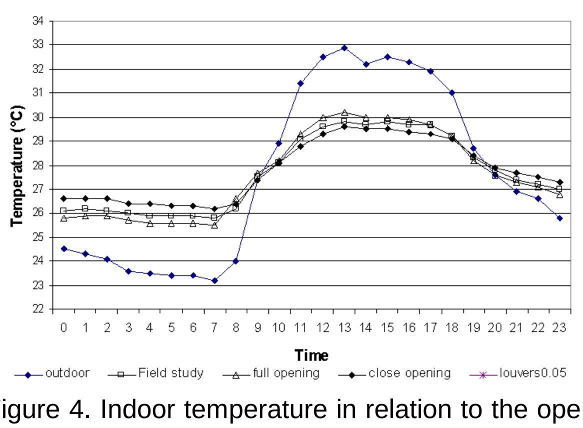

Figure 4. Indoor temperature in relation to the opening modification

However, as shown in figure 4, the temperature differences increased with reducing opening size of the tropical house model. Thus, the amount of indoor temperature without opening would be lower than that with full opening. Therefore, to anticipate the heat gain by the user (human body and equipment), the size of the opening should be smaller than tropical house window. Figure 4 shows that the average indoor temperature was achieved for each correspondence of opening modifications and the upper target of neutral temperature (28.5°C) was achieved during all day except at 11:00h until 18:00h. The results are similar with Rosangela (2002) and Prianto (2003). There is no requirement for much larger opening for the climatic conditions considered. Opening type and size should be chosen in accordance with the building passive cooling (lesser than outdoor temperature) for diurnal building operations. Small opening are advisable for night operation while for the building day operation, louver opening type should be adopted. The study is paralleled to Prianto (2003) who examined various types of louver as having significant effect on the indoor comfort level. Further, Rosangela (2002) also found that smaller opening for heavyweight construction provided better performance of indoor temperature.

Modification of Wall Responsive Design for Passive Cooling

To evaluate the effect of wall elements on indoor temperature, several modifications were simulated: wall with insulation 0.04m and 0.1m, wall with high U value (3 W/m^{2}K) and wall with light color, which correspond to roof, opening and floor similar with field study. Figure 5 show the indoor temperatures of tropical house for five different modifications. It was found that indoor temperatures decreased with increased U value of the wall. In fact, those previous researchers regarded the fact that big U value will cool the inner surface of the wall leading to decreased temperature of the room.

The comparison of present study agrees with Rosangela (2002), Garde (2004), Al-Homoud (2005) and Mallick (1996). The present results showed that temperature reduction due to light color wall and big U value wall effects were significant. Rosangela (2002) investigated the use of a white reflective surface indicated the best performance, and minimized the need for insulation. Garde (2004) used a medium colored wall for solar protection reflectance. It was recommended to put no insulation instead of the one originally planned. According to Al-Homoud (2005) the thermal performance of building envelope is determined by the thermal properties of the materials used in its construction characterized by its ability to absorb or emit solar heat in addition to the overall U-value of the corresponding component including insulation. Mallick (1996) indicated rooms with thicker walls but high u value tend to be more comfortable. Similarly, the thicker insulation material is the less thermal transmission will be (Mahlia, 2007). According to Rosangela (2002) the most of the time high mass buildings can be more comfortable than low-mass ones.

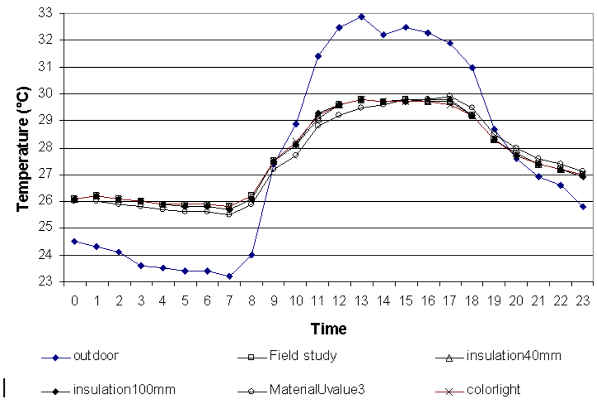

Figure 5. Indoor temperature in relation to wall modification

The Proposed Envelope Responsive Design for Passive Cooling

The discussion of the results of this simulation modification are referred to the field study configuration, model A (small wall u value, wall color light, opening louvers 0.1m), model B (wall with large u value and light color, opening louvers 0.1m) and model C (wall with large u value and light color, opening louvers 0.05m). For the purpose of comparative analysis on the effect of the new principle design (model A, model B, model C), the basic model (field study) indoor temperature and temperature difference values were used to determine the deviation of values at the proposed configurations.

The indoor temperature data shows that at proposed C the temperature value is the lowest in mid day (27.1°C until 28.5°C). The highest temperature reduction effect is recorded at model C of the big U value wall and decreases towards the increase of the ratio opening. The average indoor temperature of proposed A, B and C for the south oriented house are shown in figure 6. The minimum indoor temperature was obtained in proposed C. The results showed significant temperature reduction which the indoor average temperature values obtained neutral temperature (27.4°C) was less than upper limit neutral temperature (28.5°C). Figure 6 illustrate effectiveness of each selected proposed model in temperature reduction for the selected climate condition. The temperature reduction value increases significant at model B and C. This situation is reversed at the model A. The temperature reduction obtained from the proposed model A shows that maximum temperature reduction achieve in the night and maximum temperature addition during the day time. The results indicated that the maximum temperature reduction (5.5°C) through the model C. The maximum temperature reduction was obtained during 13:00h for model C.

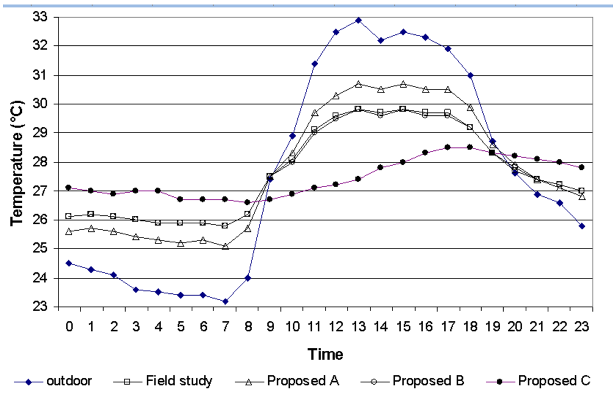

Figure 6. Indoor temperature in relation to the proposed model

CONCLUSIONS

The aim of the study is to evaluate envelope responsive design as passive cooling of tropical house for reducing impact of urban climate change. The thermal conditions were also studied based on the site climatic conditions on a selected date comparing the measured and simulated results. The study also emphasizes that modification of wall and window design can affect the indoor thermal condition in a hot humid climate. The results of the field study measurements of the air temperatures of the existing tropical house proved that the internal air temperature is higher than the external temperature. The results were compared for the neutral temperature and received higher than upper limit of neutral temperature for comfort zone. The existing tropical house is within the comfort range during late night time and in the morning hours when the external environment is cooler, while during the daytime the air temperatures were above the comfort range. During the day time, efficiency of the building envelope (wall and window) are low in order to reduce the internal air temperature than the external air temperature. Simulations of the tropical house were developed to predict the air temperature within similar condition. The resultant indoor temperature revealed that the simulation has a good agreement with field measurement result. Based on the measurement and simulation results, the indoor temperature during day time is above the neutral temperature for all selected conditions. The investigation of the indoor temperature also showed that this house on all correspondence months experienced some temperature value of uncomfortable conditions. Comparison of the average indoor temperature on field study and modification of envelope house indicated that proposed envelope responsive design obtained the minimum air temperature and within upper limit of neutral temperature. According to figure 8, the proposed envelope responsive design achieved below target of neutral temperature for thermal comfort under the selected climate condition. The average air temperature on field study indicated above of neutral temperature for mid day. However, the field study can significantly decrease indoor temperature below 30°C. Further, the proposed envelope responsive design decreased the average air temperature up to 3.5°C on respective conditions. The results showed that wall material and window opening were main contributors on improving the comfort ofindoor environment. The results revealed that the use of wall material with 3W/m^{2}K U value and the use of small louvers as opening were the important aspects towards building's envelope responsive design for indoor comfortable environment.

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DESIGN APPROACH BASED ON ENERGY OPTIMIZATION OF ATMA JAYA YOGYAKARTA UNIVERSITY LIBRARY TO ACHIEVE SUSTAINABLE BUILT ENVIRONMENTAL REQUIREMENTS

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ABSTRACT

Numerous numbers of energy conservation strategies were implemented with neither sufficient consideration of building performance nor occupancy needs and this has led to many failures in building performance. In order to find out the level of environmental conduciveness in a library, this research was done as an evaluation process to assess the building performance mandates of Atma Jaya University's library in Yogyakarta. Building performance mandates examined were ventilation performance, lighting performance (both natural and artificial), and thermal comfort represented in the form of cooling loads as the main energy usage inside the building. The result could be used as a comparison tool to identify the range of deviation occurred between the predesign and the current operational process. Furthermore, it could be utilized to form the appropriate energy management system of building. Building performance analysis was conducted in order to find the ventilation and lighting problems emerged in the existing building by help of ESI CFD, Autodesk® Ecotect™ software and local weather data of Yogyakarta. Hence, the main objective is focused on the optimization of the passive system to reduce or maintain current level of energy consumption (cooling loads) inside the building. Although the models were created according to the physical field observation and its different usage, the user pattern is not further investigated. The aim is to show how to find and solve the problems using computer simulation as the representation of the actual building. The thermal comfort is represented by level of cooling loads of chosen rooms inside the building. Lower loads lead to be lower utilization of auxiliary energy for air-conditioning and hence to lower pollutants on the energy production side.

Keywords: *energy optimization, sustainable built environment*

INTRODUCTION

Current world population and environment problems have made radical changes in building planning and construction process. The concept of total building performance application could reduce energy consumption, pollution, and waste produced by the new or existing building. This would gradually increase living quality by assuring sufficient thermal and visual comfort inside buildings, which are measured through the occupant's level of satisfaction, health, and productivity.

METHODOLOGY

The applied methodology of this research was an objective approach. It's impossible to do detailed subjective measurement because the examined building had not yet operated when this research was conducted. The Atma Jaya Yogyakarta University's library has been chosen as the case study. The information was obtained by various techniques ranging from interviews, walk-through and visual inspection. Field's measurement was recorded using *luxmeter*, *HOBO U12 data logger*, *non-contact infrared thermometer* and *anemometer.* Subjective measurement was merely carried out by conducting a survey on the building staffs to assess two performance criteria i.e. thermal comfort and visual comfort. Data obtained from the surveys were analyzed and used to simulate the actual conditions by help of computer programs. ESI CFD and Autodesk® Ecotect™ software was chosen to do the simulation tasks. *Computational Fluid Dynamics (CFD)* built by ESI is a form of numeric calculation software in order to predict and assume fluid flows aided by computer. It will be utilized to examine the airflow inside the building. Autodesk® Ecotect™ is a building analysis program that allows designers to apply all the tools, which integrate lighting, energy, acoustics and environmental analyses for an energy efficient and sustainable future. Most of the building performance analysis, i.e. visual and thermal comfort, will be measured by this software.

Non Residential Design Guideline – Energy Efficiency Building

The UAJY's library is a new building which has been designed according to energy conscious mandates in relation to the passive and active building designs, constructions and building operations pertaining to the architecture, mechanical and electrical systems, office equipments, landscaping and implementation of energy management systems. Nevertheless, there were no further studies conducted to assess the performance of the currently erected building. This research will measure the chosen mandates of thermal, visual comfort and the energy efficiency means according to the criterion below.

Table 1. Parameters of thermal, visual comfort and the energy efficiency*

Thermal Comfort		Visual Comfort	Building Facades		EEI (Energy Efficiency Index)
DBT	RH %	Illumination Lv.	OTTV	RTTV	
20^0 C (room with books) and 26^0 C (without books)	50-60	100-300 Lux	<45 W/m^2	<45 W/m^2	<189 Kwh/m^2/year

**Source: Jimmy Priatman. Energy Conscious Design, Konsepsi dan Strategi Perancangan*

Objective Measurement

Objective measurements were carried out based on a walk-through and visual inspection inside the building. All the corresponding rooms are zoned according to the usage and each particular requirement. The data recorded were about thermal and visual comfort properties in each room as well as its natural and auxiliary lighting and the air conditioning system.

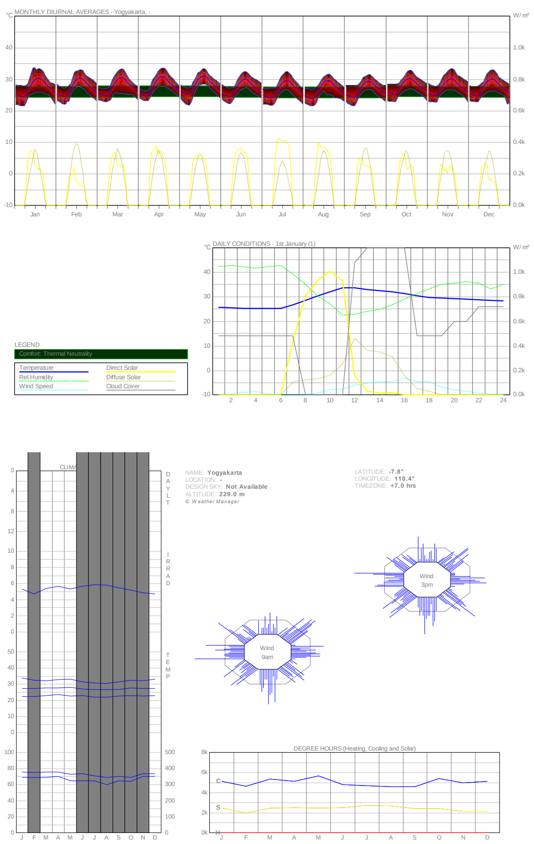
Subjective Measurement

Subjective measurements were carried out based on a personal interview from the building's staffs. The sample size for the survey is 20 staffs, and they were assumed to have the same level of sensitivity to the comfort of the environment.

Data Analysis

Due to the halted operation of the building during this research was being composed, there were assumptions created to compensate with the limited data inputs:

1. Building's energy analysis based on computer simulation without actual electricity bill input.
2. No subjective data input gathered from the occupants because the building has not operated yet.
3. Prediction of number and heat produced from electric equipment is done due to some building's equipment have not been installed.
4. Materials used for the simulation process assumed equivalent with the actual building as well as lighting properties and air conditioning system.



Picture 1. Climate Data of Yogyakarta (Source: Meteonorm)

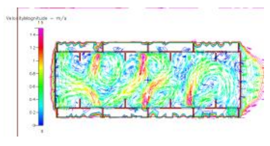
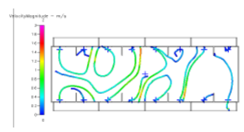
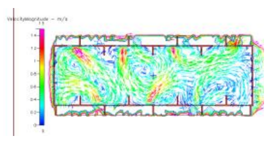
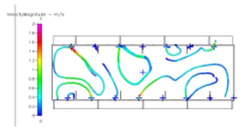
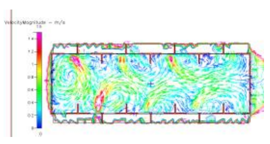
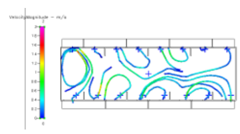
Simulation is conducted in order to compare the actual condition of chosen building's performance with the newly improved design performance. The problems occurred in the simulation process will be identified and further examined to determine the application of appropriate solution in each case.

Geographically, Yogyakarta is located on $7^{0}30'$ – $8^{0}15'$ South Latitude and 110^{0} – $110^{0}52'$ East Longitude *(Source: Google Earth Pro 4.2)*. Based on this location, Yogyakarta is classified in the warm humid climate region with high humidity and rainfall throughout the year, has constantly high temperatures throughout the year, diurnal temperature variations around 8°C, minimal seasonal variation in temperature, and solar radiation intensity varies widely with cloud conditions.

ANALYSIS

Identification process was begun with the assessment of natural airflow inside the building. The airflow distribution and its behaviour were examined to find out the best configuration of openings and other architectural elements, which may improve the air change rate and its relationship with user's comfort and indoor air quality.

Table 2. Comparison of The Experimental Models

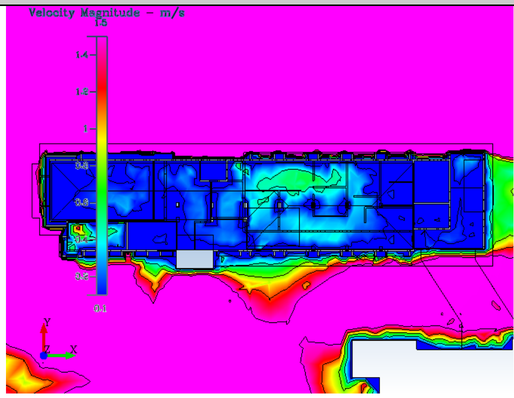
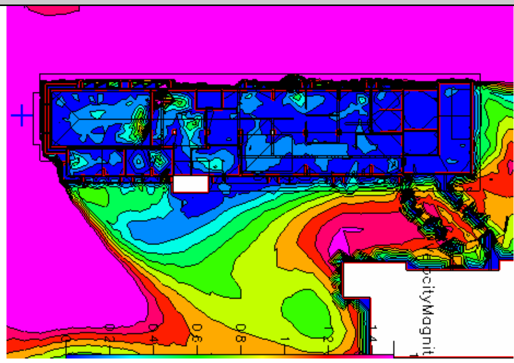
Flow Vectors	Mainstreams
Experiment Model A 	
Experiment Model B 	
Experiment Model C 	

It's found that the worst case of natural ventilation potential occurred when the wind blows parallel with the building's long axis (from west and east side). The experiment below is done by applying wing walls on the north and south side of building to create both negative and positive pressure at once on each side thus improving the airflow inside the building. The main focus is taken on the first, second and third floor where the greatest potential of natural ventilation takes place.

Model C has been chosen by reason that cross-ventilation concept will happen much often when the air got minimum distance to escape as soon as it enters the room. Furthermore, in the actual world, the availability of high book shelves will greatly affect the airflow and hinder it to cross over the other side of openings.

CFD Simulation Results

Table 3. Airflow distribution of the existed and proposed building

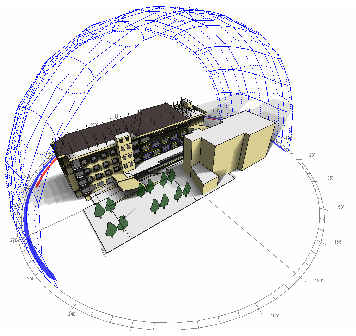
Existed 1^{st} Floor of Building
 *Existing model shows strong airflow speed (0.6-0.8 m/s) at north side and weak airflow at south side.*
Proposed 1^{st} Floor of Building
 *Proposed model shows more even distribution with air speed 0.2 – 0.3 m/s on almost every corner of examined workplane. Cross ventilation is created at each north and south side of building.*

Conclusion of Natural Ventilation Analysis

Wing-walls application on both sides of outer walls has altered airflow distribution inside building. Basement and ground floor in proposed design which are not equipped with wing-walls have the same pattern as the existing one. Wing-walls placement on the windward side proven to be effective to draw air enters and leaves the interior. On the other side, wing-walls which are on the leeward side are no longer effective, and they tend to have the same behavior as the ordinary openings due to their incapability of creating positive and negative pressure.

Daylight Analysis using Autodesk® Ecotect™ and Desktop Radiance 2.1

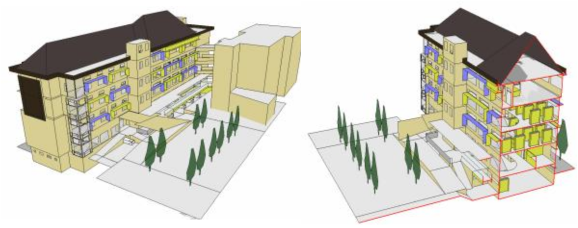
Reflectance level of surface materials inside the rooms also has a great impact on the distribution of daylight. Floors, walls, and ceilings all have reflectance value of 60%, 80%, and 90% respectively. The simulation process started by defining desired output, that is the illumination level on a work plane 80 cm above the floor level. Sky model used in the calculation is the *CIE Overcast Sky Model* to represent the worst case scenario when sky light is scattered evenly in the hemisphere. According to the field observation of existing building, the level of daylight illuminance is severely insufficient especially in the middle of the building. It was discovered that the furniture arrangement inside the building has become the major cause. Daylight enters the building through the windows is blocked by book shelves that are perpendicularly placed from the incoming daylight from the perimeter windows.



Picture 2. The existed building model

An experiment has been done by considering the factors above. Simulation once more is utilized as tools to predict the changes attempted to improve the daylight distribution qualitively and quantitatively. The improvements applied are:

1. Separating the usage of windows into view and light source windows by adding clerestories as the daylight source above the existed windows, supplemented by high reflective light shelves to allow daylight penetrates deeper into the building. View windows are equipped with rayband glass 40% to reduce glare.
2. Increasing the reflectance value of furniture to 50% by re-painting the book shelves with brighter colour.
3. Re-arranging the furniture layout, especially the tall book shelves which blocked the daylight penetration.
4. Utilizing light pipe and hidden skylight to increase the illumination level in the basement.
5. Detaching the outdoor corridor on the ground level from the main building in order to allow daylight penetrates further to the building.



Picture 3. The Proposed Building Model

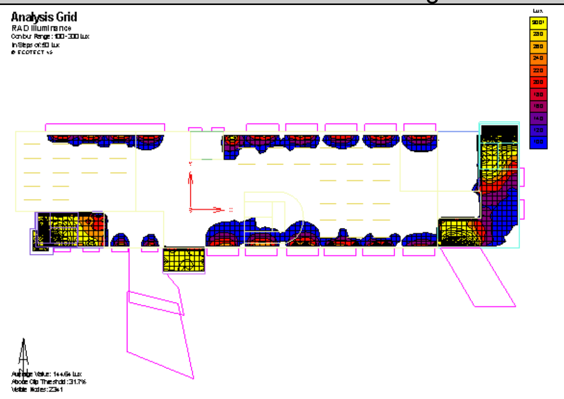
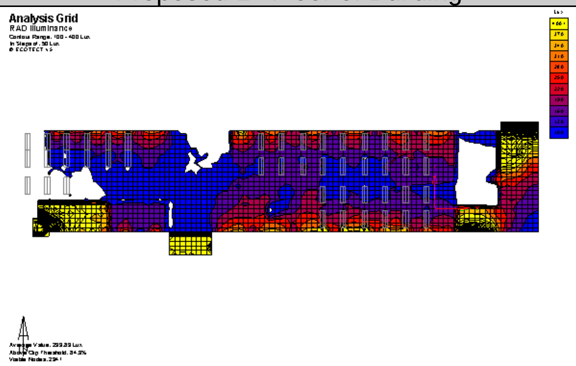
Field Measurement to Validate The Simulation Results

In order to test the accuracy of the daylight simulation results, a field observation to record the daylight levels inside the building has been conducted. The measurement was done in the overcast sky of midday at 01.00 pm to match the simulation process. All the electric lights were turned off, then a luxmeter was used to measure and record the daylight illumination level on 80 cm above the floor. Finally, the result shows the similar tendency with the simulation process.

Conclusion of The Daylight Simulation

Generally, the pattern of daylight distribution has been greatly improved. Average illuminance has increased up to 200%, especially in the basement. The previous strategies of daylight utilization are successful in improving and distributing light intensity needed by rooms inside the building. The usage of two type windows (view and light source) effectively enhanced the distribution pattern on the work plane. The placement of high clerestory windows equipped with light shelf allows the daylight to penetrate further into the middle of rooms. Furniture re-arrangement helps daylight to light the room evenly. Increased reflectance values on the book shelves add more positive effects in light distribution. Utilization of light pipe and hidden skylight has increased average illumination level in the basement up to 600%.

Table 4. Comparison of Illumination level and distribution of daylight in existed and proposed building

Existed 1st Floor of Building

Average illuminance is 150 lux. Most of them are far below the recommended level of illumination. The furniture arrangement does not accommodate the daylight distribution inside the building.
Proposed 1st Floor of Building

Average illuminance is 234 lux. The distribution is improved and the area below 100 lux is reduced. Furniture arrangement has been altered to accommodate daylight distribution. The gradation of illumination level near windows is smooth which means reduced glare.

Artificial Lighting Simulation Autodesk® Ecotect™ and Desktop Radiance 2.1

Artificial lighting simulation is done in order to measure how effective the placements of light points are in fulfilling minimum requirement 100 lux of ambient illumination level. Since there were no IES data found, the simulation assumed the photometrics are omni-directional and only lumens are used as input. Based on the blue print, the building model and the lights are created in Autodesk® Ecotect™.

In the design process, the artificial lights have been considered nicely by distributing the lights evenly in every area, yet in fact the prediction is missed because of the insufficient space needed to place the book shelves. It has made the shelves arranged closer one to another than the previous prediction. Consequently, the lights' placement is then ignored to meet the spatial needs. Furthermore, books have bad reflectance value as well as the old shelves used. The above situation makes the lights quality and distribution inside building decreasing. Experimental method in artificial lighting is done by re-arranging the furniture according to the existed light's placement and increasing its reflectance value to 50%. The method is simple yet enough to improve the lighting distribution for ambient needs.

Table 5. Lamps used based on lumens

Existing Lamp Type	Simulation Lamp Type	Lumens
Lampu Baret BCS 22 Clean	Metal Halide	3600
RM 2x36W MO SAVY	Fluorescent	2200
GMS 1x36W ACR SAVY	Fluorescent	1100
Downlight Philips FBS 18W	Compact Fluorescent	1440
Roset ESS 18W	Compact Fluorescent	1000
Spot model QBS	Compact Fluorescent	1000

Field Measurement to Validate The Simulation Results

In order to test the accuracy of the artificial lighting simulation results, a field observation to record the illumination levels of auxiliary lighting inside the building has been conducted. The measurement was done in the evening at 08.00 pm to avoid any daylight interference during the day. All the electric lights were turned on, then a luxmeter was used to measure and record the light illumination level on 80 cm above the floor. Finally, the result shows the similar tendency with the simulation process.

Conclusion of Artificial Lighting Simulation

The simulation shows positive changes on energy efficiency means since the lights installed effectively lit every area inside the building. Little adjustment in furniture layout and the application of brighter paints are able to increase the average illuminance level up to 30% as well as maintaining the effective distribution of artificial lighting inside the building.

Thermal Simulation Using Autodesk® Ecotect™

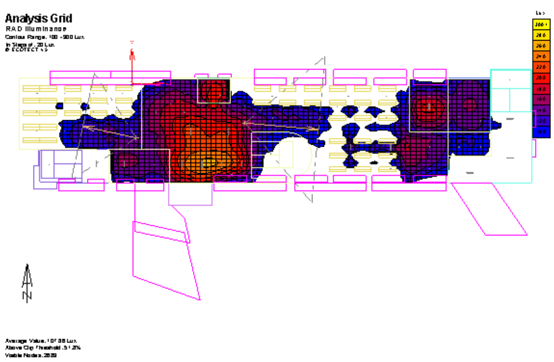
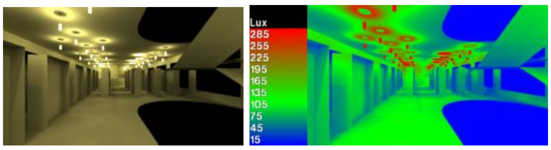
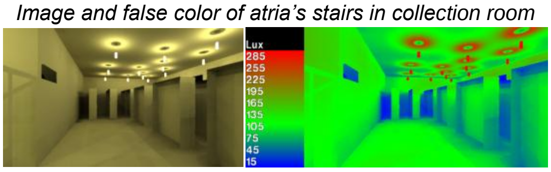
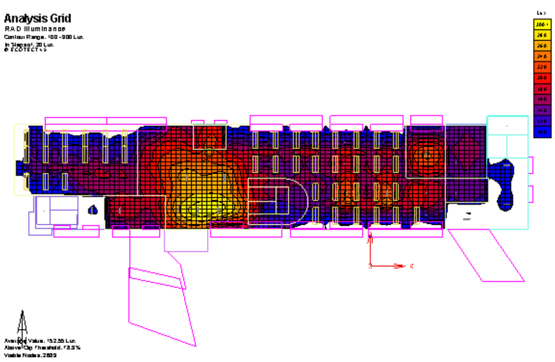
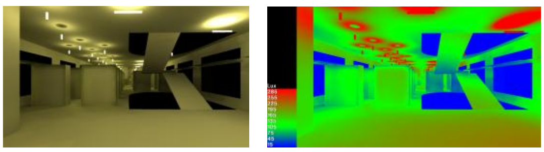
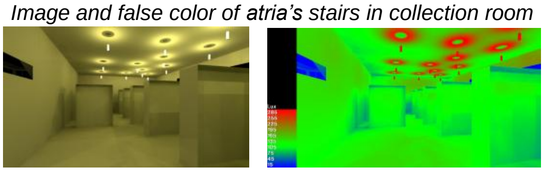
Thermal data gained from the field observation will be calculated in Autodesk® Ecotect™ to assess the building performance from the thermal comfort aspect. Energy analysis then will be done as representation for the previous thermal simulation expressed by the form of Air-Conditioning cooling loads. Focus will be given on the worst case scenario by finding the maximum cooling loads for each room in a year.

Rooms will be examined are the main room with an atria which covers the basement, ground floor, first floor, and second floor. It consists of thesis room (basement), transition room (ground floor), collection room (first floor), and reference room (second room). Additional experiment of computer room in basement is also done as comparison to the atria room. Comparison method will be done by comparing required cooling loads from the simulation result with the manual calculation done by the building's consultant.

Cooling Loads Manual Calculation

Since the manual calculation has been done in the design process by a trusted building consultant, then it will be the benchmark of the simulation process. The calculation was done based on the atria with open partition of room scenario shows the required cooling loads of 858.000 Btu/h. It needs to be converted to watts in order to compare directly with the simulation result. The calculation then becomes 251.3 kW. By the same method, the computer room in the basement shows 30.000 Btu/h or 8.79 kW.

Table 6. Illumination level and distribution of artificial lighting in existed and proposed building

Existed 1st Floor of Building	Proposed 1st Floor of Building
 Picture 3. Artificial Lighting Illuminance Contours  *Image and false color of atria's stairs in collection room*  *Image and false color of book shelves in reference room* Picture 4. Artificial Lighting Image Impressions	 Picture 5. Artificial Lighting Illuminance contours  *Image and false color of atria's stairs in collection room*  *Image and false color of book shelves in reference room* Picture 6. Artificial Lighting Image Impressions
Average illuminance level is 108 lux. Clipped area appears in the middle of room. The layout and low reflectance values of furniture do not accommodate light distribution thus degrading its quality. Even if both daylight and auxiliary lighting utilized all the day, it's still doubtful that they could provide the required light intensity inside this area, especially for reading activity.	Average illuminance level is 152 lux. The distribution has improved in the collection rooms. The layout has been adjusted as necessary and the reflectance of furniture has been increased as well to accommodate light distribution inside the room. Created ambient lighting has met the minimum requirement of light intensity in the library (> 100 lux).

Cooling Loads Simulation Using Autodesk® Ecotect™

Here the simulation will calculate cooling loads prediction in the developed design according to the previous experiments made by means of ventilation and lighting quality improvements. This process can be merely said to be a test about the impact of design changes that have been made so far on the building's energy consumption aspect.

Some variables need to be included in the simulation process are described in the table below.

Table 7. HVAC system input data

System	Efficiency	Operating time/ day
Main Room with Atria (<20^0 C)		
Full AC	80%	13 hrs
Computer Room in Basement (<26^0 C)		
Full AC	80%	13 hrs

Table 8. Occupant's input data

Occupants		
Numbers	Clothes	Activity
Main Room with Atria (<20^0 C)		
325	Light	sedentary
Computer Room in Basement (<26^0 C)		
41	Light	sedentary

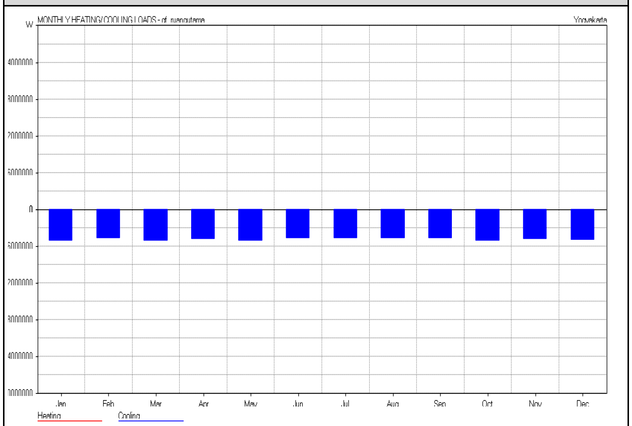
Table 9. Heat and ventilation input data

Equipment Heat		Air Infiltration	
Latent	Sensible	ACH	Sensitivity
Main Room with Atria (<20^0 C)			
6	2	0.5	0.25
Computer Room in Basement (<26^0 C)			
24	2	0.5	0.25

Main Room With Atria

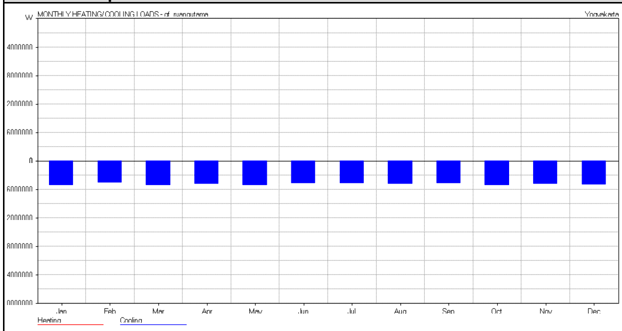
Table 10. Comparison of max cooling loads on the existing and proposed design of main room with atria

Existed Ground Floor's Transition Room



Max Cooling: 63176 W at 12:00 on 11th April

Proposed Ground Floor's Transition Room

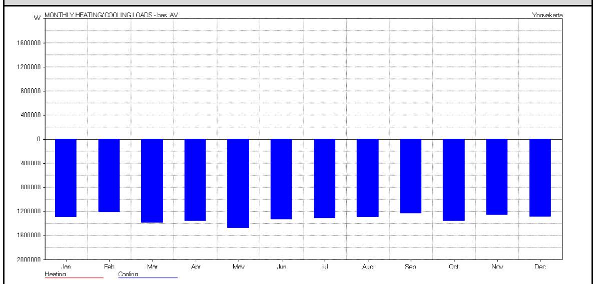


Max Cooling: 60553 W at 12:00 on 11th April

Computer Room (Basement)

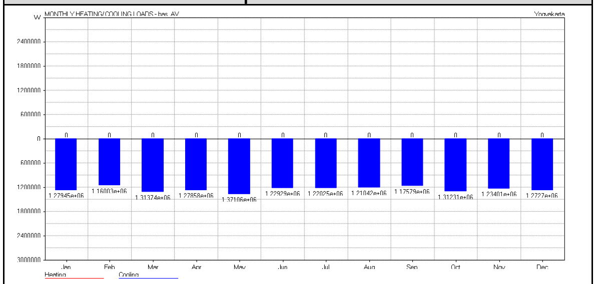
Table 11. Comparison of max cooling loads on the existing and proposed design of computer room

Existed Room



Max Cooling: 6056 W at 12:00 on 11th October

Proposed Room



Max Cooling: 5599 W at 12:00 on 11th October

Cooling loads profile in the main atria room shows the required energy to maintain room temperature below 20^0 C. Lowest loads shown by thesis room, which has the smallest room volume, otherwise the greatest loads is shown by collection room in the first floor due to its biggest volume among others. Total cooling loads required in the existing main atria room is 245 kW and the proposed one is 242 kW. Meanwhile, cooling loads required in the existing computer room is only 6 kW and the proposed is 5.5 kW.

Conclusion of Cooling Loads Calculation

Autodesk® Ecotect™ simulation has a lower prediction of maximum cooling loads than the manual calculation. It is likely that the assumptions used in the manual calculation for unpredictable loads up to 30% have caused little differences between them. However, it needs further investigation to find out the exact cause of this deviation. For now, the error of Autodesk® Ecotect™ for cooling loads calculation based on the manual prediction is 2.4%. The developed design which has been made so far could not reduce the energy consumption significantly, it can only save about 10-15% of total cooling loads in the chosen room.

CONCLUSIONS

The result indicates that the investigated building performance in the form of actual ventilation and lighting quality have many unexpected deficiencies. The worst natural ventilation performance occurred when the wind blows from west and east side of building. The improvement is done by applying wing walls on the north and south side of building in order to create both negative and positive pressure at once on each side thus improving the airflow distribution inside the building. Daylight and artificial light distribution inside the building are not satisfactory either, there are many areas which have the illumination level below the standards of 100 lux. The utilization of view type and light source type windows, light shelf, light pipe, skylight, furniture rearrangement, and reflectance value modification contribute significantly in improving the visual quality and daylight as well as artificial light distribution up to 200% inside the building. The cooling loads calculation on proposed design could not reduce the energy usage significantly (only 10-15%) due to the restrictions that forbid to do major changes on the building. Nevertheless, the previous building performance problems in ventilating and lighting quality have been solved and greatly improved.

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ANCHORAGE ZONES OF POST-TENSIONED SLABS: CONFINEMENT AND EARLY AGE CONCRETE EFFECTS

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ABSTRACT

Highly concentrated stresses are imposed on hydrating concrete in the vicinity of the anchorage assembly when the post-tensioning (PT) load is applied. Thermal and visco-elastic effects are more pronounced in early ages (2 to 7 days) due to a higher rate of hydration reaction. Typically, high early strength type concrete mixes are required to meet the fast paced construction cycles. The stresses associated with confinement effects, thermal and visco-elastic effects due to hydration reaction can introduce more pronounced tensile strains within the slab section than is anticipated. The resulting micro-cracks within the concrete mass can then instigate anchorage zone failure of concrete once the PT load is applied. To illustrate this case, Finite Element simulation of a rectangular section anchorage specimen is investigated. The model validation and a parametric study of the effects of member dimensions, confinement effects, and stress localization are discussed. Results show that while an increase in member dimensions tend to reduce the imposed strains, the specimen confinement has the opposite effects. It is also demonstrated that the AS3600 underestimates the governing transverse tensile forces imposed.

Keywords: Anchorage zone, thermal stress, hydration reaction, stress localisation

INTRODUCTION

Post-tensioning of concrete slabs is a popular due to the many advantages it provides. Faster construction pace, larger clear spans, thinner concrete slabs, and better flexibility in the spacing of columns are some of the advantages of post-tensioning. Large open floor areas are therefore possible, and can be achieved at a reasonable cost. These factors, combined with the ease of access to such systems, have made post-tensioning especially popular in the construction of tall buildings. In order to achieve optimum construction speed and overall economy, the floor construction cycle needs to be carefully optimized. As a part of this, it is important that post-tensioning of the slab is done as early as possible, and according to the project time schedule, so that the slab has sufficient strength when the cycle starts over for the next floor above (Cross, 2007).

To control the internal concrete stresses due to shrinkage and volume changes, an initial 25% of the total PT load is usually applied 24 hours after the concrete pour (Cross, 2007). The criterion for allowing this is that the concrete must have gained a minimum compressive strength of 7MPa. When a compressive strength of 22MPa is reached, typically at 3 to 7 days age, the remaining 75% of the transfer load is applied.

In post-tensioning systems, the prestressing force is transmitted to the concrete section by direct bearing of a steel anchorage plate or assembly on the concrete. It is common, on the basis of elastic analysis of the anchorage zone, to identify two regions in which transverse tensile stresses exist. The tensile stresses that develop along the longitudinal axis of the prestressing tendon have been termed 'bursting stresses'. Those which develop on transverse planes that do not intersect the tendon axis have been termed 'spalling stresses'. The purpose of anchorage zone design is to successfully transmit prestressing forces into concrete members and to continue to do so throughout the life of the member. To achieve this purpose, cracking of the concrete where it occurs must be adequately controlled to an extent determined by the designer. The anchorage zone must have sufficient strength, yet be simple to construct and as economical as possible (CPN29, 1996).

Despite a conservative design approach many anchorage zone failures have been reported in the construction industry. Figure 1 shows a typical anchorage zone failure in a post-tensioned suspended slab. Anchorage failures happen during the post-tensioning process, mostly at the second stage of post-tensioning. As demonstrated, the failures can be serious, explosive in nature and require replacement and repair costs. Reinforcement congestion in the local zone, poor concrete quality and inappropriate workmanship have been blamed for the failures. Inadequate strength prediction of in-situ concrete at the time of application of the post-tensioning has been another prevalent hypothesis. Anchorage failures have been occurring at the dead and live ends, resulting in loss of load in the strand, delamination and spalling of concrete around the anchorage.

Figure 1. Typical local anchorage failure of slab

ANCHORAGE ZONE DESIGN

While the anchorage assembly and the anchorage zone design take shape and depend on the structural form and the tendon profile, for design purposes a number of simplifications are made. The simplest case is a bearing-plate imposed in a rectangular section member. Figure 2 shows a single concentrated anchorage plate on a rectangular section and the resulting principle stress contours after (Breen and Sanders, 1997).

The anchorage zone is divided into two distinct regions: local zone and general zone. Compressive stresses happen immediately ahead of the anchorage assembly whereas as spalling and bursting stresses (tensile stresses) happen elsewhere as pointed out. In the figure, the prestressing force is indicated by (P) and the region of the local anchorage zone is defined by (a) which is a function of anchorage plate dimension and the required cover for the prestressing member.

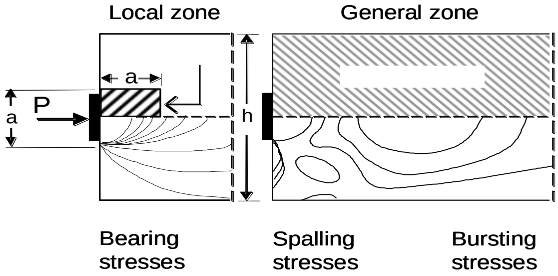

Figure 2. Principle stress contours

Guyon's 'symmetrical prism' concept and his widely used design graphs were published in 1960 and are still widely referenced today. Guyon defined the symmetrical 'prism' (or notional prism) as a prism whose central axis corresponds to the axis of the prestressing anchorage and whose half width is determined by the closest external surface (Guyon, 1953). This suggests that when more than one anchorage is used in an end-block, they can be considered as single symmetrical prism each and be designed as separate entity.

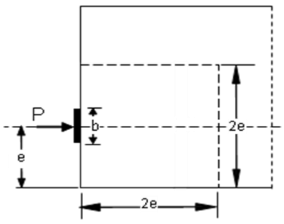

Figure 3. Symmetrical prism

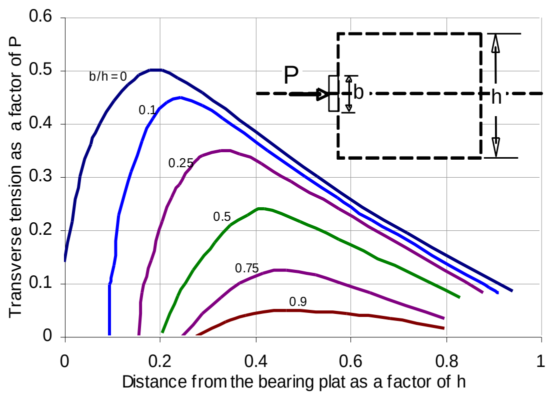

Figure 4. Transverse tensile stresses

Further, the magnitude of the busting stress in the end-block is described to be a function of the bearing-plate to member side ratio. On this basis, a number of experimental and numerical investigations have been carried out on axially loaded prism to determine the capacity of the anchorage in concrete (Guyon, 1960; Zielinisky and Rowe, 1960; Wheen, 1977; Fenwick and Lee, 1986; Breen et al., 1994). Guyon's solution for bursting stress distribution for various ratios of bearing plate width (b) to member depth (h) is presented in Figure 4. Clearly, Figure 4 indicates that as the plate size increases, the transverse tensile stress induced in the member decreases.

The maximum bursting stress (*max* f_t) is written in terms of tendon force *P* and maximum bursting force (T_{burst}) according to Breen et al (1994):

$$\max f_t = \frac{T_{burst}}{0.55h \times t} \tag{1}$$

Where, $T_{burst} = \frac{P}{4}\left(1 - \frac{b}{h}\right)$; (2)

t is the member width and it is noted that the relation is limited to members with rectangular sections only.

Review of Code Development

Reinforcement is provided to resist the bursting and spalling forces induced by the concentrated loads at the anchorage zones. To contain the bearing stresses a spiral-type reinforcement is used. The quantity of reinforcement is usually specified by the post-tensioning kit suppliers who base their decisions mainly on anchorage efficiency tests carried on beams or slabs depending on the type of anchorage. In both ACI 318R (2002) and AS 3600 (2009), the bursting force at rectangular sections is calculated using a relation that is consistent with Equation 3. In The Austroads 92 Bridge Design Code (11), the bursting force is calculated using a similar equation to that of Equation 3 but the factor of safety has been increased by changing the equation's coefficient from 0.25 to 0.33. A comparison of each of these formulae with the historical results of other researchers is shown in Figure 5 (CPN29, 2000).

The major difference in the amount of reinforcement required by the various codes is a result of the allowable stress. In The 92 Austroads Bridge Design Code, the allowable stress is a maximum of 200 MPa for bursting forces and 150 MPa for spalling stresses. In AS 3600–1994, the maximum allowable stress is 150 MPa for both bursting and spalling stresses (CPN29, 2000).

ANCHORAGE ZONE STRESSES

Equation 2 which is currently used by the Australian and American standards to estimate the bursting stresses is a modified version of the model proposed by Zielinski and Rowe (1960). In order to consider the performance of newer generation materials and the early age effects, it was deemed necessary to consider studying a model similar to that presented by Zielinski and Rowe (1960). In what follows, a finite element model of end-block with a circular loading anchorage surface is presented. The model is a replicate of the end-block specimen (type CIII, no embedded anchorages, no Ductubes experimentally tested by Zielinski and Rowe (1960). This will be followed by a discussion of the model validation and a parametric study including the effect of material properties.

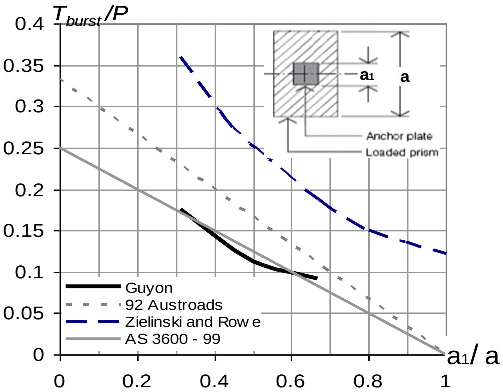

Figure 5. Relationship between tensile force (T)/prestressing force (P) and a_1/a

Experimental Work: Zielinski and Rowe

The essential information presented in this section is based on the report presented by Zielinski and Rowe (1960). The details of the experimental investigation together with some results are presented in this section with due acknowledgements to the original source. For ease of reading, the Imperial units are converted to SI units and presented within brackets.

End-Block Description

The first part of the extensive experimental work undertaken by Zielinski and Rowe consisted in prisms with single concentrated loads. Only one out three different types of specimen tested was selected for the purpose of FEM analysis. The details of the specimen which is considered in this paper are presented in Figure 6.

As can be seen from the figure, the anchorage or the loading plate is placed symmetrically. Two different types of anchorages have been used. The first one is a flat round plate as depicted in Figure 6a and the second one is the embedded female cones, part of which can be seen in Figure 6b. The test results for these two types are discussed in the following sections. The choice for the type and size of the specimens was based on the anchorage types available at the time. Although the report discusses the results of specimens with embedded reinforcements, only the results of unreinforced type specimens are discussed in this paper.

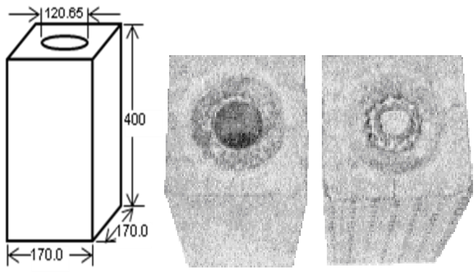

Figure 6. a) end-block dimensions; and b) end-block with embedded cone and plate loading surfaces

Materials

The concrete used had an aggregate to cement ratio of 3.55 and a water to cement ratio of 0.45. The sand and coarse aggregate ratio is reported to be 22:78. The concrete was cast in the vertical direction and vibrated into position. Standard control specimens in the form of 6 in. cubes (152.4mm) and 6 × 12 in. cylinders (152.4 × 304.8mm) were cast. Both the test specimens and the control specimens were demoulded after 24 h and then cured in water for 7 days; subsequently the specimens were stored in the laboratory until tested.

Testing Procedure

For the unreinforced specimens, load was applied to the prism by a manually operated hydraulic jack of 50 kN capacity. The load was applied at increments of 10kN.

Measurements of surfaces strain were obtained on the specimen with a 2 in. (50.8mm) Demec strain gauge. Figure 7 shows a typical specimen under test. Longitudinal and transverse strains were obtained on between four and six vertical sections at 1 in (25.4mm) centres, the number depending on the size of the cross section. In the regions where the maximum tensile stresses were expected, strain gauge rosettes were employed to determine the principle strains and their direction.

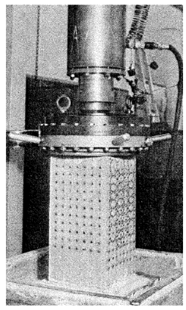

Figure 7. An anchorage specimen under test

Brief of the Experimental Results

The distribution of transverse strain at an average compressive stress of about one – tenth of the cube strength is presented in Figure 8. In the figure, each point represents the weighted mean strain obtained from two readings on each gauge length of the three sample specimens. There is no significant different in the shape of the transverse strain distribution curves although there is a difference of about 12% between the maximum tensile strains, those for loading through the male cone being the greater.

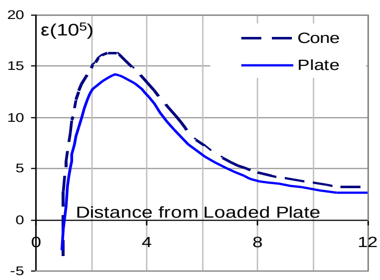

Figure 8. a) Transverse strains on central axis of end-block, uniform compression, P = 1,250 lb/in2 (8.6MPa).

The crack pattern for the two loading conditions were essentially the same although the load at which cracking first occurred was 5-15% higher for plate loadings which agreed well. The cracking pattern for the end-block is presented in Figure 9a and 9b presents the isometric diagrams for the transverse strains of the end-block.

It is stated that the first cracks appeared usually on two parallel sides near the central axis of the prism at a distance of 0-1.75 in. (0 to 44.5mm) from the loaded surface which corresponds to 0-0.5a where 2a is the width of the block. The cracking, ultimate loads and material data correspond to the end-block are presented in the following Table 1. Hence, it was concluded that although there is a difference in the maximum tensile strain, the actual distribution is independent of the manner of loading and type of anchorage.

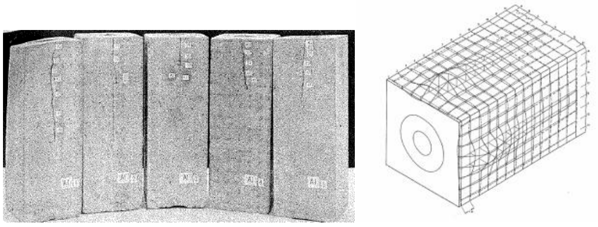

Figure 9. a) cracking pattern for the tested specimens; b) Isometric diagram of the transverse strains

Table 1. Material information, cracking and ultimate loads

Series	***f'c***		***ft***	**P_{cr}**	**P_{ult}**
	28D	Test	Test		
BI	7730 (lb/in^2)	8850 (lb/in^2)	530 (lb/in^2)	**77.5**	**80.0**
BI	53.3 (MPa)	61.0 (MPa)	3.7	**77.5**	**80.0**

Finite Element Model (FEM)

From the experimental results and discussion presented above it can be concluded that in first stage, the concentric load can be limited to the elastic range of the material behaviour. That is to measure and validate the longitudinal and transverse strains of the end-block. In a second stage, the load can be increased to material failure. In this case, non-linear material law need to be included. The use of material parameters such as Elastic Modulus and Poisson's ratio gain special importance to investigate the stress distribution.

Accordingly, the three-dimensional simulation of the end-block, as described in Figure 10, consists in a phased analysis. This is to take into consideration the early age effects such as hydration effects, thermal stresses and then superimpose these to the second phase of the study that includes the execution of the mechanical simulation. Due to the scope of the paper and space limitations, the study of the first phase of the study is no longer discussed here. The reader may refer to an earlier publication for a discussion of heat flow – stress staggered analysis (Sofi et al., 2008).

The FEM mesh of the end-block is presented in Figure 10. A pressure load is applied on the circular load surface. A non-linear calculation is performed using CTE10H (pyramid 3 sides, 10 nodes) element model available in FEM package DIANA 9.3 (de Witte and Kikstra, 2005).

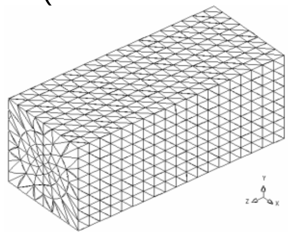

Figure 10. 3-D finite element mesh representing end-block

The isoparametric pyramid element which is based on quadratic interpolation is chosen based on the geometry of the model. DIANA uses 10-nodes elements internally for the heat analysis to ensure compatibility of the temperature strains with the interpolation functions used in the structural analysis.

Solution Methods

The numerical simulation conducted in this study uses displacement control procedure. The procedure is more stable than the force control procedure especially for extensive nonlinear sistem. The iterative procedure used for nonlinear analysis employed in this study is the Modified Newton-Raphson method. The Modified Newton-Raphson needs more iteration than the Regular Newton-Raphson method. However, as the stiffness is only evaluated at the beginning of the increment, less time is required in the computation of every iteration than in the Regular Newton-Raphson method.

FEM Results

The material properties as presented in Table 1 were used as an input for the analysis. In the report, the specified value for modulus of elasticity is E = 5.5×10^6 lb/in^2 (37921.16MPa) and two different values of Poisson's ratio (v = 0.125 and 0.167) are used to investigate the transverse strains. These values, however, are not established based on current standard testing methods. The authors mention that 'since the transverse and longitudinal strains were recorded on the surfaces of the blocks, the actual values of Young's modulus and Poisson's ratio could be determined' (Ziewlinsky and Rowe, 1960). The accuracy of these parameters can be considered open to discussion.

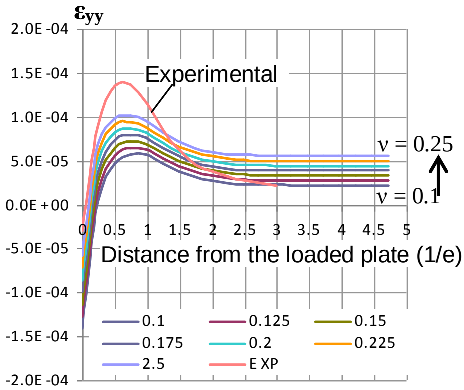

Figure 11. Effect of Poisson's ratio on transverse strain distribution

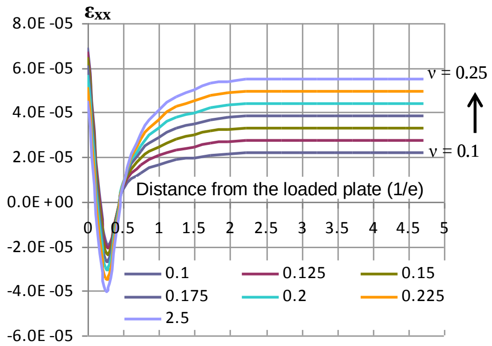

Figure 12. Effect of Poisson's ratio on out-of-plane strain distribution

In the first stage, the value of Modulus of elasticity (E = 37921.16MPa) is considered and the Poisson's ratio value is varied. The results are plotted in Figure 11 and 12 which represent the strain distribution, along the central line, on the face of the specimen. From the Figure, the effect of Poisson's ratio on transverse strain (ε_{yy}) is clear. For every 0.025 increase in ν an average strain of 7.30×10^{-06} is added to the transverse strain values. It is noted that while the maximum strain values are lower than the experimental value, the location of the maximum transverse strain compares well with that measured experimentally, i.e., if falls within 0-0.5e where 2e is the width of the block as defined in Figure 3 – which is consistent with experimental measurements.

Figure 12 plots the out-of-plane strains distribution (ε_{xx}) for the same elements for which the transverse strain are presented. Interestingly, it shows the compressive strains up to about the value of 1/e = 0.5 which jump to tensile strains afterwards. On average, the maximum out-of-plane strains are about half of those of transverse strains and, therefore, have a lower significance considering the anchorage zone capacity.

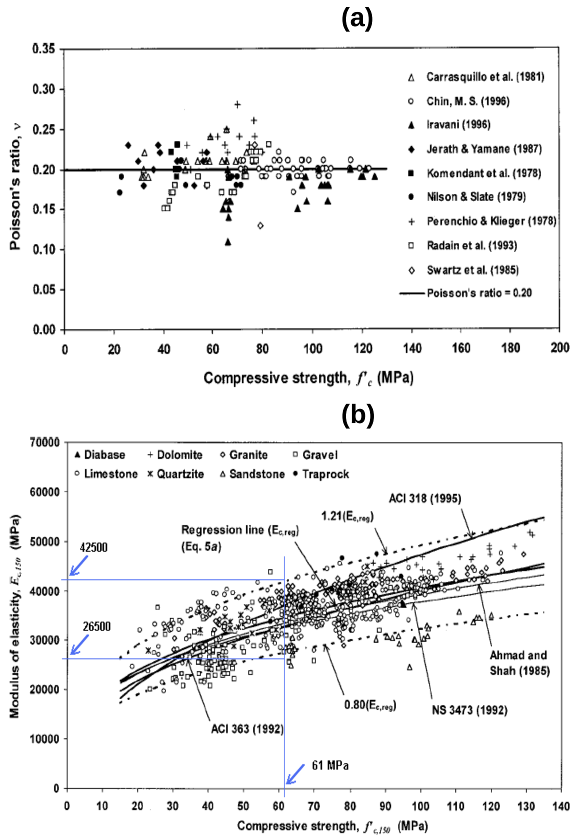

Figure 13. Range of (a) ν and (b) E for f'_c = 61MPa, (Courtesy: Rashid et al (2002)

In the second stage, a parametric study of the effects of modulus of elasticity is carried out. In order to establish a suitable range of values for the current analysis, a couple of well established relations representing material parameters such as ν and E on the basis of compressive strength were considered. Rashid et al (2002), for instance, analysed a large volume of experimental data collected from published material to relate E and ν to compressive strength. According to Rashid et al (2002) ν and E –values range from 0.15 to 0.25 and from 26500 to 42500 MPa, respectively, as pointed out in Figure 13.

Given that high strength concrete (HSC) is a suitable material for anchorage zones and that 61MPa is normally considered outside the range of normal strength concrete (f'_c = 50MPa), the relation reported by Mendis et al. (1997) is also considered for this study. An empirical relation to predict the elastic modulus of concrete, including HSC, was reported as follows:

$$E_c = 0.043\, \eta\, \rho^{1.5} \sqrt{f'_c} \pm 20\% \qquad (3)$$

where:

ρ = the density of concrete
η = 1.1-0.002 $f'c \leq 1.0$ and,
η = 1.0 for NSC and < 1 for HSC depending up 28 days concrete strength.

Research showed that the above equation, which is a modified version of the relation reported in AS 3600 has a tendency to overestimate or underestimate the elastic modulus of NSC by 20% with various types of aggregates, Mendis et al. (1997). The estimated values of v and E according to Rashid et al (cases 1-4) and Mendis et al (cases 5-8) are summarised in Table 2 and the associated results representing the transverse strain (ε_{yy}) for each case is presented in Figure 14. In Table 2 the range of modulus of elasticity values is presented.

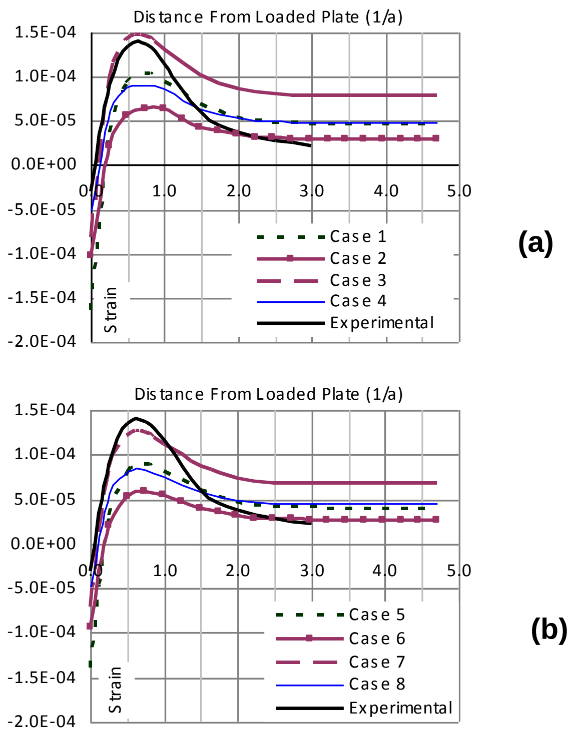

Figure 14. Transverse strain distributions (ε_{yy}): (a) according to Rashid et al; and, (b) according to Mendis et al equations

From results presented in Figure 14, it can be seen that with an increase in E value the transverse strain decreases. Clearly, from Figure 14 it can be seen that that higher v-value of 0.25 together with lower values of E better predict the experimental strain distribution. While cases, 3 and 7 are both fit for consideration for the purpose of further analysis, they both present conservative values of ε_{yy} for the region beyond a e = 1.

In what follows, a discussion of parameters such as size and confinement effects is presented. The model is then extended to briefly discuss the early age concrete effects.

Table 2. Summary of v and E values

	Poisson Ratio	Mod. Of Elasticity
Case 1	0.15	26500 Mpa
Case 2	0.15	42500 Mpa
Case 3	0.25	26500 Mpa
Case 4	0.25	42500 Mpa
Case 5	0.15	30894 Mpa
Case 6	0.15	46341 Mpa
Case 7	0.25	30894 Mpa
Case 8	0.25	46341 Mpa

Principle Stress Contours and Cracking Pattern

The Principle stress contours from increasing load level are shown in Figure 15.These represent the bursting stress next to anchor plate. It can be seen that as the as the load is increased, the bursting stresses become more significant at the location next to anchor plate. The crack patterns (Figure 16) demonstrate the material failure where tensile stress reach material's tensile strength.

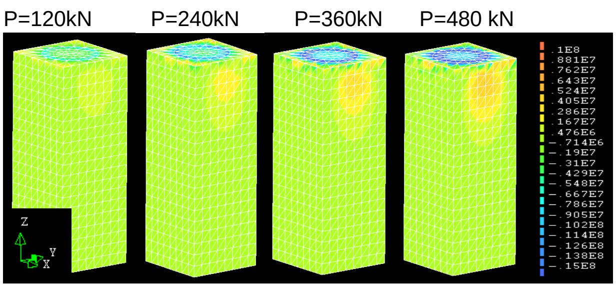

Figure 15. Progression of stress in Y direction with increase in load progression (E = 30894 MPa, v =0.25, f'_c=61MPa)

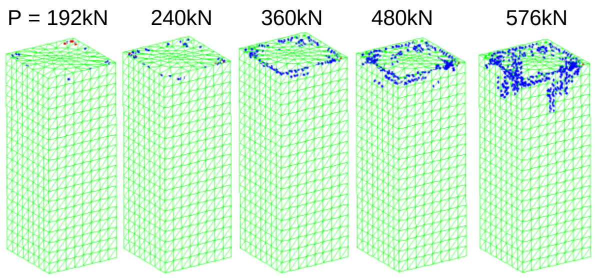

Figure 16. Cracking patterns

To model the crack, fixed crack model was used. As can be observed from the figure, cracking starts next to loading plate and with an increase in load, progresses downward. At higher loads cracks appear to progress downward along the centre line of the specimen which is consistent with the observations made in the by the Ziewlinski and Rowe's experiments (see, Figure 9).

Confinement Effects

The difference between rectangular section members such as beams and slabs is that slabs have a much higher surface to volume ratio compared to beams. It is expected that the confinement on the anchorage zone provided by mass slab reduce the bursting strains (E_{yy}), however, this effect may add to the out-of-plane strains. The current model is extended to evaluate the effects of changes in dimensions and confinement effects on the strain distribution. If the end-block is considered to be a free body diagram of part of a slab along the line of action of the load (see, Figure 17a). The slab components on the two sides will act as confining bodies to the end-block. In reality they would have the same stiffness as the end-block material. For the sake of simplicity, they can be assumed to be rigid. In FEM representation, they are modelled as constraints in nodal displacements in Y-direction on two opposite faces, as shown in Figure 17b.

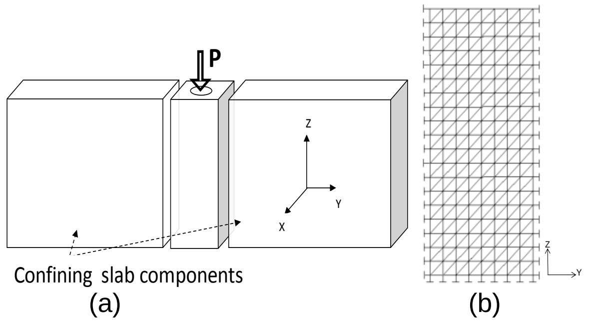

Figure 17. Confinement effects on end-block

To simulate confinement effects, case 7 in Figure 14 was chosen. The results demonstrate that with an introduction of confinement, a decrease of up to 53% in maximum strain value (ε_{yy}) can be expected. This would translate into a reduction in bursting of stresses at the anchorage zone. While the shape of the strain distribution along the member length appear to be similar to that of unconfined specimen, the location of the maximum strain is shifted closer to the loading plate, as pointed out in Figure 18. This shift can be significant in that it is now closer to a location where the bearing stresses are mostly prevalent. In practice, although regions next to the anchors are heavily reinforced, concentration of bursting and bearing stresses can easily instigate cracking or crashing of the concrete in the local zones.

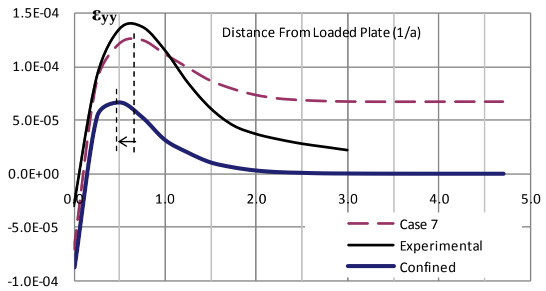

Figure 18. Reduced ε_{yy} due to confinement effects

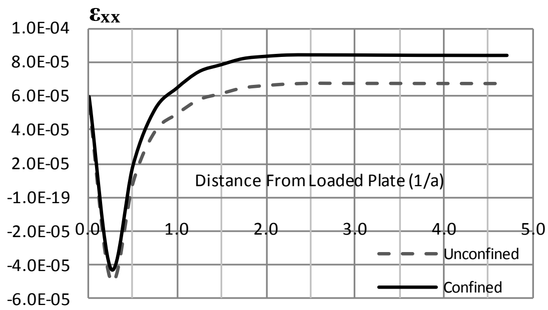

Figure 19. Reduced ε_{xx} due to confinement effects

Figure 19 plots the out-of-plane strain distribution (ε_{xx}) for both confined and unconfined specimens. Clearly, the strain values remain unchanged.

Early age effects

As mentioned earlier, the initial post-tensioning load is applied at 1-2 days after the concrete is cast. Instantaneous elastic deformation will take place at the time of application of the PT-load. This deformation is fully instantly recoverable. However, during the application of the load, a delayed, or viscoelastic, deformation equally occurs. This deformation is believed to be associated with moisture movements in the microstructure inflicted by the macroscopic stresses in the material (Neville et al., 1983). It has been stated that the visco-elastic deformation at early ages are more pronounced (Sofi et al 2008). In this section, however, the instantaneous elastic deformation is further discussed. The time-dependent effects will be covered in a future study.

In addition to a thorough knowledge of the early age volumetric dilations due to hydration reaction and associated thermal effects, the mechanical properties must be determined in order to be able to model the behaviour of early age concrete. Compressive and tensile strengths are generally used to establish material failure. Modulus of elasticity provides an indication of the state of stress which can be induced due to volumetric changes or by a mechanical action such as PT-load. For the purpose of FE- analysis in, Poisson's ratio must be known in order to obtain a more accurate indication of the state of stress.

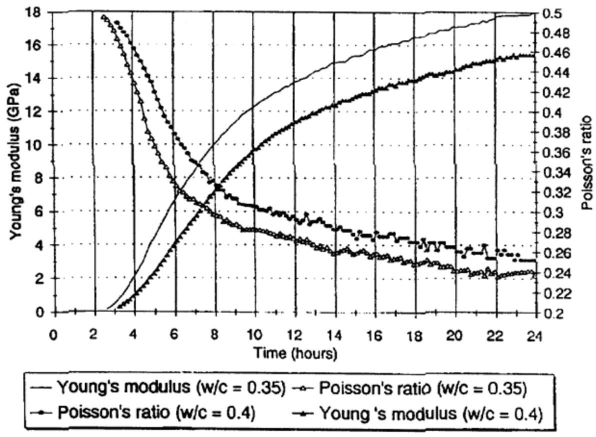

Figure 20. Development of dynamic Poisson's ratio and dynamic modulus of Elasticity with age. (Boumiz et al. 1996)

However, literature reports that the both *E* and v change with age (Byfors, 1980; Boumiz et al. 1996). At the very early ages after pouring the concrete (i.e., up to 1 day), the v is high due to presence of un-binded water particles. Then it is reduced to a lower range of 0.24 to 0.26 values as the hydration reaction proceeds within a day after pouring. The Modulus of Elasticity is characterised by a much lower value i.e., a fraction of its value at 28days and increases with time. The development of *E* and v depend amongst other on water-to-cement ratio, pour and curing temperatures and humidity. Boumiz et al. (1996) have investigated the development of the dynamic Poisson's ratio through the ultrasound measuring technique. A typical set of results from Boumiz et al. (1996) is presented in Figure 20. The results clearly demonstrate the progression of *E* and v over time and the fact that for a mix with higher water-to-cement ratio, values of v is higher and that of *E* lower. In particular for PT applications high early strength mixes are used typically with water-to-cement ratio of 0.5.

Assuming that the initial PT load is applied at approximately one day after concrete member is cast, i.e., a lower *E* and a higher value of v would be expected. To evaluate the effects of these on the bursting strains, the values of *E* and v corresponding to 20hrs and 24hrs are read from Figure 20. The results of the analysis for the simulation of the anchorage according to the current model are presented in Figure 21. In the figure, the values set under the legends represent the water-to-cement ratio, *E* (MPa) and v values, respectively. The maximum bursting strains are higher than that obtained experimentally.

The strain values range approximately from 1.5 to twice the maximum bursting strain value of the control specimen. The results presented are remarkable in that they point out to the effects of water-to-cement ratio on the bursting capacity of the anchorage zone. It is noted that with a marginal difference in water-to-cement ratio and, hence, the associated early age concrete material parameters, the strains induced due the PT load can be significantly accentuated at early ages and therefore, increasing the risk of anchorage zone failures.

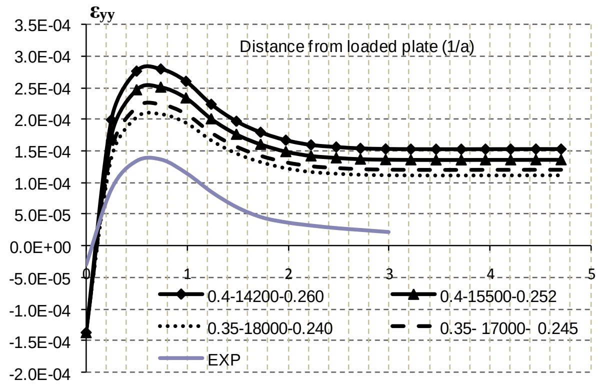

Figure 21. Bursting strains (ε_{yy}) considering early age parameters

The results in hand demonstrate that the anchorage zone performance is sensitive to water-to-cement ratio and concrete propertes. As demonstrated, a small increase in water-to-cement ratio (i.e., from 0.35 to 0,4) increased the bursting strain up to 17% of the maximum strain with adverse effects on anchorage zone capacity.

CONCLUSIONS

While the current results are obtained from a model which does not include the effects of reinforcement, it provides useful results for comparing the effect of different parameters on anchorage zone capacity. In particular it is seen that material properties such as modulus of elasticity and Poisson's ratio are important parameters. In early ages, these properties depend on degree of hydration at early ages and evolve over time. Therefore, it is important to have an accurate estimate of these parameters when designing anchors. It is argued that addition of water to the concrete mix during the construction period can highly increase the risk of anchor zones failure.

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DUCTILITY IMPROVEMENT OF DEEP BEAM BY NYLON MESH CONFINEMENT

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ABSTRACT

Indonesia is earthquake prone area which needs awareness of disaster reducing efforts. One effort to provide earthquake resistant building is to serve ductile concrete structure member such as beam. For recent time, the confinement has become important way in improving ductility of concrete beam. This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some specimens confined by expanded metal sheet. The research conducted experimentally by some deep beam specimens with specification: f'_c design = 30 MPa, b = 10 cm, d = 20 cm, a = 20 cm, and L = 60 cm; some confined by nylon mesh and some confined by expanded metal sheet. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh. The specimens are tested by third point flexural beam test. The research meets conclusions: (1) The deep beams using nylon mesh confinement improves utlimate load significantly, up to 150%, compared to unconfined one while its ultimate load is 20% higher than the ones using expanded metal sheet; (2) The modulus of rupture of deep beams using nylon mesh confinement is about 15% higher compared to beams using expanded metal sheet confinement and 230% higher than unconfined deep beams, and (3) It is proved that nylon mesh confinement can improve ductility of deep beam significantly, hence the deep beams confined by nylon mesh perform as earthquake resistant concrete structure member.

Keywords: *ductility, deep, beam, nylon mesh, confinement*

INTRODUCTION

Indonesia is earthquake prone area which needs awareness of disaster reducing efforts. One effort to provide earthquake resistant building is to serve ductile concrete structure member such as beam. For recent time, the confinement has become important way in improving ductility of concrete beam.

The importance of confinement application for beam has been delivered by previous researches in various materials and design (CFRC, *continuous fiber reinforced cement*; CFRC, *continuous fiber reinforced polymer*; ferrocement strips; wire mesh; steel stirrup) in examples Wu and Sun (2005); Rafeeqi, Lodi, and Wadalawala (2005); Delalibera and Giongos. Previous researches on nylon mesh confinement have been established by Setyanegara and Sagitha (2008), Lelono and Widi (2009), Susilorini, et al. (2009), Susilorini (2009a-d). As emphasized by Susilorini (2007; 2008; 2009a-d), nylon fiber has advantages such as great value of tension strength and elongation also unique characteristic of 'yield point elongation', and stable crack width.

Deep beam is a term of beam which has slenderness ratio (a/d) of less than 1 (Nawy, 1996). Deep beams generally used in tall building that is supported by individual column; also used as transfer girders in long span structures (Shah and Mishra, 2004). The ductility performance of deep beams is necessary for good earthquake resistant design. Hence, some parameters such as displacement, ultimate load, and modulus of rupture, are needed to define the ductility of deep beams.

Modulus of rupture is defined as theoritical maximum tensile stress at the bottom fiber of beam (Neville, 1999) which can be expressed by

$$R = \frac{PL}{bd^2} \tag{1}$$

where R = modulus of rupture, P = load, L = beam span, d = depth.

This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some specimens confined by expanded metal sheet.

METHODS

The research conducted experimentally by some deep beam specimens with specification: f'_c design = 30 MPa, b (width) = 10 cm, d (depth) = 20 cm, a (shear span) = 20 cm, and L (span) = 60 cm; some confined by nylon mesh and some confined by expanded metal sheet. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh which cover the steel bars. There is no transversal reinforcement. The specimens consist of one unconfined deep beam, 3 deep beams using nylon mesh confinement (Figure 1), and 3 deep beams using expanded metal sheet confinement (Figure 2).

The specimens are tested by third point flexural beam test as described by Figure 3. The load and displacement measured by dial gauges. A hydraulic jack used to load the specimens.

Figure 1. The placement of nylon mesh confinement for deep beams which cover the steel bar (Lelono and Widi, 2009; Susilorini, 2009a,b)

Figure 2. The placement of expanded metal sheet confinement for deep beams which cover the steel bar (Lelono and Widi, 2009; Susilorini, 2009a,b)

Figure 3. Experimental set-up with dial gauges and hydraulic jack loading equipment (Lelono and Widi, 2009; Susilorini, 2009a,b)

This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some deep beam specimens confined by expanded metal sheet.

RESULTS AND DISCUSSION

Experimental result of Figure 4 shows that confined deep beams by nylon mesh achieve maximum load about 2100-2400 N and displacement about 10-12 mm, and modulus of rupture 31.5-36 MPa; while the confined deep beams by expanded metal sheet achieve maximum load about 1800-2200 N and displacement about 14-16 mm. The unconfined beam can only achieves load of 1000 N at displacement of 8 mm.

Firstly, the deep beams using nylon mesh confinement improves utlimate load significantly, up to 150%, compared to unconfined one. The ultimate load of deep beams using nylon mesh confinement is 20% higher than the ones using expanded metal sheet. Secondly, the load-displacement curve of confined deep beams by nylon mesh has shown more ductile behaviour that there is smooth increasing of load at stage yield and ultimate while the confined deep beams by expanded metal sheet has 'jump' increasing load from stage yield to stage ultimate.

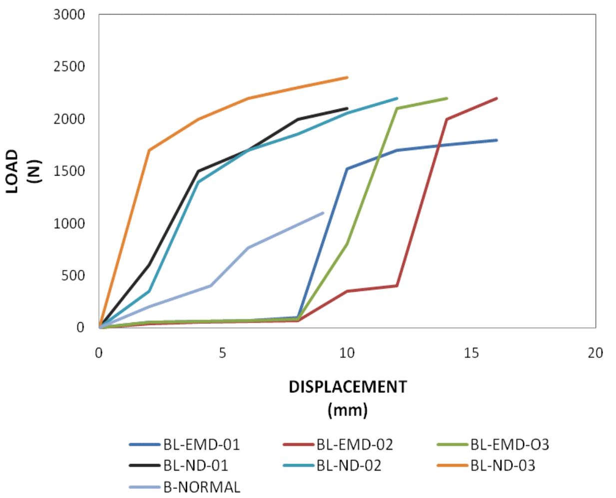

Figure 4. Load-displacement relation of beam specimens (Modified from Lelono and Widi, 2009)

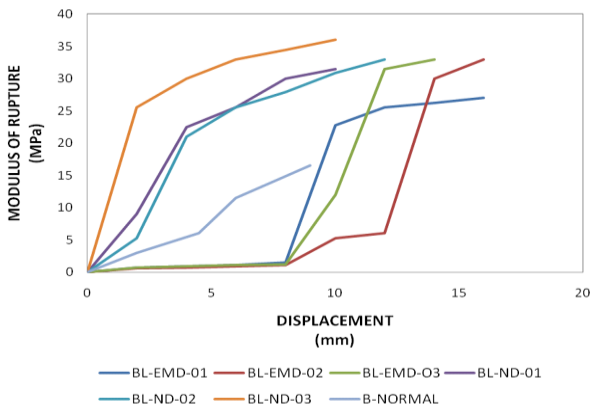

Figure 5. Modulus of rupture-displacement relation of beam specimens (Modified from Lelono and Widi, 2009)

In other words, nylon mesh confinement maintain load increasing at yield stage as well as ultimate stage. On the opposite, the expanded metal sheet confinement cannot keep the load at elastic stage as high as nylon mesh confinement. After first crack, the load jumps up and suddenly after the ultimate load achieve it is getting failure immediately. Even though the displacement of deep beams using nylon mesh confinement is lower, it still keep ductile behaviour better than deep beams using expanded metal sheet confinement.

Figure 5 shows that the modulus of rupture of deep beams using nylon mesh confinement ranged about 27-33 MPa. The values are about 15% higher compared to the deep beams using expanded metal sheet confinement and 230% higher than unconfined deep beams. It means, the nylon mesh confinement effectively improve maximum tensile stress at the bottom fiber of deep beam, much better than.

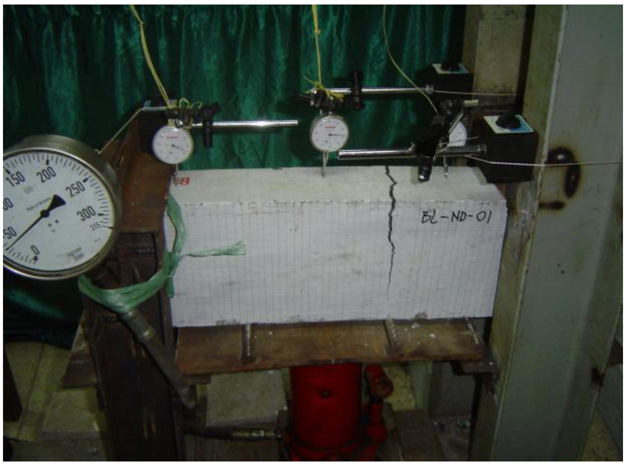

Figure 6. Crakced deep beam using nylon mesh confinement (Lelono and Widi, 2009)

Figure 7. Failure of deep beam using expanded metal sheet confinement (Lelono and Widi, 2009).

The failure of deep beam specimens can be explained through observation as follow. At failure stage, the deep beams specimen using nylon mesh confinement are not separated into two partst. Figure 6 shows that the nylon mesh keep the deep beams engaged by small width of crack in the middle of the beam. On the contrary, at the failure stage, the deep beams using expanded metal sheet confinement are broken into two parts, as described by Figure 7. It can be said that the broken deep beams have brittloe confinement, it is expanded metal sheet confinement.

CONCLUSIONS

This paper meet conclusions:

1. The deep beams using nylon mesh confinement improve utlimate load significantly, up to 150%, compared to unconfined one while its ultimate load is 20% higher than the ones using expanded metal sheet.
2. The modulus of rupture of deep beams using nylon mesh confinement is about 15% higher compared to beams using expanded metal sheet confinement and 230% higher than unconfined deep beams.
3. It is proved that nylon mesh confinement can improve ductility of deep beam significantly, hence the deep beams confined by nylon mesh perform as earthquake resistant concrete structure member.

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PERFORMANCE OF SLIM CONCRETE BEAM USING NYLON MESH CONFINEMENT

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ABSTRACT

Confinement has become significant way to improve ductility of concrete structure member which is very important in concrete earthquake resitant design. When a requirement of ductile-resistant concrete structure member is provided by beam concrete, then its performance should be supported by strength effort in reducing the hazard of earthquake, in example, by introducing the nylon mesh confinement. For slim beams, it is important to determine how the beam behave during the loading history. This research investigates the performance of slim beam using nylon mesh confinement. The research is conducted experimentally by some specimens of slim beams which are unconfined and confined by nylon mesh. All specimens have: f'_c design = 40 MPa, b = 10 cm, d = 20 cm, a = 100 cm, L = 300 cm, and slenderness ratio 5. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh. The specimens are tested by third point flexural beam test by computerized UTM and data logger of strain gauges.The research meets conclusions: (1) The confined slim beams perform higher maximum load with same displacement of 70 mm; (2) The confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not; (3) The curvature of ductility ratio and curvature of slim beams of confined slim beams are about the same; (4) The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam; (5) The confined slim beams perform higher ductility compared to unconfined beam; and (6) The nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member.

Keywords: *performance, slim, beam, nylon, mesh, confinement*

INTRODUCTION

Confinement has become significant way to improve ductility of concrete structure member which is very important in concrete earthquake resitant design. When a requirement of ductile-resistant concrete structure member is provided by beam concrete, then its performance should be supported by strength effort in reducing the hazard of earthquake, in example, by introducing the nylon mesh confinement. For slim beam, which has slenderness ratio of and more than 5, it is important to determine how the beam behave during the loading history.

Park and Paulay (1975) explain that the mechanism of confining effect is not so simple. When compressive stress achieved in lower value, transversal reinforcement is stressed, but it is lightly, then the reinforcement will not affect the concrete area. If only ultimate stress achieved, the transversal strain of concrete is increase, and crack propagation will be generated. Because of the phenomenon, concrete is expanding and then will compress the transversal reinforcement. In case compresive area confined, then the ductility of beam will be improved.

Concrete beam should be designed in ductile way to assure its earthquake resistance. When slim beams applied to the structure, its failure mechanism will become very important consideration. According to Nawy (1996), slim beams are categorized by slenderness of ratio of shear span, a, and effective depth, d, of beam. Slim beams have slenderness of more than 5, while moderate slim beams have slenderness of 2.5-5, and deep beams have slenderness of less than 1. Generally, the performance of slim beams are subjected to shear, but this paper want to discuss its flexural performance as well while nylon mesh confinement applied.

Some previous researches emphazise the advantage of confinement to improve beam ductility such as Wu and Sun (2005) use thin CFRC (*continuous fiber reinforced cement*) and CFRC (*continuous fiber reinforced polymer*) sheets for structural retrofit as external wrap to achieve maximum load; Rafeeqi, Lodi, and Wadalawala (2005) upgrade and strengthen beams with ferrocement strips and wraps with one or two layers of wire mesh; Delalibera and Giongos (2008) apply additional transversal reinforcement of stirrups in compression area. Nylon mesh confinement has been applied in concrete beams by Setyanegara and Sagitha (2008), Lelono and Widi (2009), Susilorini, et al. (2009), Susilorini (2009a-d). Those researches have shown significant ductility improvement of beam. It can be understood because nylon fiber that is applied into cementitious matrix has advantages such as great value of tension strength and elongation also unique characteristic of 'yield point elongation' (Susilorini, 2007; 2008; 2009e; 2009f).

Analitically, two parameters (Park and Paulay, 1975) discussed in this paper can be explained by equations (1)-(3) as follow.

The rotation of beam can be expressed by

$$\theta = \int_A^B \frac{M}{EI} dx \qquad (1)$$

Where θ = rotation, M = internal moment, E = material's modulus of elasticity, I = beam's moment of inertia computed about the neutral axis.

The curvature of ductility is

$$\kappa = \frac{1}{\rho} = \frac{M}{EI} \qquad (2)$$

where μ_θ = curvature ductility ratio, μ_u = curvature at ultimit stage, and μ_y = curvature at yield stage.

It is important to learn behaviour of confined slim beams, hence, this research investigates the performance of slim beam using nylon mesh confinement.

METHODS

This research is conducted experimentally by some specimens of slim beams which are unconfined and confined by nylon mesh. All specimens have: f'_c design = 40 MPa, b (width) = 10 cm, d (depth) = 20 cm, a (shear span) = 100 cm, L (span) = 300 cm. The specimens consists of one unconfined slim beam and 3 confined slim beams with slenderness ratio (a/d) of 5. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh which covers the steel bar (Figure 1). The specimens are tested by third point flexural beam test by computerized UTM and data logger of strain gauges (Figure 2).

Figure 1. Nylon mesh with mesh spacing of 5 cm which cover the steel bar (Susilorini, 2009b)

Figure 2. Experimental set-up with computerized UTM and data logger of strain gauges (Susilorini, 2009b)

RESULTS AND DISCUSSION

Experimental results show that confined slim beams perform higher maximum load, about 13000-14000 N, compared to unconfined ones, about 12000 N, with same displacement of 70 mm (Figure 3). The load-displacement curve described by Figure 3 also shows that the confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not.

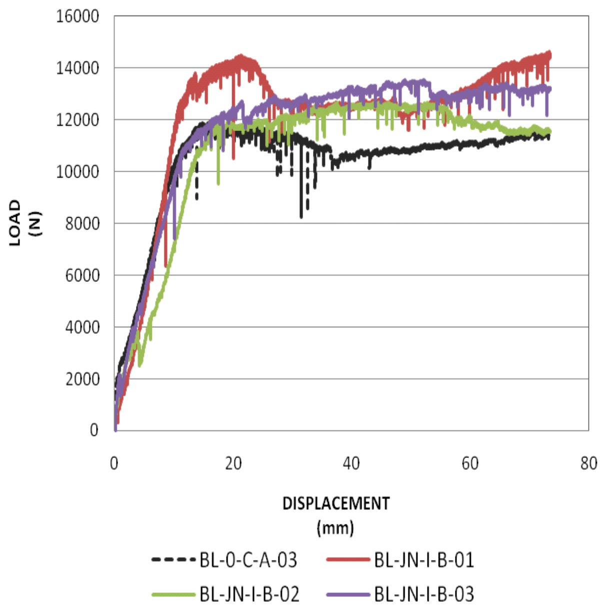


Figure 3. Load-displacement relation of beam specimens (Modified from Susilorini, 2009)

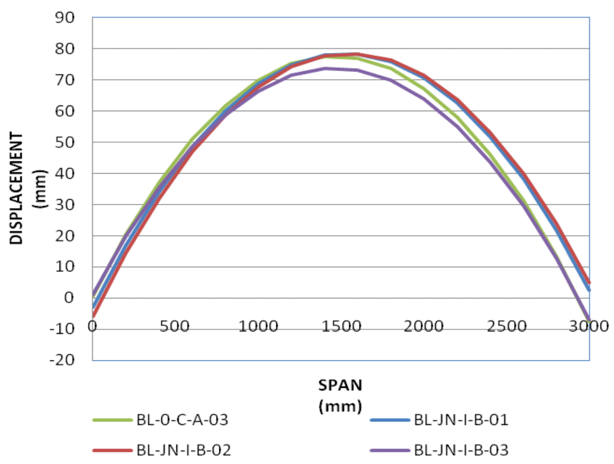


Figure 4. Curvature of beam specimens at ultimate load (Modified from Susilorini, 2009)

However, as explained by Table 1, the curvature of ductility ratio of confined slim beams are about the same, it ranged about 1.16-1.29 while for the unconfined one is 1.2. The curvature of slim beams are also about the same, 0.00000080-0.00000096. It is clear that the most important performance distinctions between the unconfined and confined slim beams are higher ultimitate load of the confined slim beams and strain-hardening character in ultimate stage of load-displacement curve of confined slim beams.

Table 1. The value of curvature of beam specimens at ultimate load

NO	SPECIMEN CODE	CURVATURE DUCTILITY RATIO	CURVATURE OF BEAM	ROTATION (rad)
		μ_ϕ	K	θ
1	BL-0-C-A-03	1.200	0.0000008091	0.105
2	BL-JN-I-B-01	1.157	0.0000009675	0.107
3	BL-JN-I-B-02	1.292	0.0000008765	0.109
4	BL-JN-I-B-03	1.293	0.0000009068	0.099

Failure mechanism of slim beams can be observed by crack pattern of slim beams at ultimate stage of displacement of 70 mm (Figure 7). The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam (Figure 5, 7, and Table 1).

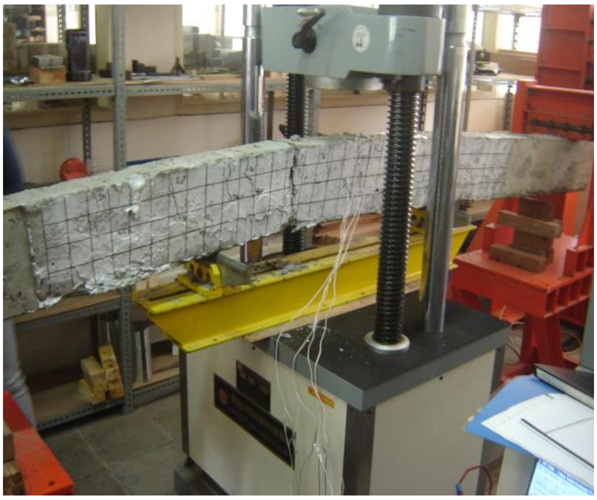
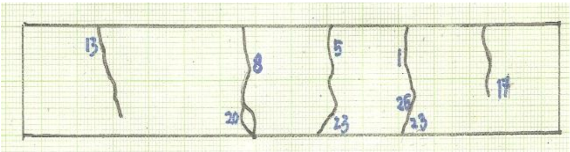


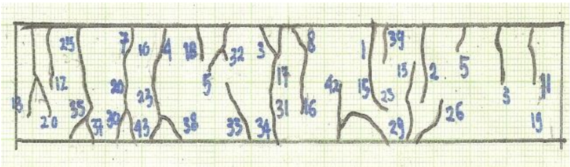
Figure 5. Curvature of beam specimens during loading history (Susilorini, 2009b)

While the bigger load resisted by the confined slim beams, then cracks start to propagate. Hence, the confined slim beams performs bigger curvature of beams because more cracks grow (Figure 6) while the beams resist load increasing. Therefore, the confined slim beams perform higher ductility compared to unconfined beam. This research proves that the nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member.

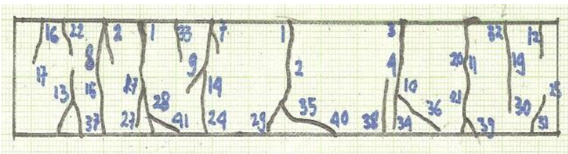
Figure 6. Crack at middle span of beam specimens at ultimate stage (Susilorini, 2009b)



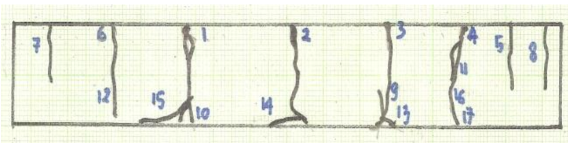
(a)



(b)



(c)



(d)

Figure 7. Crack patern of beam specimens at ultimate load (Susilorini, 2009b)
(a) BL-0-C-A-03
(b) BL-JN-I-B-01
(c) BL-JN-I-B-02
(d) BL-JN-I-B-03

CONCLUSIONS

This paper meet conclusions:

1. The confined slim beams perform higher maximum load with same displacement of 70 mm
2. The confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not.
3. The curvature of ductility ratio and curvature of slim beams of confined slim beams are about the same
4. The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam
5. The confined slim beams perform higher ductility compared to unconfined beam
6. The nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member

ACKNOWLEDGEMENT

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STRENGTH AND DUCTILITY DEMAND OF REINFORCED CONCRETE STRUCTURAL MEMBERS

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ABSTRACT

Seismic design codes for high rise buildings consider that response analysis should be performed to accurately investigate strength and ductility demand of reinforced concrete (RC) structural members. The strength and ductility of RC members are imperative requirements in the development of seismic response analysis method. A mathematical expression of stress-strain relationships of unconfined and confined concrete was developed to conduct moment curvature analyses of structural members. Important parameters of confinement involved, such as the type, volumetric ratio, spacing, yield strength, arrangement of specified confinement, concrete strength, and section geometry, were taken into account during the analysis performed. A sectional analysis utilizing the compression field theory was conducted to determine moment-curvature relationships of various RC structural members. The analytical strength and ductility at each section are compared and presented in this paper.

Keywords: *curvature ductility, stress-strain relationships, moment-curvature analysis, unconfined, and confined concrete*

INTRODUCTION

The capital city of Jakarta, Indonesia is one of the fast growing cities in the world that directly affects to the problem of ever decrease land space as a result of the ever expanding economic activities, accompanied by significant population growth due to urbanization, while the land area remains the same. This is reasonable since the land prices surrounding the main business districts increase significantly. Given this reality, the vertical trend of building development becomes unavoidable to meet the increasing demand for living and office space, which are mostly part of larger scale mixed-use developments as superblocks (Wangsadinata 2008). The construction of high rise building in Jakarta mostly utilizes general structural concrete because the price is much more competitive as compared to structural steel. In addition, open frames combined with shear walls are commonly used for high rise building constructions in Jakarta. According to the Indonesia National Standard for Earthquake Resistant Design (SNI 03-1726-2002), over 40 m height or 10 stories of high rise buildings should be designed based on the results of dynamic response analysis utilizing the method of response spectrum modal analysis. During moderate earthquakes, structural members of the high rise buildings experience inelastic responses that are dependent on their strength and ductility.

There are at least two national codes must be followed in the design of concrete high rise buildings. They are Seismic Resistant Design Provisions for Building Structures (SNI 03-1726-2002) and Concrete Design Provisions for Building Structures (SNI 03-2847-2002). It is clearly observed in the code that Jakarta is located in Zone 3 of the Indonesian Seismic Zoning Map with a peak bedrock acceleration of 0.15 g. This is acceleration with a return period of 500 years, so that its probability of occurrence during the life time of a building of 50 years is about 10%. The Indonesian Seismic Zoning Map has been formally cited in the code that it was developed based on the results of two-dimensional probabilistic seismic hazard analysis (PSHA). This is essentially required as a basis of dynamic analysis of high rise buildings in a seismic zone.

The quest for suitable strength and serviceability has been considered and it becomes trends in constructing high-rise buildings. As described, a main aim of constructing high-rise buildings is to increase the building capacity without increasing the area of land property that the building is built on. Increasing the building capacity means strength of the structure should sufficiently resist applied loads. Consequently, a structural engineer should precisely design each structural member of the building, such as beam, column, beam-column joint, and pile foundation system. Seismic resistant design becomes the most significant threat for high-rise buildings in order to produce sufficient strength and ductility to minimize seismic risk and protect human life. On the development of good performance of high-rise building, the structure should resist applied loads and does not put lives and properties at great risk, and therefore adequate strength and safety of the building are essentially taken into account in the design process. In line with the aforementioned seismic resistant design, superblocks of condominium, apartment, and hotel (Figure 1) that have been built surrounding Jakarta business center should sufficiently provide good facilities, comfort, and convenience stay to their customers.

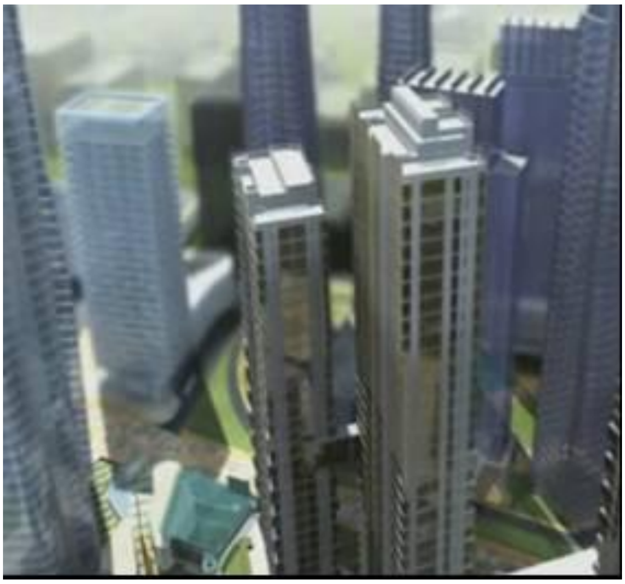

Figure 1. Condominium, Apartment and Hotel

It should be noted that the critical sections in structural members of high rise buildings against seismic actions, in general, are predicted at the beam-column joint, the pile-to-pile cap interface, and at the regions within the soil layer. Maximum moments and curvatures are likely to occur at these critical sections during an earthquake event. The strain rates of concrete for structural members vary from normal to high strength concrete. In addition, normal strength concrete (NSC) and high strength concrete (HSC) have different behaviour in strength and ductility characteristics in resisting compressive loads. The required ductility of a concrete member subjected to applied is essentially based on the shape of the moment-curvature relationship of the section, as most of the deformations of the structural member arise from the deformations associated with flexure (Park et al., 1984). Theoretical moment-curvature relations for concrete sections can be calculated using an established procedure for moment-curvature analysis, which assumes that plane sections before bending remain plane after bending, and this satisfies the requirements of strain compatibility and the equilibrium of forces (Park and Paulay, 1975; Thompson and Park, 1980).

The most fundamental requirement in predicting the Moment Curvature behavior of a flexural member is the knowledge of the behavior of its constituents. With the increasing use of higher-grade concretes, the ductility of which is significantly less than normal concrete, it is essential to confine the concrete. In a flexure member the shear reinforcement also confines the concrete in the compression zone. Hence, to predict the Moment Curvature behavior of a flexural member, the stress–strain behavior of confined concrete in axial compression is essential. With the development of performance-based design methods, there is an increasing need for simplified but reliable analytical tools capable of predicting the flexural behavior of reinforced concrete members. Design offices will be faced more and more with the need of predicting the deformation capacity of concrete members. A general approach to account for confinement of concrete and predicting the flexural behavior of concrete member is needed.

It is clearly understood that ductility evaluation is essential to avoid fragile collapse on the structure. In the extreme loading conditions of a structure being loaded to failure it will behave in a ductile manner. In earthquake zones which require a building design with seismic loading to ensure the structure from collapse, ductility becomes an important consideration. It can be justified if the structure has sufficient ductility to absorb and dissipate energy by the earthquake.

The ductility demands, however, must be smaller than the ductility supplied to produce equilibrium in its basic design. In general, the greater achievable ductility without significant strength is loss the better. But solving for this problem with its complexity of seismic behavior of high-rise building should be carried out with reliable computer programs to reduce time consuming during an analysis process.

This paper presents moment curvature analyses of selected structural RC members to investigate strength and ductility demand of high rise buildings. Two methods of numerical solution based sectional analysis and modified compression field theory were performed utilizing both Xtract and Response 2000 programs.

MOMENT-CURVATURE ANALYSIS

Moment-curvature relationships for reinforced concrete beams were previously investigated to determine curvature ductility of concrete sections. It is obvious that moment-curvature analysis is a method to determine the behavior of a concrete section using nonlinear material stress strain relationship and also an essential tool for understanding the load behavior of structural elements. Moment-curvature plot illustrates strength, stiffness, cross sectional ductility and shows the behavior of a section under combined axial load and bending moment (Alaoui and Klingner, 2007). Theoretical moment-curvature relations for structural members can be calculated using an established procedure for moment-curvature analysis, which assumes that plane sections before bending remain plane after bending, and this satisfies the requirements of strain compatibility and the equilibrium of forces (Park and Paulay, 1975; Thompson and Park, 1980).

Material Models

1. Concrete

Various models have been proposed to model stress-strain relationships of confined and unconfined concrete and available to facilitate analytical work to defined moment curvature. Each model seems to have efficiency for a specific situation while not for others. The following reviews and provides a short summary of the most popular stress-strain model for concrete. Mander, Priestley, and Park (1988) have developed a general model for concrete confined by various types of transverse reinforcements. The main equation describing stress-strain relationship for confined concrete is:

$$f_c = \frac{f'_{cc} x r}{r - 1 + x^r} \tag{1}$$

$$x = \frac{\varepsilon_c}{\varepsilon_{cc}} \tag{2}$$

where f'_{cc} = the compressive strength for confined concrete (defined later) (ε_c) = uniaxial strain or longitudinal compressive concrete strain, (ε_{cc}) = Strain at the maximum concrete stress and corresponding strain,

$$\varepsilon_{cc} = \left[R\left(\frac{f'_{cc}}{f'_{co}} - 1 \right) + 1 \right] \varepsilon_{co} \tag{3}$$

$$r = \frac{E_c}{E_c - E_{\sec}} \tag{4}$$

where E_c = the initial tangent modulus of elasticity (1 MPa = 145 psi) and E_{sec} = the secant modulus at peak stress.

$$E_c = 5000\sqrt{f'_{co}}\, MPa \tag{5}$$

$$E_{\sec} = \frac{f'_{cc}}{\varepsilon_{cc}} \tag{6}$$

The parameter *R* (in Eq. 3) is an empirical determined value experimentally, Mander et al suggested *R* value from 3 to 6. Pam et al recommended 3 for higher strength concrete. *R* decreases the slope of the ascending branch, but the magnitude of strain at the peak of the curve decreases. f'_{co} and ε_{co} are the unconfined concrete strength and corresponding strain, ε_{co} can be assumed generally 0,002. The main parameter figuring the equations of the peak longitudinal compressive stress for confined concrete (f'_{cc}), expressed as:

$$f'_{cc} = f'_{co}\left(2{,}254\sqrt{1 + \frac{7{,}94 f'_l}{f'_{co}}} - \frac{2 f'_l}{f'_{co}} - 1{,}254 \right) \tag{7}$$

where f'_l is the effective lateral confining stress, defined as:

$$f'_l = \frac{1}{2} K_e \rho_s f_{yh} \tag{8}$$

f_{yh} is the yield strength of the transverse reinforcement and K_e is the confinement effectiveness coefficient. K_e is given by Eq. 9 as follows

$$K_e = \frac{1 - \frac{s'}{2d_s}}{1 - \rho_{cc}} \quad (9)$$

where d_s is diameter of transverse steel, ρ_{cc} is the ratio of area of longitudinal steel to area of core of section and s' is the clear spacing between spiral or hoop bars. Mander et al. (1988) proposed equation for K_e for circular sections and the spiral-shaped transverse reinforcement (Eq 9). As K_e defined, it takes into account of the efficiency of the various possible arrangements of transverse reinforcement.

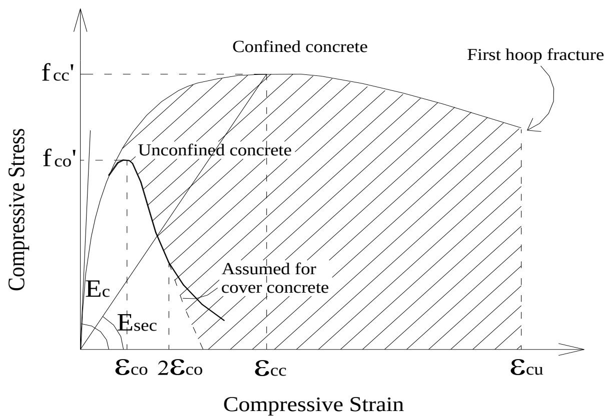

Figure 2. Mander et al. (1988) model for confined and unconfined concrete.

2. Reinforcement

The stress-strain relationships for nonprestressed reinforcing steel proposed by Park and Paulay (1975) have been extensively studied by other investigators (Mander et al., 1988; Thompson and Park, 1980). In a seismic region where ductility requirements may mean considering the possibility of reaching strains many times the yield strain, it is necessary to evaluate the steel stress at strains higher than yield to more accurately measure the strength of a member at a large deformation. To satisfy this concern, values for the stresses and strains at the onset of yield, strain hardening, and tensile strength are necessary to idealize a complete curve of the stress-strain relationship. Mander et al. (1988) have proposed the complete curve of the stress-strain relationship for steel in tension or compression, and this model, as presented in Figure 3, was adopted in this study for the normal strength concrete.

For $0 \le \varepsilon_s \le \varepsilon_y$;

$$f_s = E_s\, \varepsilon_s \quad (10)$$

where $\varepsilon_y = f_s / E_s$
E_s = modulus of elasticity,
f_y = yield strength,
ε_y = yield strain.

For $\varepsilon_y \le \varepsilon_s \le \varepsilon_{sh}$; $f_s = f_y$ (11)

where ε_{sh} = strain at commencement of strain hardening.

For $\varepsilon_{sh} \le \varepsilon_s \le \varepsilon_{su}$; (12)

where ε_{su} = strain at ultimate (peak) strength,
f_{su} = ultimate strength,

$$P = E_{sh}\left(\frac{\varepsilon_{su} - \varepsilon_{sh}}{f_{su} - f_y}\right) \quad (13)$$

and ε_{sh} = strain at commencement of strain hardening.

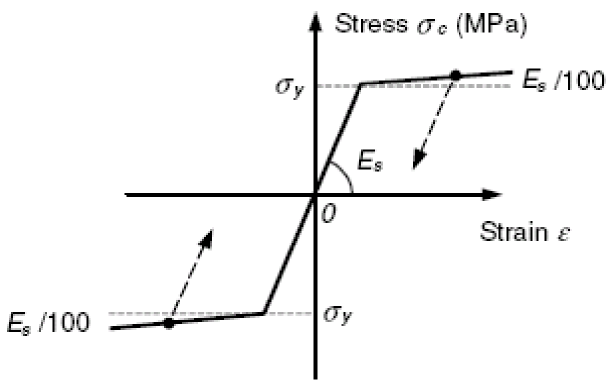

Figure 3. Uniaxial stress-strain relation reinforcing bar.

NUMERICAL APPLICATION

Model Description

Table 1 outlines typical dimension and reinforcement details of selected beams properties. The 10 common cross sections of the beam structural members presented in this study were selected as major typical models for determining the strength and ductility demand. The analysis of moment curvature was undertaken in this study with regard to the determination of curvature ductility for each beam. No axial loads were employed during the momen-curvature analyses. Steels with yield stress 400 MPa were used for reinforcements and 240 MPa for confinement. The compressive strength of concrete was 35 MPa. The moment-curvature analyses were carried out by XTRACT ver 3.0.8 and Response 2000.

Table 1. Mechanical properties of concrete

No	Samples	Dimension (mm)		Longitudinal steel		Ties	Span	Stirrup spacing
		width	height	Tension	Compression			
1	B01-F7T	400	800	8D25	5D25	D10-500	4000	100
2	B22-F7T	400	600	4D25	3D25	D10-500	7025	150
3	B42-F5L	350	600	4D25	7D25	D10-100	5850	200
4	B23-F7T	400	600	7D25	5d25	D10-500	7650	150
5	B18-F5T	350	600	3D25	3D25	D10-100	5850	100
6	B40-F5T	350	600	4D25	3D25	D10-100	7025	100
7	B50-F7T	250	400	2D16	2D16	D10-150	3000	150
8	B58-F7T	350	700	3D25	3D25	D10-150	1585	200
9	B20-F7T	350	700	6D25	3D25	D10-150	8625	150
10	B45-F7T	300	500	4D25	3D25	D10-150	3150	150

Deformed Shape

During seismic excitation of a high-rise building or of long bridge structures, axial forces vary due to overturning demands. This, in turn, affects the ultimate curvature capacity and consequentially causes the seismic displacement capacity of the structural elements. By generating a plot of force verses ultimate curvature, curvature demands can be checked directly for vertical structural elements; for example, in concrete beams within a seismic force-resisting frame (Teguh, 2009). Figure 4 shows undeformed and deformed shape of typical beam.

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(a) Undeformed Shape (b) Deformed Shape

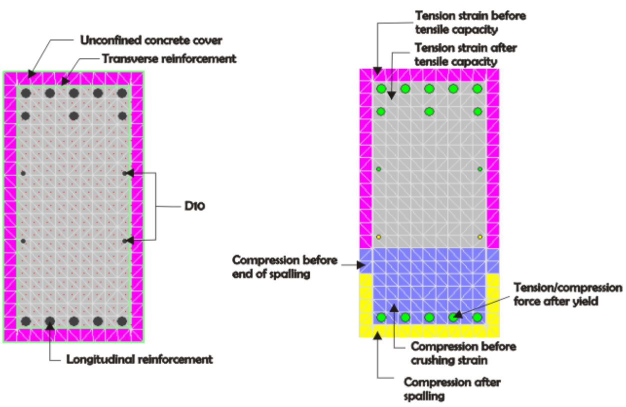


Figure 4. Xtract model of sectional analysis

NONLINEAR SECTIONAL ANALYSIS

This section focuses on theoretical reviews of moment-curvature analysis. The moment-curvature analysis is often used in earthquake engineering as a necessary step toward assessment of the displacement capacity of reinforced concrete components. To conduct the moment-curvature analysis, it is necessary to establish models for the stress-strain behavior of materials. The moment-curvature analysis establishes the ductile capacity of a cross-section by plotting the curvatures against corresponding moments.

Monotonic moment-curvature relations for reinforced concrete beams subjected to combined axial load and flexure are obtained by assuming that plane sections remain plane after bending and using the stress-strain relationships for concrete, non-prestressed steel as described in aforementioned equations. By constructing the moments and curvatures into a curve, then ductility can be determined. Figure 5 shows the definition of curvature ductility.

The ductility of reinforced concrete section could be expressed in the form of the curvature ductility (μ_φ):

$$\mu_\varphi = \frac{\varphi_u}{\varphi_v} \qquad (14)$$

where μ_u is the curvature at ultimate when the concrete compression strain reaches a specified limiting value, μ_y is the curvature when the tension reinforcement first reaches the strength. The definition of μ_y shows the influence of the yield strength of reinforcement steel on the calculation of μ_φ, while the definition of reflects the effect of ultimate strain of concrete in compression.

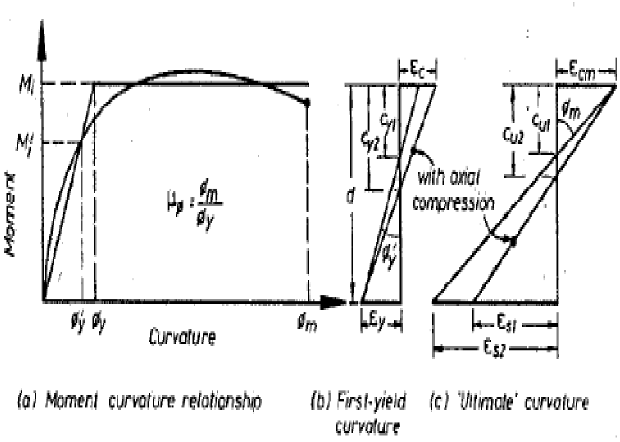


Figure 5. Definition of curvature ductility (Paulay and Priestley 1992).

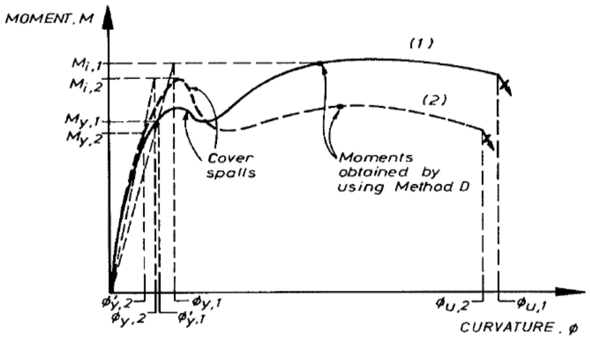


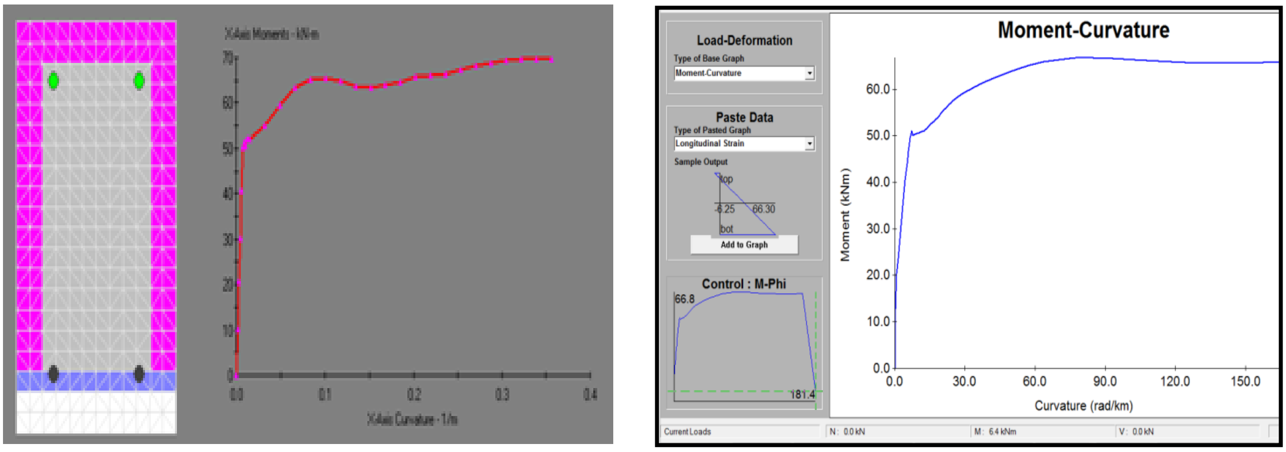
Figure 6. Moment-curvature relationships (Pam and Park 1990)

Pam and Park (1990) identified two common cases of moment-curvature curves as shown in Figure 6. The first moment-curvature curve indicated by the solid line represents a case where the compressive axial load level, the longitudinal reinforcement ratio, and the volume of spiral reinforcement are relatively large but the cover concrete thickness is relatively small. Moment occurs in the region of curvature after the concrete cover spalled. In this case, the moment of resistance does not reduce significantly after spalling of the cover concrete and then increases considerably during the sequent increase in curvature when the confinement takes effect.

RESULTS AND DISCUSSIONS

The strength and ductility of beam is highly dependent of confinement, loads, concrete strength, bar diameter, content of longitudinal steel, and yield strength of the confinement. In an attempt to increase the strength and ductility, different hoops confinement pitches, were applied in each type of beam section and provided a variety of curvature ductility as presented below. Each beam was reinforced with various longitudinal reinforcement and transverse reinforcement. To calculate moment-curvature relationships for each beam, no axial loads were employed and an incremented moment at the x axis (M_{xx}). The application of no axial load level presented in this study was due to the beam-column joint loading distribution.

The moment capacity at each section tended to be similar between Xtract and Response 2000, however the curvature consistently showed decreasing values. In contrast, the curvature ductility at each section has proportionally increased as presented below in Figure 7, 8, and 9. All analysis results of curvature ductility are summarized in Table 2.



(a) XTRACT. (b) Response 2000.

Figure 7. Moment-curvature relationships for different representation

Table 2. Curvature ductility for typical RC beam secctions

Sample	Concrete		Steel			Curvature Ductility (rad/m)	
	Section Area (mm^2)	Core Area (mm^2)	Tension	Compression	Ties	XTRACT	Response 2000
B1-F615T	320000	230400	8D25	5D25	D10-500	11.13	19.19
B22-F7T	240000	166400	4D25	3D25	D10-500	16.24	21.11
B42-F5L	210000	140400	4D25	7D25	D10-100	8.7	19.2
B23-F7T	240000	166400	7D25	5d25	D10-500	16.24	19.2
B18-F5T	210000	140400	3D25	3D25	D10-100	23.29	21.11
B40-F5T	210000	140400	4D25	3D25	D10-100	13.76	10.8
B50-F7T	100000	54400	2D16	2D16	D10-150	23.82	13.11
B58-F7T	245000	167400	3D25	3D25	D10-150	18.12	21.11
B20-F7T	245000	167400	6D25	3D25	D10-150	23.41	17.4
B45-F7T	150000	92400	4D25	3D25	D10-150	11.8	21.1

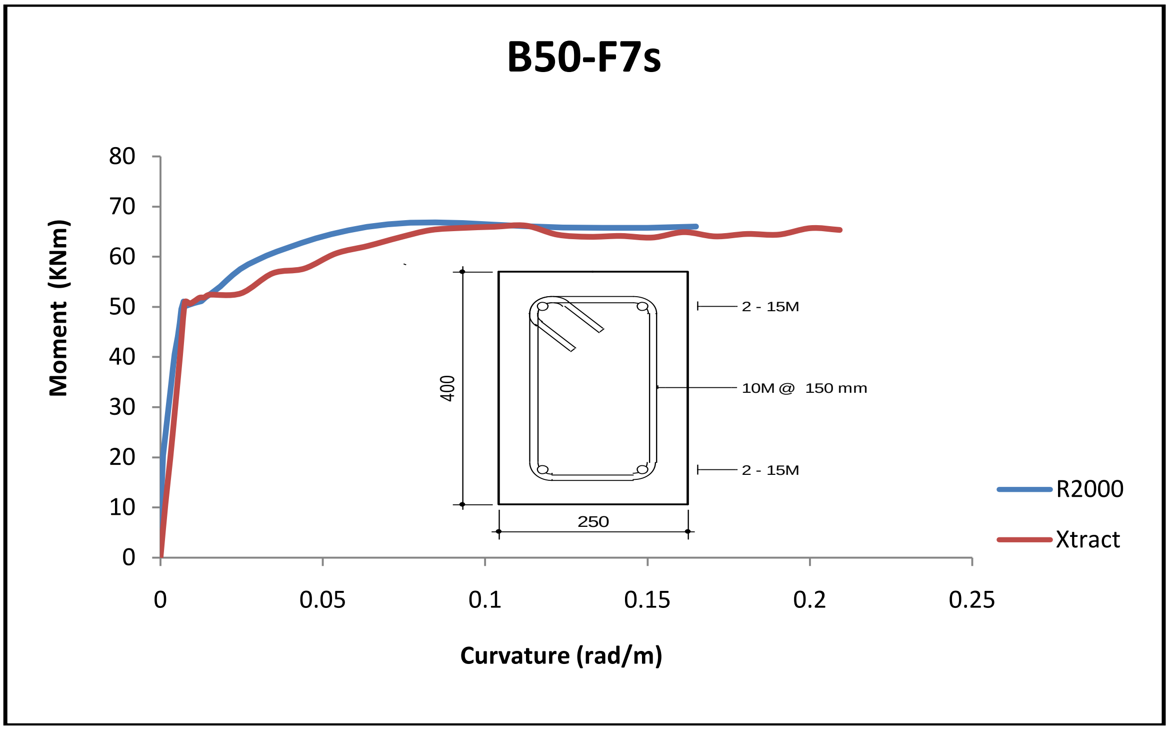


Figure 8. Moment-curvature relationships of beam B50-F7s

The moment curvature curve is plotted from the values of moment and curvature. It is obtained from calculating the corresponding stress strain relationships of concrete and reinforcement, load and compressive concrete. The most critical parameter in curvature ductility is ultimate compression strain, ε_{cu} (Paulay and Priestley 1992). Different results between Xtract and Response 2000 possibly caused by the used stress-strain relationship curves models or the algorithm of each program that becomes one of the basis assumptions in determining of moment curvature relationships and the ultimate compression strain of confined concrete. Response 2000 uses 0.003 as its default ultimate strain, while XTRACT uses two ways e.g ultimate compression strain defined by its calculation tools or input the value directly. The curvature ductility result from XTRACT can be higher than Response 2000, if uses strains results from XTRACT calculation tools. Input the same value to Response 2000 then the curvature will be likely similar between both programs. The Xtract program shows smooth transition before and after cracking, with slightly higher value of moments than Response 2000. On the other hand Response 2000 tends to be a lower and shorter curve, eventhough in some cases it could be higher and longer than XTRACT but if the ultimate compressive strains is similar to XTRACT.

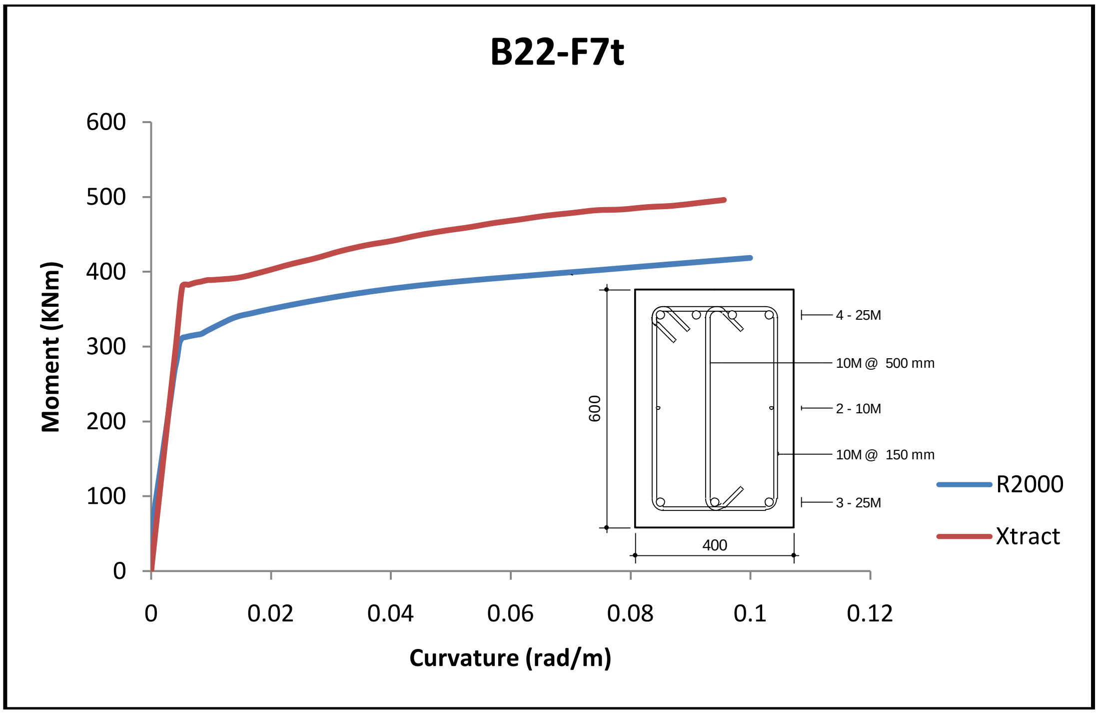


Figure 9. Moment-curvature relationships of beam B22-F7t.

CONCLUDING REMARKS

A beam section with less reinforcement and small dimension resulting in a significant moment compared with the beams sections with large dimension and reinforcement; however, it results in a smaller curvature than other sections, where a longer curvature produces a higher curvature ductility of the beams. Beam dimension and reinforcement details have provided greater curvature ductility capacities. The most critical parameter in affecting the ductility, ε_{cu}, is the main factor between XTRACT and Response 2000 in determining the moment-curvature relationships than later curvature ductily.

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THE STATE-OF-THE-ART SEISMIC BEHAVIOR OF PRESTRESSED CONCRETE PILE-TO-PILE CAP CONNECTIONS

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ABSTRACT

Reports and publications regarding pile foundation systems for high-rise buildings or long-span bridges contain limited information to validate the seismic behavior and the capacity of pile-to-pile cap connections. Recent earthquakes around the world have caused extensive damage to important structures, however, most structural damage reports focused on the superstructure components. The main reason for this relates to difficulties associated with investigating substructure elements such as piles and pile caps. In contrast, the repair of damaged piles and pile-to-pile cap connections in high rise building systems is impractical because of the expensive cost and structural hazards relating to ground excavation. This paper reviews recent studies focusing on issues relating to seismic behavior of the pile-to-pile cap connections. The review also establishes the state-of-the-art for the analytical modeling, experimental test, and design practice of prestressed concrete pile-to-pile cap connections in seismic regions. Two types of prestressed concrete pile-to-pile cap connections are recommended.

Keywords: *analysis model, design practice, seismic behavior, finite element, pile-to-pile cap connections*

INTRODUCTION

Severe earthquakes occurring over the world, dating from the 1964 Alaskan earthquake to the 2009 West Sumatera (Padang) earthquake, have caused extensive damage to important structures not only infrastructures but also public facilities such as schools, government buildings, hospitals, military facilities, and mosque buildings. Most of the structural damage reports focused on the superstructure components, but limited foundation damage reports were found. It is observed that investigating substructure elements and repair of damaged pile-to-pile cap connections are costly and impractical affecting structural hazards relating to ground excavation.

This paper reviews recent studies that focus on issues relating to the pile-to-pile cap connections subjected to seismic actions. The review also establishes the state-of-the-art for the analytical modeling, experimental test, and design practice of pile-to-pile cap connections in seismic regions. The current issues incorporate code provision requirements for the design of prestressed concrete piles and their connections to the reinforced concrete pile cap are discussed as well.

SEISMIC BEHAVIOR OF PILE SYSTEM

Seismic Waves Influence

Seismic waves during earthquake occurrence radiate and travel from bedrock to ground surface within a few seconds or even minutes producing ground movement. The strength and duration of ground movement at any particular site depends on the earthquake source and specific site characteristics. At sites near the source of a large earthquake, ground movement may result in significant damage to buildings and other structures. In fact, strong ground movement resulting from a variety of seismic hazards has devastated human life and produced extensive damage in many essential facilities, such as buildings and bridges.

Although seismic waves usually travel through bedrock over the overwhelming majority of the trip from the source of an earthquake to the ground surface, the final portion of that trip is often through soil, and the characteristics of the soil can greatly influence the nature of shaking that occurs at the ground surface (Kramer, 1996). Soil behavior is complex, and site conditions often vary dramatically over short distances. As a result, levels of ground shaking can vary significantly within a small area. This behavior has resulted in nonlinear soil analysis being a most important aspect of geotechnical earthquake engineering practice, and this involves a sound understanding of the effects of local soil conditions on strong ground motion. To establish a greater understanding of earthquake ground motions and the associated response spectra for a particular area, soil effects must be established for design and analysis purposes. In contrast, the soil phenomena affected by the seismic wave have not been taken into consideration in the design of the pile foundation systems, particularly in the design of pile-to-pile cap connections.

Elastic and Inelastic Behavior of Pile Systems

By applying elastic behavior to pile foundations, sections of the structure are designed assuming a straight-line stress-strain relationship while ensuring that at service loads the stresses in the steel and the concrete do not exceed the allowable working stresses. The bending moment and forces acting on the structures are calculated assuming linear-elastic behavior and this simple approach has been the basis of reinforced concrete design for many years (Park and Paulay, 1975).

When an elastic response in the design procedure is appropriate, the entire structure, including the pile foundation, is expected to respond within the elastic limit. Usually, only in regions of low seismicity is it possible to satisfy overall stability criteria for this high level of lateral forces. Moreover, the most common and desirable situation is that of a ductile cantilever column with piles and pile cap designed to resist at ideal strength load-input from the superstructure. However, in certain situations, a greater degree of conservatism than that used in the capacity design of superstructures is necessary if it is intended to ensure that piles remain elastic at all times. This design consideration is costly and inefficient.

Referring to the earthquake resistant design, pile foundation systems supporting structural columns are subjected to large concentrated forces consisting of moments (M), axial (P) and shear (V) forces that are developed in the column during an earthquake event. These forces affect the piles' group behavior in both tension and compression, and maximum bending moments occur at the plastic hinge regions along the pile.

For inelastic behavior of pile foundation systems, it is possible to assign energy dissipation to the piles, while the column above remains elastic. This could be affected by yielding of the longitudinal reinforcement of the tension pile or by the use of friction piles. Neither alternative is particularly desirable. In the early stages, wide cracks develop well below ground level, and because of alternate tension and compression actions on the pile, large amounts of confining reinforcement are required. Because of this, the accurate behavior of a pile embedded in the ground and subjected to lateral forces and consequent bending moments, shear forces, and distortions is extremely difficult to predict with good accuracy (Paulay and Priestley, 1992).

Furthermore, predictions of the dynamic response due to the inelastic behavior of such piles depends on, among other variables, modeling techniques, simulation of soil stiffness and density distribution, frequency variability of soil reactions, and damping resulting from wave radiation and internal friction. In more simplified approaches, the Winkler model of beams on elastic foundations was commonly used, where allowances were made for the relative position of a pile within a group with suitable variation of the modulus subgrade reaction over the pile length. Nonlinear Winkler springs were used to represent soil properties adequately under strong seismic response.

Nonlinear inelastic finite element analyses of the proposed pile-to-pile cap connections were initiated with static linear analyses, using early checks of overall parameters to eliminate further errors (Teguh, 2007).

CODE PROVISIONS FOR PILE-TO-PILE CAP CONNECTIONS

Code Provisions for Pile Design

In developed countries, building standards are generally systematized for various combinations of loads including seismic load, while in many developing countries, seismic criteria, such as a seismic design code, are prescribed separately. In general, provisions for the seismic design criteria of foundation systems in different areas were dependent on the seismic zone and its intensity (Tamura, 2002).

A building code is commonly used to specify earthquake potential from a seismic zone map. The seismic potential often changes as new earthquake data is available as well as when the existing codes are evaluated. For example, one of the main factors that contributed to the damage at the Port of Kobe during the Kobe earthquake was that the area had been previously considered to have a relatively low seismic risk; hence, the earthquake design criteria were less stringent than in other areas of Japan. The building code also specifies general requirements that must be fulfilled by the geotechnical engineer. For example the Uniform Building Code (1997) requires an analysis of the potential for soil liquefaction and soil strength loss during an earthquake. This code provision requires that the geotechnical engineer evaluates the potential consequences of any liquefaction and soil strength loss, including an estimation of differential settlement, lateral movement, and reduction in foundation bearing capacity, and it considers mitigating measures. In addition, the code provides detailed seismic analyses to determine a response spectrum. Common limitations of building codes are that they may not be up to date or may underestimate the potential for earthquake shaking in a particular area.

Since concrete piles are the most common form of piles used to support high-rise buildings and bridges, the Prestressed Concrete Institute (PCI) has recommended four typical types of section properties commonly found throughout the world, and has also provided guidelines based on current knowledge and standards (P.C.I.Committee, 1993). The intent of these recommendations and guidelines for prestressed piles is generally to limit the shape of prestressed concrete piling used anywhere, not just in the United States or Canada.

Design of axially and cyclically loaded piles, either for reinforced or prestressed concrete, is similar to the design of columns. The main difference is the location of the structural elements, which are substructure elements and are a part of pile foundation systems, while columns are superstructure elements. When a pile is designed to resist earthquake-induced effects because of soil interaction, the pile behavior would be significantly different to that of columns, which normally withstand axial loads and bending moment only. However, in many cases, code provisions describe detailed design requirements for piles and columns separately, in order to satisfy the code design considerations. Past research on prestressed concrete piles has referred to the American Concrete Institute (2002), the Canadian Codes (CAN/CSA-S6_00, 2000), NZS 3101 (1982), and NZS 3101 (1982). Australian Standards, AS 1170.4-1993, and AS 2159-1995, AS 3600-2001 (1993; 1995; 2001) provide detailed design and installation for piling, including a design and testing under static and dynamic loads. These standards state that in a mathematical model, the physical structure represents the spatial distribution of the mass and stiffness of the structure, which is to be analyzed with a three-dimensional model to provide adequate prediction of static and dynamic responses.

In design practice, tendons are prestressed up to 0.7 f_{pu}, where f_{pu} = ultimate strength of prestressing steel, or equivalent to 1845 MPa as indicated by the manufacturer's test certificate. The NZS 3101 (Section 13.3.4) requires initial stress in the prestressing steel, f_{pi} to be greater than 0.8 f_{pu} or 0.94 f_{py}, whichever is smaller; and that the tendon stress immediately after transfer be no greater than 0,7 f_{pu}. The tendon stress immediately after transfer can be assumed to have 5% losses. In contrast, the Ministry of Works and Development design for 400 mm diameter octagonal piles assumes 22% losses in prestress. This assumption is much more conservative than the NZS 3101 standard. In addition, the compressive axial load level used in the analysis was varied from 0.1 to 0.2 $f_c' A_c$, where f_c' is compressive strength of concrete and A_c is the area of the concrete core of a section measured to the outside of spirals. These code requirements have been adopted in the pile model that is analyzed with finite element analysis.

Code Provisions for the Design of Pile-to-Pile Cap Connections

Current detail design procedures for prestressed concrete piles connected to cast-in place reinforced concrete have not been referred to in any codes, and therefore the design procedures for pile-to-pile cap connections do not provide engineers, practitioners, or the academic community with any guidance concerning the physical behavior of these elements during seismic ground motion. The ACI Building Code (ACI 318-02) provides a design procedure for pile caps by proposing a 'section force' approach similar to that used for two-way slabs.

There are almost no technical criteria for the seismic force on underground structures, other than in Japan and Mexico (Tamura, 2002), however these criteria are specific in both areas and may not be applicable in any other areas, except that the design of seismic force is intended to use the earthquake ground acceleration recorded from both areas. There is clearly a need for an improved understanding of the factors that control the magnitude of pile cap resistance, and for rational analytical procedures to include pile cap resistance in the design of pile groups to resist lateral loads. An in-depth study was undertaken by Mokwa (1999) to address this need, through the performance of experimental and in-situ tests, as well as the development of analytical procedures. Furthermore, it is necessary to avoid deleterious pile-cap resistance results in estimates of pile group deflections and bending moments under load that may exceed the actual values by 100% or more. Advances could be achieved in the design of economical pile-supported foundations, and their behavior more accurately predicted, if the cap resistance can be accounted for (Duncan and Mokwa, 1999; 2003).

In the ACI Building Code procedures (2002), the shear design of pile caps is unable to match the experimental results because the design procedures neglect certain important parameters, such as the amount of longitudinal reinforcement, and overemphasize other parameters, such as the effective depth. In order to achieve an efficient design, high strength concrete is likely to be introduced into the pile cap designs. ACI 318-02 (2002) recommends the use of the strut-and-tie model for deep and slender beams, and beam-column joints. Furthermore, studies on the use of high strength reinforced concrete pile caps are still limited. Strut-and-tie models combined with the use of high strength concrete in the design of pile caps provide the potential to improve current design practice and more accurately predict the behavior of deep pile caps (A.C.I. Committee 318, 2002).

There are also limited provisions concerning the effect of soil-pile interaction in the design considerations of pile-to-pile cap connections. The strut-and-tie model was not fully adopted because it did not significantly affect the strength and ductility of the connection. However, the strut-and-tie model might be useful in the design of a deep cap supported pile group. Furthermore, the soil-pile interaction effect was integrated into the complex finite element analyses of the proposed PPC connections.

Observed Seismic Performance of Pile-to-Pile Cap Connections

When the tentative provisions for the Development of Seismic Regulations for Buildings, ATC 3-06 (Centre for Building Technology, 1978), were first issued in 1978, the use of precast prestressed concrete piles in regions of high seismicity was virtually prohibited through a requirement that such piles should not be used to resist flexure caused by earthquake motions unless they remained elastic. Their use for essential facilities in the most severe seismic regions was absolutely prohibited. These restrictions had both an experimental and analytical bases. Some precast pre-stressed piles had performed inadequately in the 1964 Alaska, the 1971 San Fernando, and the 1978 Miyagi-ken Oki (Mizuno, 1987).

In view of a recent proposed code change restricting the use of prestressed concrete piling in the United States, several testing programs have been contemplated to verify a prestressed concrete piles' ability to develop the required strength of the pile cap embedment and ductility at the pile-to-pile cap interface. The 1995 Hyogo-ken Nanbu earthquake in Japan has been carefully investigated by the Building Research Institute, Ministry of Construction Japan (Building Research Institute, 1996). It was observed that damage in recent earthquakes resulted in mechanical reinforcement joints and plastic hinges occurring at the pile-to-pile cap connection zones (Figure 1). Although cases of pile distress and fatigue have been noted in several severe recent earthquakes, most of them occurred because of deficiencies in pile design due to inadequacies in soil analysis or overall building design.

It has been observed that plastic hinges have occurred in the critical regions of pile foundations during severe earthquakes. For example, inadequate detail connections caused the headed reinforcement of the pile to be released from the connection (Figure 1a). Due to a plastic hinge occurring at the pile head region, the concrete was then crushed and the pile reinforcement yielded (Figure 1b). Liquefacted soils affected the occurrence of several plastic hinges elsewhere along the pile length as a result of releasing 'lateral bracing' from pile surrounding soil (Figure 1c), and also because lateral deformations took place at the interfaces between pile head and pile cap (Figure 1d).

(a) Pile head released from pile cap due to inadequate detail connection

(b) Damage at pile head interface with pile cap

(c) Plastic hinges occurred within soil layers along pile height

(d) Plastic hinge at the interface pile head and pile cap

Figure 1. Damage of pile foundation by Kobe Earthquake (1995)

In the case of a pile foundation supported bridge, the pile is embedded partially due to the different soil elevation surrounding the bridge (Figure 2a). The behavior associated with the bending moment of the pile-to-pile cap connections and potential plastic hinge regions is slightly different to the pile foundation-supported building (Figure 2b), which is fully embedded in the soil. To propose viable pile-to-pile connections, confinements along the piles and reinforcement detail in the pile-to-pile cap connection were refined to increase their strength and ductility. In addition, the effect of soil pile interaction was also studied and showed that the curvature demand was potentially high at the interface between stiff and soft layers of soil and at the interface between pile head and pile cap.

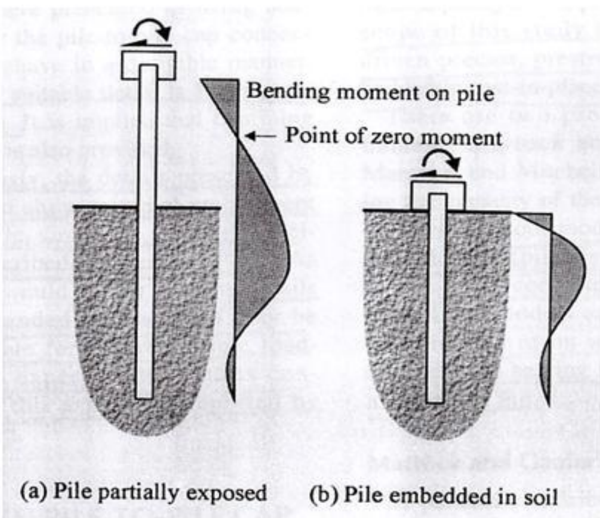


Figure 2. Bending moment of long piles due to horizontal ground motion (Pam and Park, 1990b)

PILE-TO-PILE CAP CONNECTIONS

Prestressed Concrete Pile

This section reviews previous studies on the design of prestressed concrete piles in respect to seismic actions. Park and Falconer (1983) investigated and analyzed five pretensioned prestressed concrete piles with a 400 mm octagonal cross-section. All full scale specimens were subjected to an axial compressive load and to intense cycles of lateral loading which simulated severe seismic loading. The tests were designed to establish whether the specifications for transverse spiral reinforcement required for reinforced concrete columns and piers would result in ductile behavior of the prestressed concrete piles.

Unit P1 of the series also contained a combination of non-prestressed longitudinal reinforcement and strand confined with spiral steel, while the rest contained only strand prestressing steel confined with spiral steel. Each pile had the same amount of longitudinal prestressed steel, but quantities of non-prestressed longitudinal and spiral reinforcement were varied. To simulate the effects of a severe earthquake, each pile was initially loaded in compression to a predetermined axial load level and then laterally loaded with cyclic loading. Based on the test results it was found that having a satisfactory quantity of spiral reinforcement, the pile had the capability to resist large inelastic deformations caused by cyclic lateral loading without significant loss in load carrying ability.

Sheppard (1983) carried out laboratory tests, analytical studies, and observations of piling during earthquakes. Three series of tests were conducted in California to establish the elastic and inelastic behavior of particular prestressed concrete pile sections as follows.

1. Santa Fe Pomeroy Tests, 1972

The elastic limit deflections and curvatures were determined for 406 and 457 mm square piling. The piling was prestressed to induce an effective pre-compression of 4.82 MPa and confined with W3.5 (5.4 mm) spiral steel spaced at a 150 mm pitch. The piling was subjected to an axial load of 2.7 x 10^6 N, and then loaded monotonically to failure by increasing the loading at the centre of the pile. The piles were approximately 13.1 m long. The 406 mm square pile developed a maximum curvature of 9.2 x 10^{-6} mm^{-1}. The 457 mm square pile developed an elastic curvature of 7.9 x 10^{-6} mm^{-1} at midspan. The axial load levels in the piling were 0.29 $f_c'A_c$ and 0.22 $f_c'A_c$ respectively, where f_c' and A_c are the compressive strength of the concrete and pile cross-section area, respectively. It was concluded that complete failure followed shortly after first cracking.

2. Santa Fe Pomeroy Test, 1974

The elastic limit deflection and curvature for a 305 mm pile with 4.82 MPa effective for pre-compression and a nominal spiral confinement (5.4 mm at 150 mm) were determined.

The pile was subjected to an axial load of 9.0 x 10^5 N (0.23 $f_c'A_c$) by post-tensioning and loaded monotonically to failure by loading at the centre of the 9.1 m pile span. The results showed that the pile developed an elastic curvature of 1.1 x 10^{-5} mm^{-1} at midspan followed by an immediate and sudden failure.

3. PCMAC/Santa Fe Pomeroy Tests, 1976

Several different 205 mm square pile specimens were tested in a program sponsored by the Prestressed Concrete Manufacturers Association of California (PCMAC). Specimen 1 was prestressed to induce an effective pre-compression of 4.82 MPa and confined with W3.5 (5.4 mm) spiral steel spaced at a 150 mm pitch. Specimen 2 was identical to Specimen 1 except for the confinement steel, which was W8.5 (8.4 mm) spiral steel spaced at a 50 mm pitch. Spiral reinforcing ratios were ρ_s = 0.003 and ρ_s = 0.021 for specimen 1 and 2, respectively. Each specimen was loaded axially with an initial prestress of 13.50 x 10^5 N.

Similarly, in Park and Falconer's tests (1983), eleven full scale pretensioned prestressed concrete piles with a 400 mm octagonal cross-section were investigated and analyzed by Park at al. (1984). The tests were to establish the existing ductility of the piles when subjected to large inelastic cyclic deformations from a lateral load simulating a severe seismic load. The variables of the tests, however, were kept unchanged from earlier tests, where the quantity of longitudinal non-prestressed reinforcement, the applied axial load level, the amount of transverse spiral reinforcement and the utilized spiral steel (either Grade 275 or hard drawn) were applied as the main variables.

The results showed that using a quantity of spiral steel specified by the code resulted in piles that were capable of undergoing very large inelastic deformations due to cyclic lateral loading without significant failure in load carrying ability. Piles with about 50% of the code specified quantity of spiral reinforcement were capable of reaching displacement ductility factors of at least ± 4, providing the spiral spacing did not exceed about 4 tendon diameters. When the spiral reinforcement was provided by hard drawn wire the pile reinforcement was eventually limited by the fracture of the confining steel reinforcement, whereas piles with Grade 275 steel spirals did not suffer confining steel fracture.

An extension of Park and Falconer's (1983) tests on six octagonal pre-tensioned prestressed-concrete pile units was undertaken by Pam and Park (1984), where all specimens were tested under two different axial load levels and with different quantities of transverse reinforcement. The six full-scale units were tested under a compressive-static axial load and a cyclic lateral force to simulate earthquake loading. Prestressing longitudinal steels were used in all units with the same amount of steel prestressed to the same level. The pile units were axially loaded to a pre-arranged level and then a lateral load was applied at mid-height to simulate the behavior of a severe earthquake.

Banerjee et al. (1987) investigated fourteen piles under a series of reversed cyclic lateral load tests, to determine curvature capacities when the piles were subjected simultaneously to service axial loads and cyclic lateral deformation. All specimens were tested in a horizontal self-reacting rig and then, after failure in the middle, the two end pieces of some specimens were cast in a block of concrete simulating a pile cap and were retested as cantilevers. In both cases, the moment arm was four times the member depth. Where possible 711.2 mm long x 355.6 mm deep octagonal cylinders were cut from the broken cantilever specimens and tested uni-axially.

The tests results showed that ductility was improved by confining the concrete with spiral wire reinforcement, conforming to the state-of-the-art code equations for ductile moment resistant compression members. Current code relationships used to calculate confinement to satisfy seismic ductility demands were inappropriate and further testing is required, coupled with analytical studies to determine a more precise and rational model for confinement requirements related to curvature ductility, rather than to axial load carrying capacity. Further investigations are also required to refine detailing provisions for the anchorage of spiral confinements in ductile regions, in addition to developing design criteria for hollow-core prestressed concrete piling. Six full scale specimens of prestressed concrete piles tested by Pam and Park (1984) were used as a preliminary study on the pile-to-pile cap connections.

All previous studies on piles have been performed experimentally under a compressive-static axial load and a cyclic lateral force at mid-height to simulate earthquake loading. A series of prestressed concrete piles, which had different cross-section types, axial static loads, reinforcement details, and spiral reinforcing ratios were tested. These studies were to investigate the seismic performance of prestressed concrete piles; however none were analyzed by simulation with the finite element method. As a result, selected experimental results were used as a rational comparison with analytical results proposed in this research (Teguh, 2007).

Reinforced Concrete Pile Cap

An investigation to study the behavior of thick slabs using approximately half scale models was conducted by Sabnis and Gogate (1984). Such slabs occurred as pile caps and, until recently, were designed without any provisions in the ACI Building Code (2002). Nine details of the designed pile cap recommended by the Concrete Reinforcing Steel Institute (CRSI) Handbook were reviewed and analyzed to provide experimental verification of the behavior of thick pile caps. The specimens had varied nominal depths of steel, reinforcement ratios, and arrangement of wires. Based on the experimental results, the excess strength of thick slabs can be used with sufficient conservatism in the new design methods. The present provisions of the ACI Building Code (2002) require major revision to properly reflect the behavior of thick pile caps in particular, and deep beams and deep slabs in general, as manifested in the design equation.

Adebar et al. (1990) conducted a comprehensive series of tests on about six large-scale pile caps by introducing strut-and-tie models. The ACI Building Code procedures (2002) for shear design of pile caps are unable to predict the experimental results because the procedures neglect certain important parameters, such as the amount of longitudinal reinforcement, and overemphasize other parameters, such as the effective depth (Adebar et al., 1990). The results showed that strut-and-tie models were found to describe more accurately the behavior of deep pile caps. The shear strength of slender pile caps is proportional to the thickness of concrete. However, the shear strength of deep pile caps with steep compression struts is better enhanced by increasing the bearing area of the concentrated loads rather than further increasing the depth of the pile cap.

Siao (1993) used similar approaches to strut-and-tie models to predict the shear strength of deep beams and pile caps failing in diagonal splitting. The accuracy of this approach was verified by comparison against results of actual strength obtained from experimental testing and published by others. Siao has summarized the two series of experimental tests on pile caps undertaken by previous researchers (Adebar et al., 1990; Sabnis and Gogate, 1984).

As mentioned earlier, information and publications on the pile cap design is also limited and the existing codes have not cited specifically the design procedure for pile caps. Consequently, the strut-and-tie model should be performed in the design of deep pile caps.

Pile-to-Pile Cap Connection Models

1. Sheppard's Models

In early 1983, Sheppard initially proposed eight varieties of connection details where piles are embedded in cast-in-place reinforced concrete pile caps (Harries and Petrou, 2001; Sheppard, 1983). Figure 3 shows schematic connection details, which are generally described as follows:

a. Type-A: no treatment is required and the pile is simply embedded in the pile cap (plain embedment model).
b. Type-B: the exterior of the pile head is roughened using a rotary or chipping hammer to provide an additional mechanical bond between pile and pile cap.
c. Type-C: the pile is grooved by cutting the exterior of pile head.
d. Type-D: the vertical dowels are embedded in the driving head of the pile (after driving).

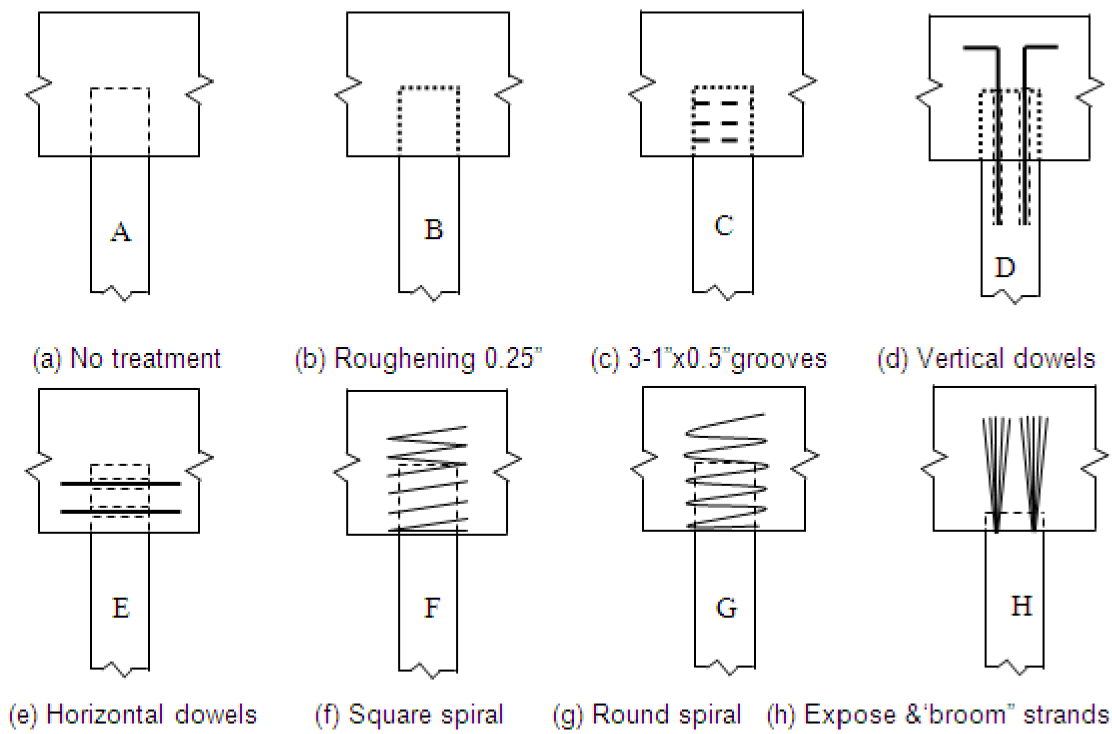


Figure 3. Typical pile-to-pile cap connections proposed by Sheppard (1983)

e. Type-E: the horizontal dowels are drilled through the pile head.
f. Type-F: the embedded pile head is confined with hoop or square spiral reinforcement.
g. Type-G: the embedded pile head is confined with round spiral reinforcement.
h. Type-H: the strands are exposed and embedded in the cast-in-place pile cap. The wires are often separated or twisted open to form an annular space (a so-called 'olive' anchorage) to improve their strength development.

The first of the three types of connections is categorized as a simple pile foundation system used in non-significant structures; for instance, in low-rise buildings and short-span bridges. The other types of connection details are applied to important structures requiring higher levels of seismic resistance, such as high-rise buildings and long-span bridges. However, Sheppard (1983) did not investigate all proposed connection details.

Next, Sheppard (1983) proposed details for the design of pile connections based on tests conducted by the Concrete Technology Associates (Concrete Technology Associates, 1974). Sheppard proposed four types of pile connections, as illustrated in Figure 4.

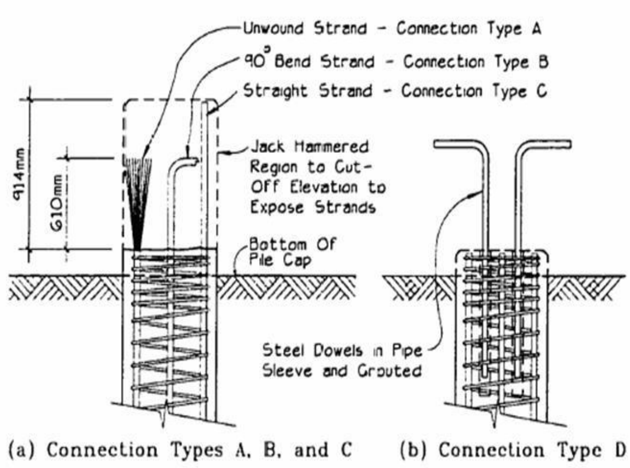


Figure 4. Pile-to-pile cap connections recommended by Sheppard (1983).

Three of the suggested connections involve jack hammering a portion of the pile length to expose the prestressing strands, and are based on earlier proposed connection details (Figure 3). In one of these connections (Type A), the prestressing strands are exposed over a length of 610 mm and unwound to form a broom-like shape, as illustrated in Figure 4a. In another connection (Type B), the exposed strands are bent at 90^0 at a distance of 610 mm from the pile cut-off elevation, as illustrated in Figure 4a. In the third connection (Type C) the strands are placed straight over the 914 mm length of exposed pile, as illustrated in Figure 4a. In the fourth connection type (Type D), flex tubes are cast in the pile within the spiral cage for the insertion of steel dowels. The reinforcing anchor dowels are then placed inside the sleeves as deep as the development length, l_d, required for the corresponding reinforcing bar and grouted in place as shown in Figure 4b. There was no transverse reinforcement provided in these connections for the region of pile embedded in the cap. This connection is very similar to the California Department of Transportation (standard Caltrans) Class 625 pile design detail, Alternative X, but the steel dowels are cast with the pile section during the pre-casting operation (Caltrans, 1990).

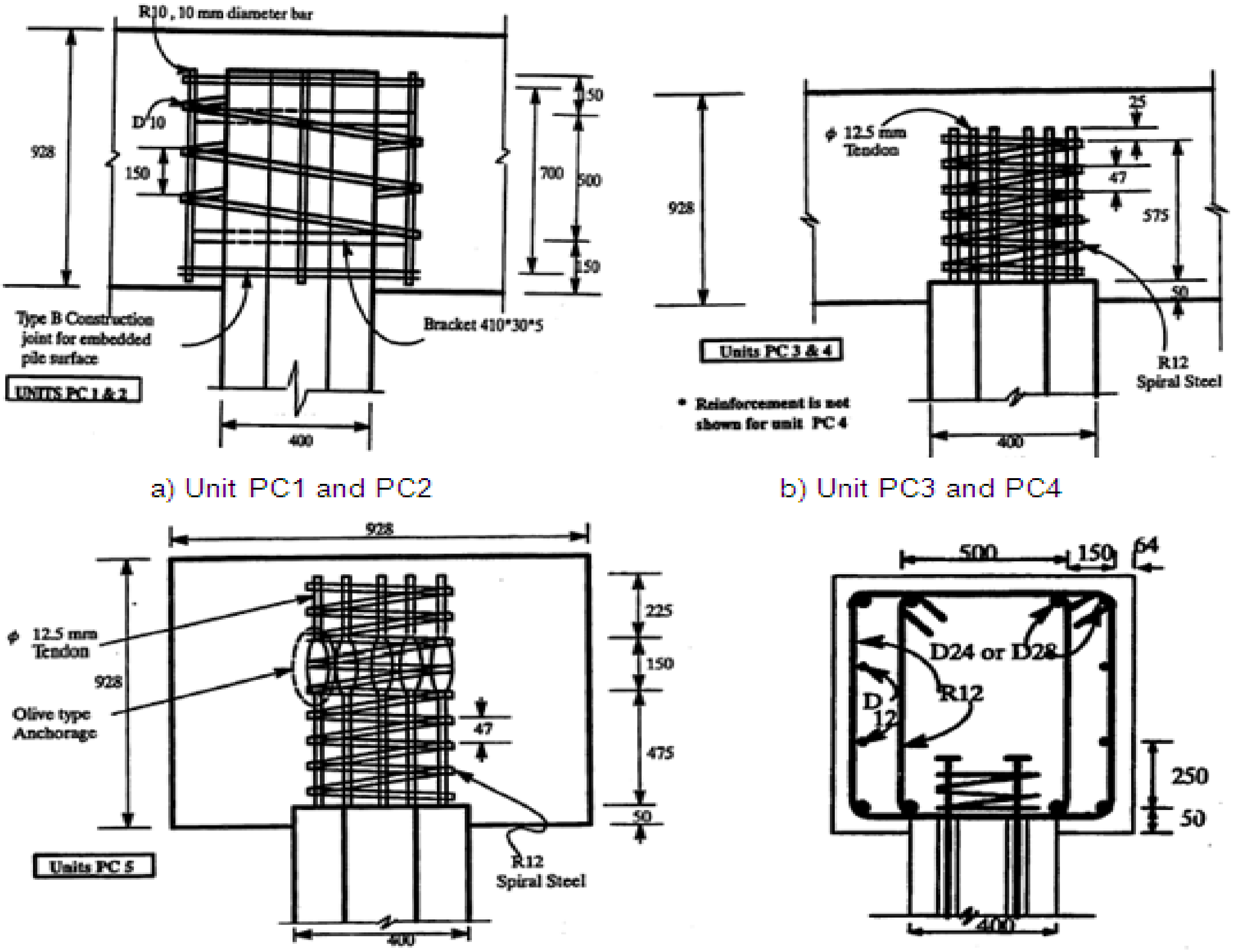
2. University of Canterbury Models

A research project conducted by Pam and Park (1990a) investigated the adequacy of the different connection details of precast prestressed concrete piles to the pile cap. Four different types of connections were used in the construction of six full-scale tests. All six tests (Figure 5) were designed in accordance with the New Zealand Standard (Standard, 1982) and used 400 mm octagonal precast prestressed concrete piles.

Test units PC1 and PC2 were prestressed with ten 12.5 mm diameter seven-wire strands and the pile was embedded 800 mm into the pile cap. A spiral cage was placed around the pile in the pile-cap connection region, as illustrated in Figure 5a. In addition to the prestressing strands, test unit PC2 contained ten additional D20 bars of 275 MPa steel. Test units PC3 and PC4 were reinforced similarly to test units PC1 and PC2, respectively. The connection of these test units to the pile cap consisted of removing the concrete in the upper 600 mm of the piles to expose the steel cage, and the piles were embedded 50 mm into the pile cap, as illustrated in Figure 5b.

The reinforcement of test unit PC5 was identical to test unit PC3. Each exposed strand had a length of 850 mm and an olive-shaped anchorage was inserted in the strands at a distance of 475 mm from the pile cut-off elevation, as shown in Figure 5c.

Test unit PC6 was reinforced as in test unit P3, and the connection to the pile cap was constructed by providing four D20 steel dowels, bent 90^0 inwards, inserted in a flex- tube dowel sleeve and grouted with an epoxy resin (Figure 5d). This connection type was similar to the connection detail illustrated in Figure 5b. Pam and Park (1990b) indicated that all four connection types were adequate in developing a moment resisting connection to the pile cap. Test units PC1 and PC2 connections had adequate moment resisting capacity to develop the expected flexural strength, and distress in the joint region was not observed at large displacement cycles. The connection in these two test units proved to be the most advantageous because no damage was observed in the joint region. In addition, of all four different connection types, the connection type depicted in Figure 5a proved to be the easiest to implement and construct, because the as-built pile is embedded into the pile cap. In contrast, in test unit PC6, the expected flexural strength was not reached due to the concentration of inelastic deformations over a very small region, as a single-wide open-crack formed at the pile cap interface.



a) Unit PC1 and PC2

b) Unit PC3 and PC4

c) Unit PC5

d) Unit PC6

Figure 5. Pile-to-pile cap connection details for UC models (Pam and Park, 1990b)

In the test series, all of the six units were tested with a constant applied compressive axial load level of 0.2 $f_c' A_c$. However, during a seismic event, piles in a pile group are subjected to changes in the axial load because of rotations of the pile cap.

3. University of California, San Diego Models

Silva (1998) investigated three standard Caltrans test units, which were tested under increasing cyclic lateral load or deformation and fully reversed varying axial loads (compression and tension). The three standard Caltrans pile test units were defined as STD1, STD2 and STD3. The pile in test units STD1 and STD2 was a Class 625 pile, and for test unit STD3 the pile was a Class 1780. The test unit STD1 (Figure 6) was a full scale pile of 305 mm square precast prestressed concrete and the test unit STD2 was also a full-scale of 356 mm diameter steel encased un-reinforced concrete. The test unit STD3 was a 7/12-scale model of 356 mm diameter steel encased in un-reinforced concrete.

The piles in test units STD1 and STD2 were designed as members with a pinned connection to the pile cap, and bending moments that might develop at the pile head were not considered in the design phase. This approach leads to a conservative design, as previously described. However, bending moments that developed at the connection to the pile cap imposed higher stress demands in the section than expected when only axial stress was considered. As a result, damage at the pile head and in the connection was likely to occur due to the interaction of axial and flexural stresses. Because of the low bending moment capacity at the connection region, this pile was designed be used only in stiff soil conditions. On the other hand, the pile of test unit STD3 was implemented for soft soil conditions as a member that developed a moment connection for the displacement control of the pile cap. However, bending moments that developed at the pile head were not considered to add bending moment resistance to the rotation of the pile group.

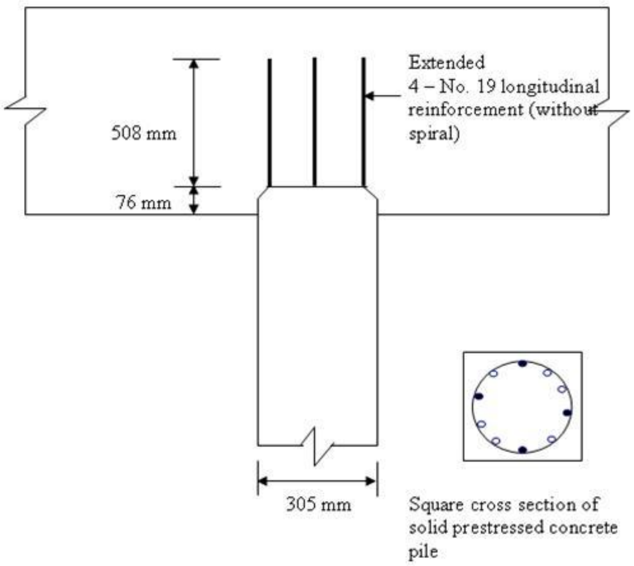


Figure 6. Unit STD1 model of pile-to-pile cap connection (Silva et al., 1997)

4. University of South Carolina Models

Harries and Petrou (2001) undertook experimental tests at the University of South Caroline (USC) Structures Laboratory as shown in Figure 7. Two 18 in. (450 mm) square by 18 in (5.49 m) long piles were fabricated simultaneously in a 40 ft (12.2 m) prestressing bed. The compressive strength of concrete used was 46.2 MPa. The piles were prestressed with eight 12.7 mm (½ in.) diameter low-relaxation strands and given an initial prestressing force of 138 kN, which was equivalent to $0.75f_{pu}$ at each pile, where f_{pu} is the ultimate strength of the prestressing steel. In this experiment, a detail connection of Type A recommended by Sheppard (1983) was adopted, as seen in Figure 3a, where the pile was simply embedded in the pile cap without any treatment. This is called plain embedment (i.e. no static bars).

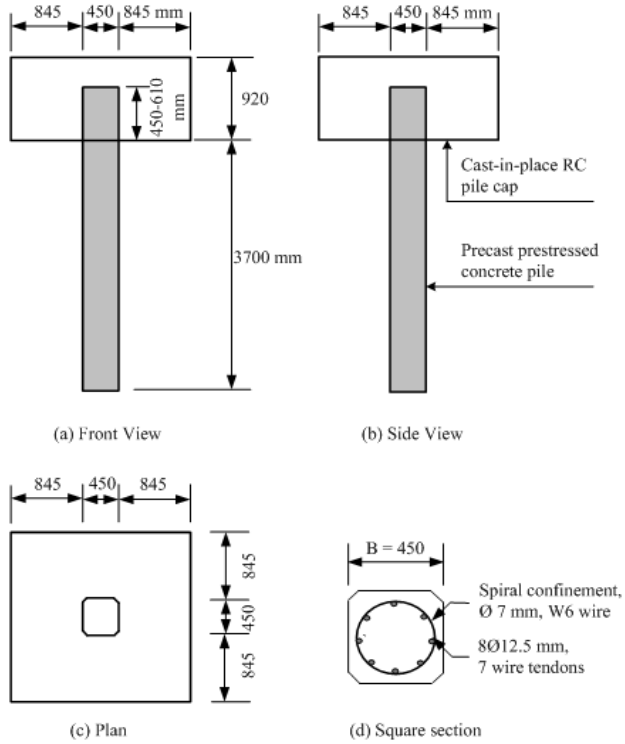


Figure 7. Detail of prestressed square concrete pile for the USC models (Harries and Petrou, 2001).

The strands were confined with a (0.276 in) W6 plain wire spiral at 38 mm pitch. Each pile was embedded in a 2.14 x 0.92 x 2.14 m cast-in-place pile cap with a compressive strength of concrete of 34.5 MPa. The pile cap was reinforced with No. 7 bars on the top and bottom and No. 3 ties at 152 mm spacing in the transverse direction and through the depth of the pile cap. In addition, both specimens of pile-to-pile cap connections used plain embedment models having different pile embedment lengths.

The connection details used in the first three experimental test models of pile-to-pile cap connections were based on recommendations by the Caltrans and New Zealand standards (1990; 1982). The objectives of the studies were to check the capabilities of pile-to-pile cap connections to resist large inelastic deformations caused by cyclic lateral loading. Another experimental test for the University of South Carolina model, however, studied a simple pile foundation in relation to design practice for low-rise buildings.

As described earlier, this study was primarily focused on the prestressed concrete pile connected to the pile cap. To validate the proposed new development of the pile-to-pile cap connections, the Unit PC4 of the University of Canterbury test and the Units P1 and P2 of the University of South Carolina tests were selected based on the aforementioned reason.

CURRENT DESIGN PRACTICE

This section primarily deals with the typical existing international design practice for pile-to-pile cap connections. As expected, the seismic behavior of pile foundations depends on the reinforcement details of the piles and their connections to the pile cap. Where there is no possibility for inelastic deformations to develop during the seismic response, detailing of the reinforcement, as for foundation components subjected to gravity and earthquake induced loads, should be adequate. Consequently, during earthquake actions, yielding is intended to occur at the pile-to-pile cap connection and within piles, and the affected regions must be detailed in accordance with the principles, which enable them to sustain the imposed ductility demands.

It is observed that several types of pile-to-pile cap connections have been used globally in design practices, as seen in the following sections, but these have not been completely studied. As a result, potential pile-to-pile cap connections should be investigated under seismic action.

Indonesian Models

Figure 8 shows the current design practices for piles and their connections to the pile cap that are often used in Indonesia. In both types of connections (Model-1 and Model-2), the pile head needs special treatment, which involves the provision of auxiliary steel bars confined with spiral reinforcement and concreting within a hole with a depth of approximately twice the pile diameter. The extended tendons and auxiliary steel that is used as headed reinforcements are bent at approximately 60^0. In practice, both types of connections provide similarity in reinforcement details but dissimilarity in pile geometries. However, the length of the embedded pile should be greater than pile width or pile diameter, and the pile seating is approximately 50 mm.

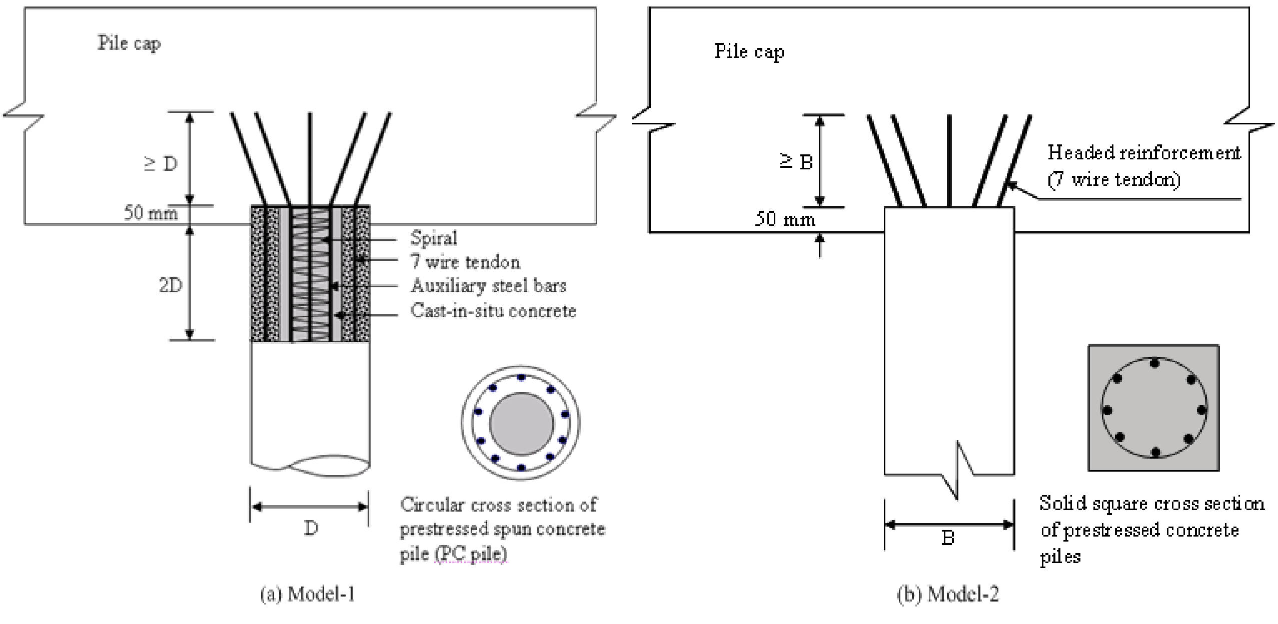


Figure 8. Current design practices of pile-to-pile cap connections in Indonesia.

These types of Indonesian design connections have not been extensively investigated, and are therefore still under review by the Indonesian Code Committee for a revised version of the Indonesia seismic code (S.N.I.03-1726, 2002). It should be noted that neither of these current design practices have encountered any problems in high-rise buildings or long-span bridges during earthquake events that have occurred in the Indonesian seismic zone 2, in places such as Jakarta. Both types of connections, however, require extensive study to check their ductility and their capability of withstanding deformation when subjected to seismic actions.

The New Zealand Ministry of Works and Development

In the standard design drawings for 400 mm octagonal prestressed concrete piles, the New Zealand Ministry of Works and Development (MWD) has recommended two types of pile-to-pile cap connections to be used as design practices (Standard, 1982). The first type involves casting the end of the pile in the pile cap. The second type involves stripping back the pile concrete at the end of the pile and casting the exposed reinforcement in the pile cap. These connections are shown in Figures 9a and 9b.

A recommended pile is of 400 mm octagonal prestressed concrete, and prestressing strands are confined with spiral reinforcement. The first type involves casting the pile head in the cast-in-place pile cap, which is confined with spiral reinforcements up to the minimum embedded length. The second type involves stripping back the pile head and casting the exposed strands in the pile cap. The headed tendons and reinforcements are confined with hoops along 570 mm.

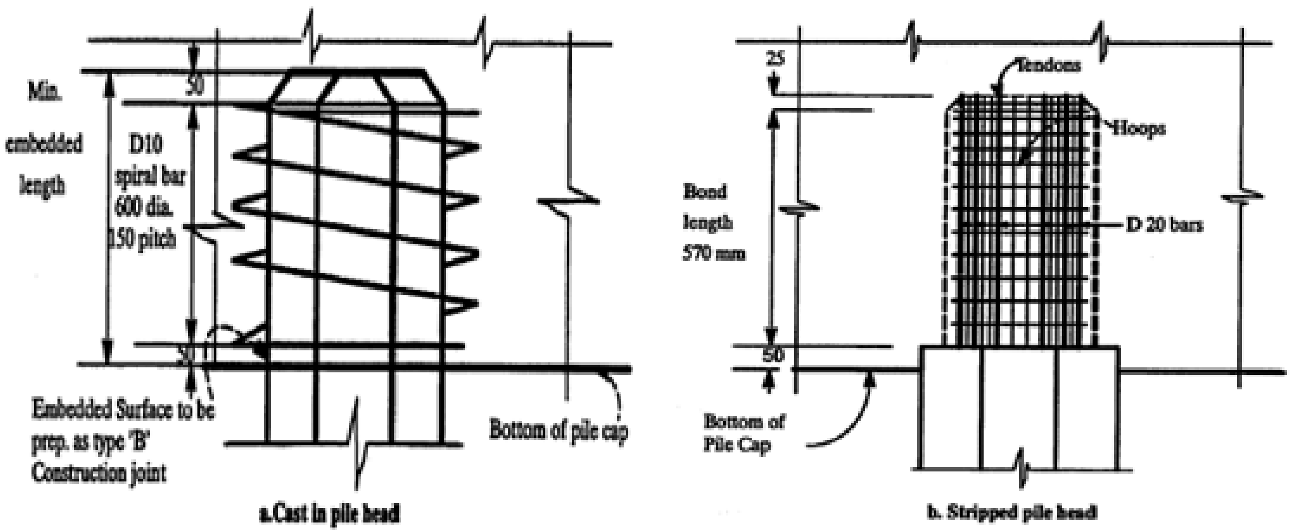


Figure 9. Current design practices recommended by the MWD (1982)

South Carolina Department of Transportation Model

A connection detail that is currently used by the South Carolina Department of Transportation (SCDOT) is shown in Figure 10. Typically, this type of connection is a combination of details that incorporates Type-B, Type-D, and Type-G. In this connection, a precast prestressed concrete pile head is embedded in the cast-in-place pile cap with the length of embedment in the range of 305 – 508 mm. The pile head is roughened up to approximately 7.62 mm amplitude over the entire surface of embedment (similar to Figure 3b, d, and f). The embedded vertical dowels and the auxiliary steel bars are then confined with round spiral reinforcement. This type of connection is basically a combination of the connection models B, D, and F that were proposed by Sheppard (1983), as shown in Figure 3.

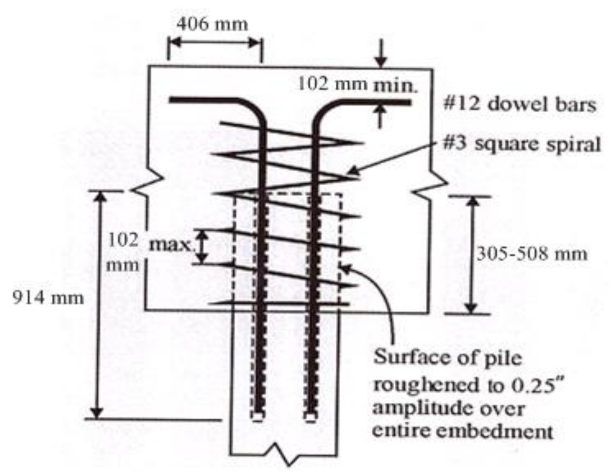


Figure 10. Pile anchorage detail required by the SCDOT (Harries and Petrou, 2001)

ANALYSIS MODELS

In analytical modeling, prestressed concrete piles were designed for ductility in order to withstand considerable lateral soil displacements during major earthquakes. The maximum curvature or deformation capacity was based on the section properties (internal factors) of the pile and the curvature or deformation demand due to external factors, such as the properties of surrounding soils, soil-pile interaction, and the displacement produced by a particular selected earthquake record.

The principal objective of modeling is to enumerate the seismic response of pile-to-pile cap connections in terms of structural displacements, member forces and deformations. This modeling is used to determine the seismic demand in the form of the required member forces and deformations to satisfy the seismic performance of pile-to-pile connections.

In the finite element modeling, concrete and reinforcing steel are represented by separate material models, which are combined with a model of the interaction between reinforcing steel and concrete through bond-slip to describe the behavior of the composite reinforced concrete material. The material behavior of concrete is described by two failure surfaces in the biaxial stress space and one failure surface in the biaxial strain space. Concrete is assumed as a linear elastic material for stress states, which lie inside the initial yield surface. For stresses outside this surface, the behavior of concrete is described by a nonlinear orthotropic model, in which the axes of orthotropy are parallel to the principal strain directions. The concrete stress-strain relation is derived from equivalent uni-axial relations in the axes of orthotropy. The behavior of cracked concrete is described by a system of orthogonal cracks, which follow the principal strain directions and are thus rotating during the load history. Crushing or cracking of concrete takes place when the strains lie outside the ultimate surface in the biaxial strain space.

The design models that were developed to calculate the seismic demand are based on approximate member dimensions from a preliminary design, utilizing estimated effective section properties, and nominal or design material characteristics. To capture the seismic demand, models representing the entire or global structural system were developed, and various analysis techniques, mostly linear elastic, provided a computation of member forces for equivalent static or dynamic earthquake load input. Based on this, member forces, dimensions, and detailing were iteratively refined. Referring to the capacity design philosophy and principles, these analyses were used primarily to determine: (1) the flexural strength characteristics of critical plastic hinge regions; and (2) the required strengths of other members or of the section to be protected by capacity design considerations. In this research, the pile-to-pile cap connection was modeled incorporating the improved material properties as well as the detailing of reinforcement.

Linear Static Analysis

The pile foundation structures of high-rise buildings or long-span bridges are often complex, with static behavior that is difficult to assess. Yet, understanding their static behavior is necessary to adequately preserve and maintain these structures. The aim of the linear static analysis is twofold. The more general aim is to develop the use of the finite element method in combination with visualization and to demonstrate its potential both for providing an understanding of structures and their static behavior and for supporting ideas of further analyses. The more specific aim is to examine the static behavior of one particular connection and the damage that occurs.

The computational process in this study is reported elsewhere in previous publication. A detailed model of the pile-to-pile cap connection was initially carried out with three-dimensional linear static analysis, from which a set of possible causes for the damage that was observed earlier was simulated and evaluated before proceeding into nonlinear analyses. Whenever reliability problems were found, three-dimensional visualizations were presented to identify their respective influence on the overall structural behavior.

Nonlinear Static Analysis

A nonlinear static analysis is a pushover analysis in terms of studying the failure mechanism of a structure, such as a sequence of the formation and propagation of plastic hinges of piles and their connections to the pile cap. It should be noted that the most important property of a structure is its nonlinearity, which comes mostly from the nonlinearity of materials and geometry, such as the local or micro-failure of its components. At small amplitudes, a structure is considered linear.

A nonlinear model was implemented as a second computational process for pile-to-pile cap connection analyses when the first process of linear static model was successfully finished. In this research, nonlinear static and cyclic models were performed in two and three-dimensional systems to seek the seismic behavior of the pile-to-pile cap connections.

As expected, the use of visualization, through graphs, contour levels, symbols, and maximum and/or minimum response values in the nonlinear analysis, was very helpful for interpreting the relationship between the computational models and the experimental tests. In addition to the nonlinear inelastic analysis, the analysis models were laterally performed with monotonic and cyclic loadings, producing results at a higher confidence level. This technique has been applied successfully to the nonlinear inelastic analysis of the pile-to-pile cap connections and has been proven to be a very useful and exact method for analyzing the structures.

Nonlinear Time History Dynamic Analysis

The nonlinear time history dynamic analysis was preliminarily used to study the vulnerability of major structures; this is shown in a prior publication (Teguh et al., 2004). This analysis requires a recorded earthquake, drawn from time history input files, to capture the worst-case scenario. During the analysis, each of the time steps produces a seismic response in terms of force and displacement. In this research, dynamic analysis was used to study piles group connected to the pile cap and considered as a frame-type structural model. The maximum forces and displacements of the structural components were summarized at the end of the analysis.

Advance Finite Element Analysis

In the seismic design based on the inelastic displacement concept, specific necessary lateral loads, story drifts and structural member deformations should be kept within the design limitation during the earthquake in order to ensure the seismic performance. The correct analytical predication of the energy absorbed by structural elements is necessary to assure this design concept. In the FEM analysis of RC elements, the target of the analytical model is to simulate the hysteretic behavior of the structural elements correctly.

In this study, more realistic analysis models such as a transition hysteresis model for concrete stress-strain relationships especially in tension-compression regions, an orthogonal fixed cracking model, bond-slip model, and a hysteresis model for shear characteristics of cracked concrete, considering deterioration and fracture mechanics were taken into account in the nonlinear analysis. The characteristics of the behavior of reinforced concrete elements under cyclic shear, such as the tangent stiffness for unloading and reloading, slip stiffness, residual strain and the deterioration, can be simulated more precisely.

RESULTS AND DISCUSSION

A lack of information for the seismic design requirements of pile-to-pile cap connections in the existing code provisions, and limited publications concerning studies on pile-to-pile cap connections, have motivated engineers and researchers to further study in this area. Previous studies undertaken by a number of researchers were mostly on a single pile connected to the pile cap and were experimental in nature. Since then, analytical models have been developed to complement the experimental research and enhance understanding and design of pile-to-pile cap connections under seismic actions. However, previous tests have neglected soil response and not much work has been done on pile-to-pile cap connections, nor a consideration of the soil-pile interaction when subjected to earthquake loading.

As it is difficult to estimate underground seismic intensity and the embedment effect of an underground structure, the design process for pile foundations that take into consideration severe earthquake motion is not well established. Predicting the seismic response of pile-to-pile cap connections, in which potentially affects plastic hinges along the pile and at the interface between pile head and pile cap, is not clearly understood. This condition has subsequently motivated researchers undertaking extensive studies to simulate the structural component under earthquake loading. The researchers concluded that prestressed concrete piles containing modest amounts of spiral reinforcement provided satisfactory performance of the piles.

As discussed earlier, many previous studies on prestressed concrete piles and reinforced concrete pile cap connections have been conducted; however, research work concerning pile caps and pile-to-pile cap connections is very limited. The depth of previous studies has been detailed above and it has been established that there are still many questions to contemplate.

The ACI Sectional Force (A.C.I. Committee 318, 2002) and Canadian Code (CAN/CSA-S6_00, 2000) does not provide universal strut-and-tie approaches. The ACI Code approach is considered valid for multiple pile caps, but is not realistic in the case of a pile-to-pile cap connection. The CSA Strut-and-tie procedure accurately models the behavior of planar members, but its application to 3-D problems runs into difficulties (Adebar et al., 1990). Both methods assume the equal distribution of loads to various piles, which would be logical if the pile cap is rigid. Nevertheless, it is assumed in both approaches that the cap is ductile. This seems to be an incorrect assumption. The NZS 3101 (1982), the CSA (2000), and the SNI 03-1726-2002 codes mainly refer to the ACI 318-02 with minor modifications. Other aspects, which have not been comprehensively examined, are listed as follows:

1. The effect of the spiral steel ratio to confine headed reinforcement in the pile region has not been investigated.
2. The bond-slip of tendons within the pile cap has not been recorded during the pile-to-pile cap connection tests.
3. Soil response due to soil-pile interaction was not considered.
4. The length of the potential plastic hinge region, which occurred when the compressive axial load exceeded $0.3f_c'A_g$ was increased by 50%. There is no provision for this.
5. The effect of non-prestressed steel on ductility and shear strength has not been fully investigated for the joint core region.
6. The load applied was load controlled during the first cycle and displacement controlled for the remaining cycles.
7. Analytical analysis was done mostly by hand methods (Pam and Park, 1984) or by using computer methods (PSCOL and MOMENT) developed by Mander et al. (1984) and modified by Whittaker (1987), and no major finite element program was utilized.

The seismic behavior of the pile-to-pile cap connections has been examined further with regard to pile embedment models, pile embedment length, and boundary condition models including support models and variants of the axial loads. As discussed in previous sections, the problem of soil-pile interaction in a seismic environment is complex, and a substructure method, which allows the structure and foundation portions to be calculated separately, was adopted as a simple and realistic procedure. As a result, the adequacy of the methodology from the viewpoint of engineering practice was shown to have good agreement between the analytical and experimental results.

CONCLUSIONS AND RECOMMENDATIONS

Based on the review as detailed in early sections, a summary of conclusions can be drawn up as follows.

1. The past experimental investigations on prestressed concrete piles, as undertaken by a number of researchers, indicate that the amount and spacing of transverse steel is not adequate for piles in resisting major earthquakes. The amount of transverse steel provided in the critical region confines the core concrete inadequately if a high axial compressive load and large curvature occurred. In addition, the specified minimum spacing of transverse steel does not prevent premature buckling of tendons even during small displacement ductility factors.
2. Further study on the effect of soil-pile interaction in the pile-to-pile cap connection is essential, and it seems that results from simulations that utilize three-dimensional finite element models may assist. Previous test specimens of the pile-to-pile cap connections were selected as a benchmark for verifying the analytical modeling against experimental tests. In this regard, a review for developing material constitutive laws used in the finite element modeling.
3. Analysis of pile-to-pile cap connections using the finite element method is also very limited. Correlation studies between analytical and experimental results and several parameter studies are conducted with the objective of establishing the validity of the proposed models and identifying the significance of the parameter effects used in this study.

The connection details of the pile-to-pile cap connections recommended herein are based on current analytical studies (Teguh, 2007) and the available experimental tests, in order to provide reliable connection details and to avoid congestion of steel in the connection. The recommendation for the connection details includes two pile-to-pile cap connection models as presented in Figures 11 and 12. These two connection details are recommended for any solid section of precast prestressed concrete piles connected to cast-in-place reinforced concrete pile caps. The three common pile sections include square, circular, and octagonal sections.

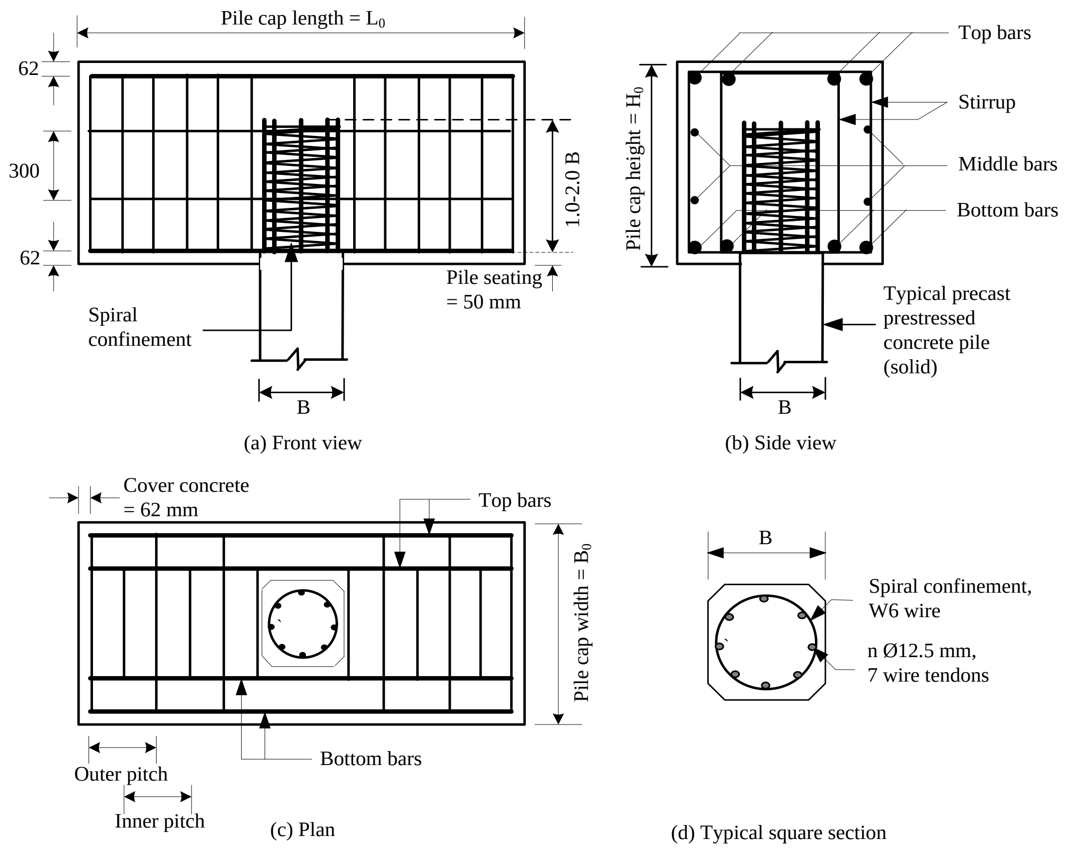


Figure 11. Detail of recommended pile-to-pile cap connection Type-I

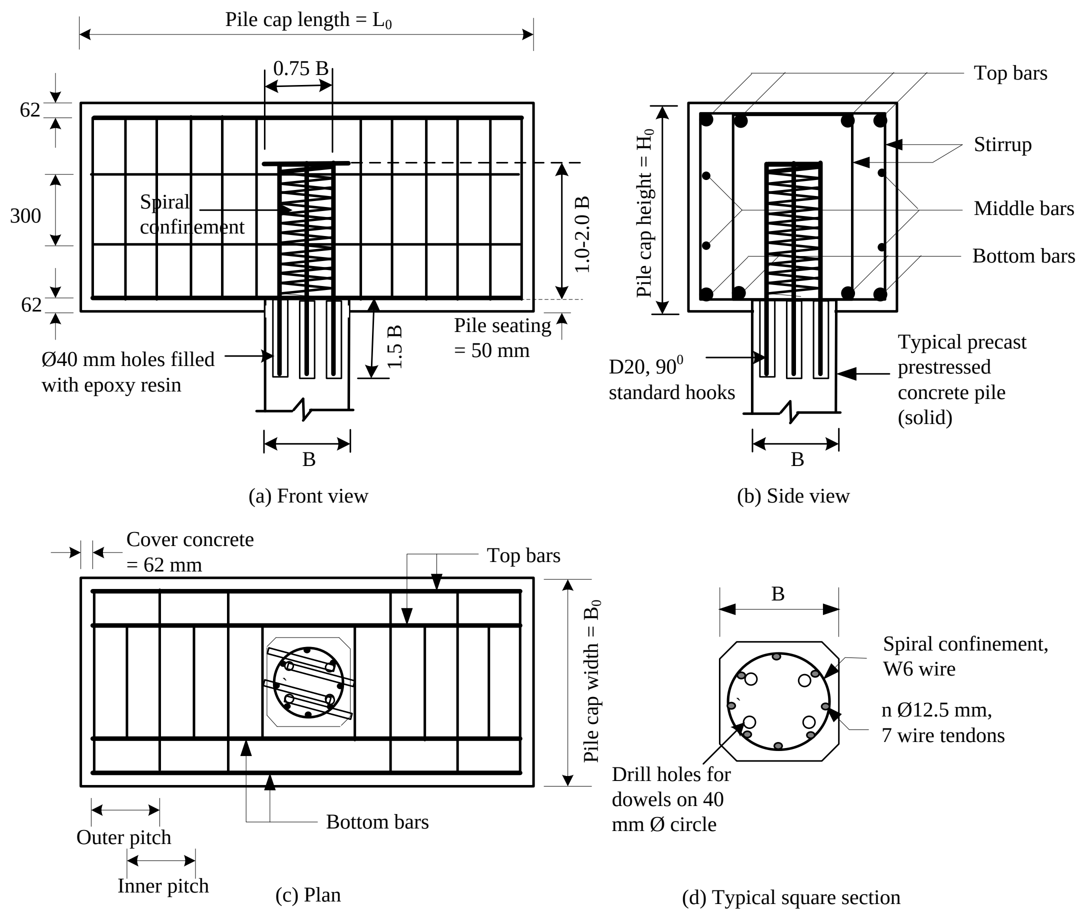


Figure 12. Detail of recommended pile-to-pile cap connection Type-II

The first recommendation for the pile-to-pile cap connection detail is Type-I, which consists of a headed embedment model confined with spiral reinforcements and an embedment length in the range 1.0-2.0 of pile depth or diameter. The pile embedment length is excluding the 50 mm pile seating. The pile and pile cap dimensions should be accurately designed based on the forces resulting from the global superstructure analyses, and also in consideration of the soil conditions in which the pile foundation will be constructed.

The second recommendation for the pile-to-pile cap connection detail is Type-II, which similarly comprises a headed embedment model confined with spiral reinforcements and embedment length in the range 1.0-2.0 of pile depth or diameter; however, this model requires special treatment in the connection details. The Type-II connection model was a modified version of one of the connections proposed by Sheppard (1983), with reference to the tests undertaken by the University of Canterbury (Pam and Park, 1990b), and the University of Washington (Roeder et al., 2005)

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MASONRY UNIT UTILIZING AGGREGATE FROM CONSTRUCTION DEMOLITION BOUND WITH ASPHALT

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ABSTRACT

In line with increasing pressures to reduce the exploration of natural aggregates, utilization of waste aggregates materials for construction industry had been encouraged. One alternative material that can be used as masonry unit is aggregate from construction demolition with asphalt as the binder (an alternative to cement). Construction demolition may available due to various reasons such as demolition for reconstruction, war, natural disasters etc. The investigation was carried out in the United Kingdom (UK), which is applicable elsewhere in the world especially in oil producing countries where large amount of asphalt is available. The asphalt used as the binder was 100pen grade asphalt. The objective of the investigation was to produce masonry unit with performance equal to concrete block commonly used in the United Kingdom with compressive strength between 2.8-10 MPa. This requirement is slightly higher than the minimum compressive strength of 2.5 MPa in line with Indonesian standard. The specific creep strain targeted was less than 100 microstrain. The masonry unit requires suitable particles size proportion, in order to obtain the expected results: stable during handling with low compaction effort with satisfactory compressive strength and to meet demand in using minimum bitumen content. The materials were proportioned, hot mixed, compacted than heat cured. The masonry unit requires sufficient heat curing. It was found that construction demolition materials (CDM) were suitable to be used for making masonry unit with asphalt as the binder. Compaction level of 2 MPa and curing regime of 200°C for 24 hours were sufficient and gave an overall satisfactory result. It was also found that the masonry unit volume stability was affected by relative humidity (moisture). Its volumetric movement due to moisture was not fully reversible, but highly reversible on thermal exposure. The compressive strengths of the unit produced using locally available construction demolition material, well meet the Indonesian standard, i.e. minimum of 25 kg/cm2.

Keywords: *masonry, construction, demolition, aggregate, asphalt*

INTRODUCTION

Demands on aggregates for construction industries world wide continue to increase. For example, aggregate demand of the United Kingdom (UK) raise from a level of 270 million tonnes in 1989, to a predicted demand of 420-490 million tonnes by 2011 (Whitbread et al., 1991).

Meanwhile there has been an increasing pressure to reduce the exploration of natural aggregates. This situation encourages the utilization of waste and secondary aggregate materials for construction industry.

Currently, 160,000 new homes are built each year in the UK of which 90% are constructed from masonry. Each house on average requires approximately 200m^2 of building block work resulting in approximately 350 million blocks being manufactured each year. Waste or by product materials such as steel slag, crushed glass, and coal fly had been incorporated into masonry building blocks (Forth et al. 2006).

Another alternative material that can be used is construction demolition waste (CDW) from building or road pavement (Craighill et al., 2006). Around 17% of the total UK waste arises from the construction and demolition industries (DoE 1994). Although a large proportion of the waste created is recycled in some way, most of it is used for low grade purposes such as access roads within landfill sites and only 4% is used to replace primary aggregates (Humphreys et al., 1994).

There are many potential uses for CDW materials, however they are deterred by the perceived risks involved due to its low strength. There is a need to increase confidence in the use of CDW recycled materials, which can only be achieved by identifying, undertaking and monitoring appropriate demonstration projects, and disseminating the results through publications and seminars. The coarse fraction of the aggregate for concrete mixtures can be replaced by up to approximately 20% with CDW aggregates without significantly affecting the compressive strength (Soutsos et al., 2004)

The objective of the investigation described within this paper is to produce CDWblock with performances at least equal to concrete blocks commonly used in the United Kingdom (UK) with compressive strength between 3.5-7 MPa (Sear, 2005) or minimum of 2.8 MPa (BS6073, 1981), and specific creep strain less than 100 microstrain (Tapsir, 1985).

The application of this research is possible when large amount CDW is available due to demolition of old buildings, and/or due to inevitable natural disasters, such as earth quake, flood, cyclone, etc. This works is more attractive in areas close to oil refinery, especially in oil producing countries, where a lot of asphalt (oil distillation residue) which can be used as an alternative binder is widely available. The people in unfortunate disaster areas can be trained to make CDWblocks for providing building materials for them selves.

METHODS

Materials

The aggregate used is aggregate from construction demolition waste (CDW), which would be of non homogeneous material as it may come from demolition of various types of buildings or constructions. The CDW used for this investigation was taken from a supplier that consisted of a mixture of broken concrete, clay brick masonry, sand cement mortar, and reclaim asphalt pavement (RAP) in a random proportion with minor clay brick component as can be seen in Figure 1. The CDW particle size distribution is shown in Figure 2, with maximum particle size of 10mm.

The bitumen used as the binder was 100pen grade bitumen. This is relatively soft grade bitumen. Utilization of softer grade bitumen had given satisfactory results (Thanaya et al., 2006).

The properties of the CDW aggregates were tested in line wit the BS 812 (BS812, 1995),

Figure 1. The construction demolition waste (CDW) aggregate material

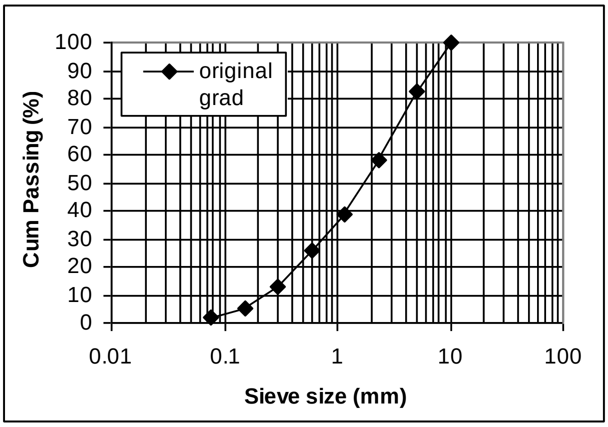

Figure 2. The CDW original gradation (max diameter of 10mm)

and are given in Table 1.

Table 1. Properties of the CDW aggregates

Properties	Unit	Coarse CDW (> 2.36mm)	Fine CDW (< 2.36mm)
Density (bulk)	g/cm3	2.415	2.341
Density (ssd)	g/cm3	2.478	2.433
Density (app)	g/cm3	2.569	2.578
Water abs.	%	2.5	3.9

Referring to Table 1, the properties the CDW aggregates were found very comparable with commonly aggregates available for building industries.

However, as the CDW is processed from waste materials, therefore the homogeneity of the aggregate component may not be consistent.

Initial Trials

Building block units bound with asphalt can be produced with either using continuous or gap aggregate grading. When using continuous aggregate grading, higher compaction effort commonly needed (Forth et al., 2006).

Within this investigation gap aggregate gradation was selected in order to enable the use of lower compaction effort. As there is no standard specifically available for building block aggregate grading bound with asphalt, Hot Rolled Asphalt (HRA) aggregate gradation was referred to as an initial reference, then modified based on trials results.

During the initial trials, the CDW material particles sizes were graded (sieved) into: coarse fraction of 10-5mm and 5-2.36mm, and fine fraction of all passing 2.36 mm. Initially the aggregate grading used for the CDWblock was the same as the Bitublocks (similar block incorporating various waste aggregate materials) previously produced with a gap graded aggregate grading (Forth et al., 2008), but with maximum particle size of 10mm. The aggregate composition was: 40% coarse fraction, 50 % fine fraction, and 10 % coal fly ash filler as shown in Figure 3, which is completed with a hot rolled asphalt (HRA) grading of the BS 594 (BS594-1, 2005) , for a general comparison, and for a better appreciation on the aggregate composition.

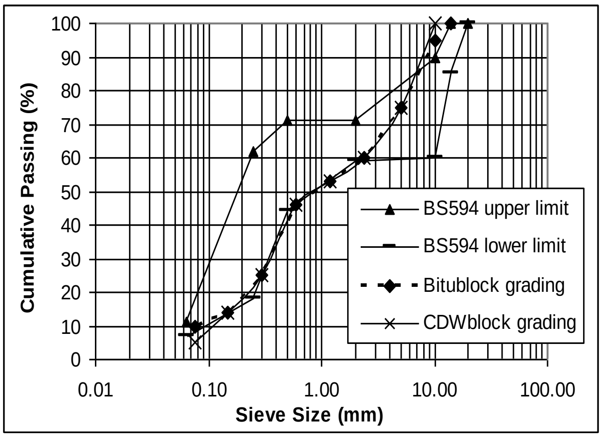

Figure 3. The CDW block aggregate grading compared with the Bitublock grading and the BS594

The bitumen used as the binder is a commercially valuable by product material from crude oil refinery industry, therefore the CDWblocks were produced with lowest bitumen content possible, that can give sufficient or adequate bitumen coating with satisfactory shape stability during handling and satisfactory performances when compacted at low compaction effort.

Minimum bitumen content of 5 % by weight of total mixture was initially tried. The static compaction effort was 1 MPa for 1 minute. The degree of bitumen coating was satisfactory; however the shape of the blocks was not stable. The corner sides or edges were easily taken off. The surface texture was rather smooth, and some aggregate particles on the edge sides of the samples were taken off. This had caused some part of the samples had an open texture, therefore water absorption after 24 hour immersion was found high (6.9%), as shown in Tables 2b (Mix A).

Gradation Modification and the Properties of the CDWblock

The specific gravity of the CDW materials were not the same with the Bitublock previously made (Forth et al., 2008), so it affects the volumetric composition of the materials. This was found to give effect of the sample's shape stability (compactness). In order to improved the CDWblock shape stability, the aggregate grading was slightly modified. The max particle size used was 10mm, instead of 14 mm as used for the Bitublock. The filler content was reduced from 10 % to 5%, but increasing the fine fraction from 50 % to 55 %, where the coarse fraction remains at 40 % (Figure 3). This gradation modification was found to give more compact samples with surface texture neither too smooth nor too rough. Overall, the aggregate gradation of the mix became coarser, hence theoretically it has lower total surface area. Even at the minimum bitumen content of 5 % as initially tried the asphalt film thickness would increase.

In order to improve impermeability, asphalt film need to be made thicker. For this reason the bitumen content was increase from 5 % to 5.5 %, in addition to the reduction of aggregate surface area as mentioned above. The shape stability during handling was found satisfactory and the surface texture of the newly produced sample was found neither too smooth nor too rough.

By visual observation, the asphalt coating was also satisfactory, and theoretically with thicker asphalt film. This was considered necessary in order obtain satisfactory overall performances. The increase of the bitumen content was also done for anticipating the variation in quality of the CDW materials which are very likely of various absorption properties, as they are indeed a waste material. CDWblock with modified gradation (Mix B in Tables 2a and 2b), were then produced with compaction effort of 1, 2, and 4 MPa, with bitumen content of 5.5 % by weight of total mixture.

Table 2a. The Density, Porosity, and IRS of the CDW blocks

Mix	Comp. effort (MPa)	Density (g/cm^3)	Porosity (%)	IRS (kg/m2.min)
Mix A	1	1.925	15.1	0.105
Mix B	1	1.872	17.5	0.028
	2	1.950	14.0	0.021
	4	1.992	12.2	0.018

Table 2b. The Density, Porosity, and IRS of the CDW blocks

Mix	Comp. effort (MPa)	Water Abs* (%)	Comp. Strength (MPa)	
			uncured	cured
Mix A	1	6.9	2.0	8.1
Mix B	1	3.3	2.8	10.2
	2	2.7	3.8	17.5
	4	1.6	5.4	25.8

* 24 hours immersion in water

Heat Curing

Asphalt is a viscoelastic material. It has viscous and elastic component. The viscous component of the asphalt would cause creep when loaded. It had previously been found that curing regime played a very significant role for hardening the asphalt due to the evaporation of the volatile component and increasing the asphaltene component of the asphalt (Forth et al., 2006, Whiteoak, 1991), hence can reduce creep deformation due to static load (Forth et al., 2006).

It had been previously investigated that when using a 50 pen bitumen and cured in oven at 160 °C, the curing duration required to satisfy creep performance was 72 hours (Thanaya et al., 2006). In order to reduce curing duration, in this investigation the samples were cured at 200°C just for 24 hours, and the sample was found to gave satisfactory creep resistant.

Initial Rate of Suction (IRS)

IRS test was carried out by immersing the sample in 3mm depth of water for 60 second. The weight of water absorbed by the sample was then calculated and divided by the area in contact with water (BS3921, 1985). IRS is a parameter that can provide an indication of the effect of the unit on the sand cement mortar. Units with high IRS require very plastic mortar (high water/cement ratio), while units with lower IRS need stiffer mortar (Vekey, 2001).

In addition to the data presented in Table 2, the compressive strength of Mix B is also plotted in a graph as shown in Figure 4.

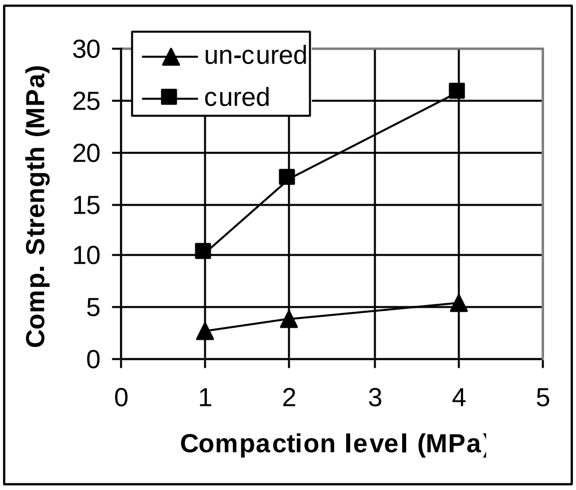

Figure 4. Compaction level vs compressive strength

Referring to Tables 2a and 2b, the performance of Mix A was affected by its grading which contained 10% filler compared with Mix B with 5 % filler content, and also affected by its lower bitumen content. As Mix A finer than Mix B, at 1 MPa compaction level Mix A was of lower porosity than Mix B. However the water absorption was higher as the bitumen film was thinner. The compressive strength of Mix B was better than Mix A, as Mix B was slightly coarser and of thicker bitumen film. It is logical, that the performance of Mix B was improved at higher compaction level. Curing regime had been experienced to significantly improve the compressive strength of the samples.

The water absorption of Mix B was overall in a reasonable level, which indicated that at 5.5 % bitumen content, the samples became more impermeable. The IRS values were found relatively lower than the typical IRS values of clay brick found in the UK (0.25 – 2.0 kg/m2/min). This indicates that the CDWblocks require sand cement mortar with lower water cement ratio (Vekey, 2001).

Expansion/Shrinkage Test

This test was carried out by measuring the expansion and shrinkage of the samples at different environment condition. The equipment used was a 50 mm Demec gauge with its supporting facilities such as demec points. Two Demec points were pasted on each of the four sides of the samples in vertical (V) direction, as shown in Figure 5.

Figure 5. The CDWblock sample and strain measuring equipment

Creep Test

This test was done in order to evaluate the resistance of the samples to deformation due to static load. The samples were loaded by means of a simple arm load machine (Figure 6), with 1 MPa stress. This stress (specific creep stress) is commonly applied in masonry creep test (Tapsir, 1985).

Figure 6. Arm load machine used for creep test loading

RESULTS AND DISCUSSION

Compressive Strength and IRS

Referring to Figure 4, it is revealed that the cured compressive strength of the samples were satisfactory, i.e well exceeded 7 MPa, where common compressive strength value for concrete blocks found the UK is between 3.5-7 MPa (Sear, 2005). The IRS values of the CDWblock were found somewhat lower than the range of IRS values for clay brick found in the United Kingdom (between 0.25-2.0 kg/m^2/min). Low IRS values were obtained because the aggregates were evenly coated by asphalt which has hydrophobic character. This suggest that the CDWblock tested in this experiment would require or more suitable to use stiffer mortar.

Expansion Due to Moisture Absorption

Before doing creep test, the cured samples were tested for their expansion at room environment condition (21±0.5 °C and 46 % relative humidity-RH). It was found that the samples expanded then stabilized after about 7 days. The samples with higher compaction level gave lower expansion as shown in Figure 7.

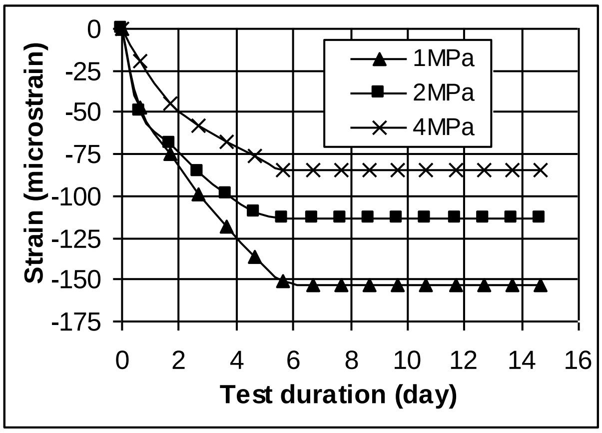

Figure 7. The vertical expansion test results

In order to evaluate the performance of the samples at different relative humidity, a further volume stability test was done. Two samples were initially conditioned at room environment (at a different room from previous experiment). The temperature was relatively constant at 21.0 ± 0.5 C°, but the humidity fluctuated at 62±2% RH.

The samples were also conditioned at 12%RH and 85%RH which were carried out by using desiccators filled with lithium chloride and potassium chloride hygrostatic solution respectively.

The expansion reading was taken at certain time interval until the expansion stabilized. Then the conditioning was changed. The results are shown in Figure 8 where the starting of conditioning changes are coded from A to E.

The samples were initially left overnight at room environment with 62±2% RH before the first strain reading was noted. After conditioning at room environment, the samples were then conditioned in a desiccator with 12%RH , using lithium chloride hygrostatic solution (start of conditioning A). The samples gradually shrunk then stabilized at +100 microstrain. Starting on day 11th, the samples were taken out from the desiccator and left at room environment (62±2% RH), (start of conditioning B). The samples slowly expanded then stabilized at -20 microstrain. Starting from day 24th the samples were put back into a different desiccator with 85%RH, using potassium chloride hygrostatic solution (start of conditioning C). The samples expanded (towards negative strain values) then stable at -340 microstrain. Starting for day 44th and then the following days, the samples were consecutively condition until stabilized at room environment (start of conditioning D), then at again at 12%RH (start of conditioning E).

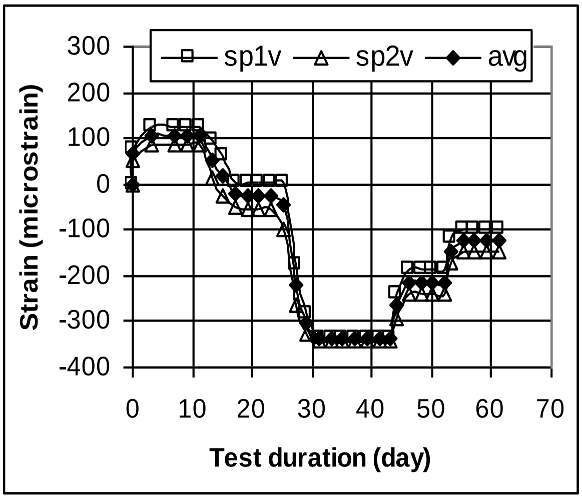

Figure 8. Average movement of the samples (sp) in vertical (v) direction

This further test confirmed that the volume stability of the samples was affected by changes in relative humidity. Conditioning to lower relative humidity caused the samples to shrink and vice versa. However, the magnitude of expansion and/or shrinkage was found not proportional to the changes in RH. The results indicated that the samples movement were partly reversible and irreversible. Quiet a large portion of the movement was irreversible. This situation is similar to clay brick (Vekey, 2001).

The results suggest that the expansion of the samples were of similar mechanism with cement paste or concrete, i.e. due to moisture adsorption. Due to adsorption of water molecules onto the surface of the particles reduces the surface energy on the capillary system, hence reducing the balancing internal compressive stress leading to volume increase or swelling (Domone, 1994).

This is also described by Neville (Neville 1991), that during water adsorption, the water molecules act against cohesive forces and tend to force the cement gel particles further apart. The ingress of water also decreases surface tension, and results in swelling.

It was also observed that the samples did not crack which indicates that the expansion was not excessive. The expansion of the unit would be neutralized by the shrinkage of the sand cement mortar joints in wall construction. The expansion can also give a pre-stressed condition to the wall structure which can improve the ability of the wall to receive horizontal load.

Thermal Expansion

Thermal expansion test was carried out by conditioning the samples in oven at 70 °C for 3 hours. This time was sufficient to generate the targeted heat on the core of the samples (tested using a thermocouple inserted into one of the samples).

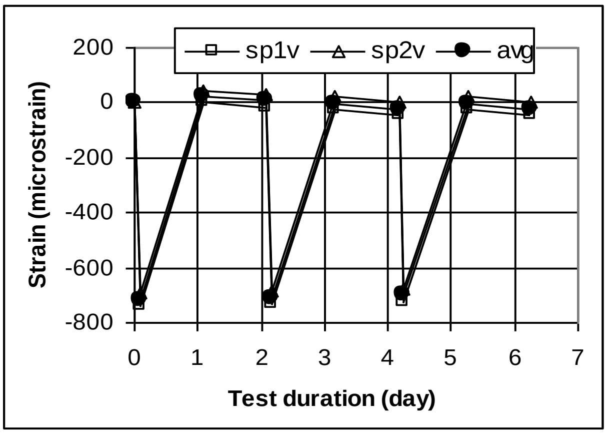

Figure 9. The strain profile of the samples (sp) during heating at 70 °C for 3 hours in vertical (v) direction

After heating, the samples were left at room environment (21.0 ± 0.5 °C, with 50±2% RH) until stabilized. The results are presented in Figure 9.

Referring to Figure 9 (strain in vertical direction), within the first heating cycle the samples expanded to 750 microstrain (10^{-6}). Then the samples were taken out from the oven and conditioned at room environment for 2 days. Within the fist day at room environment the samples shrunk almost to its original position and then slightly expanded on the next day due to the moisture absorption from the environment (as had been experienced). Similar procedures were carried out on the next two cycles.

Thermal expansion of the blocks was found highly reversible, similar to concrete masonry (CST, 2007). The coefficient of thermal expansion on the Building Blocks was around 600-700 microstrain or (10^{-6}) per 70 °C, or about 8.6-10x10^{-6} /°C. This coefficient should have affected by the size of the samples (100x100x65mm) and the level of curing regime applied. The coefficient is comparable to the coefficients of expansion of concrete masonry units, i.e. 7.2 to 9.0 x 10^{-6} /°C (Drysdale et al.,1994).

Creep Performance

After the expansion test with results as in Figure 7 (after the volume of the samples stable), the samples were then tested for creep at the same environment. The stress applied was 1 MPa.

This stress is commonly applied in masonry experiments in order to evaluate specific creep, i.e. creep strain per MPa unit stress. The creep test results are shown in Figures 10 and summarized in Table 3.

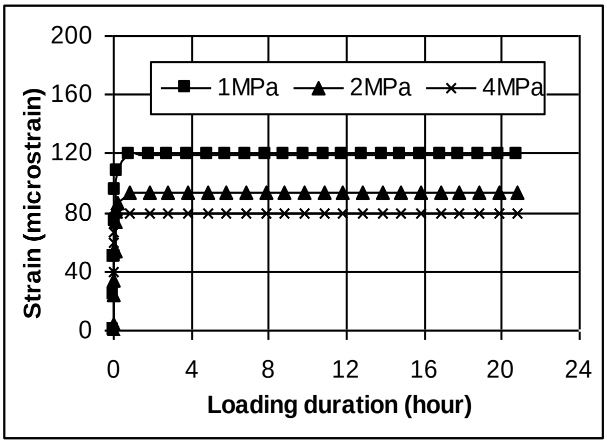

Figure 10. The creep strain of the samples compacted at different compaction level

The creep test results indicated that the all of the samples gave creep strain at least equal of concrete block commonly used in the UK (Sear 2005, BS6073 1981). In order to ensure a better deformation resistant, creep strain of less than 100 microstrain is recommended (Tapsir 1985), therefore compaction level of at least 2 MPa is suggested.

Table 3. Creep performance of the CDWblock samples

Comp Level (MPa)	Total Strain (με)	Elastic Strain (με)	Creep Strain[1] (με)	Exp. at creep test* (με)
1	173.25	54.45	118.8	*
2	143.55	49.5	94.05	*
4	113.85	34.65	79.20	*

[1] creep strain = total strain–elastic strain–shrinkage or expansion.

* the samples were tested for creep after the expansion stabled (at zero expansion).

RECENT EXPERIMENT

The author had carried out recent experiment on masonry block unit using locally available construction demolition material in Bali. After carrying out trials, the aggregate particles composition was determined to consists of 40% coarse particles (14-2.36)mm, 50% fine particles (2.36-0.075)mm and 10 % filler (passing 0,075mm). Waste concrete was used for the coarse particles. The fine particle portion consisted of 25% waste concrete, 50 % concrete blocks, and 25 % clay brick. Rice husk ash was used as the filler. Compaction was carried out by applying 50 blows Marshall hammer. The asphalt used was of 60/70 pen, and the content was varied and gave optimum at 5.5%. At this stage the curing regime applied was 200 °C for 24 hours as shown in Figure 11.

Then at optimum asphalt content, the heat curing regime applied was 200 °C for 4, 8, 16, and 24 hours. The samples were tested at dry condition and after soaking in water for 24 hours. The results are given in Figure 12. Some additional properties of the samples are given in Table 3.

The average porosity, water absorption, and initial rate of suction (IRS) of the samples cured at 200 °C for 4 - 24 hours is summarized in Table 4.

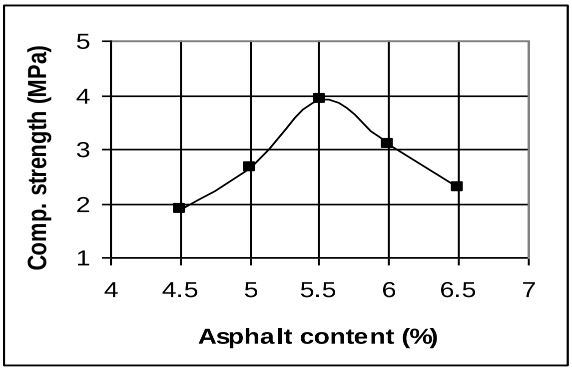

Figure 11. Compressive strength of the samples at varied asphalt (60/70 pen) content, cured at 200 °C for 24 h

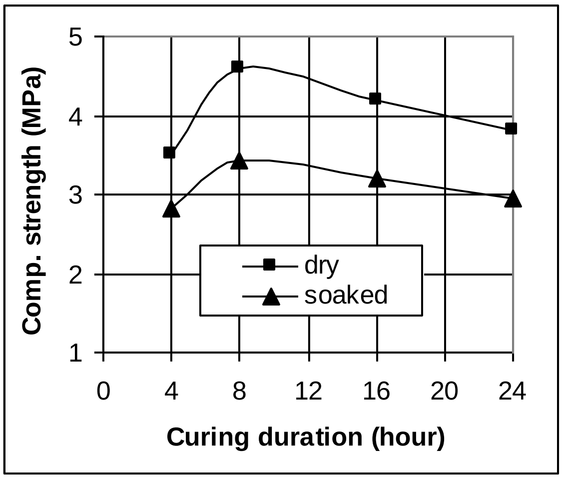

Figure 12. Compressive strength of the samples at 5,5% optimum asphalt content, cured at 200 °C with varied curing duration

In line with the Indonesian National Standard the (SNI) for masonry concrete block/unit, the minimum compressive strength is 25 kg/cm2 or 2.5 MPa (SNI 03-0348, 1989). Referring to the results in Figures 11 and 12, the compressive strength of the block unit well meet the standard. There is no requirement on porosity, water absorption and IRS. The IRS values in Table 3 suggest the use of mortar with higher water content, as the unit gave relatively high IRS and water absorption.

CONCLUSIONS

Some conclusion can be withdrawn from the investigation, i.e.:

1. The CDW materials were found very suitable for producing asphalt bound construction demolition waste masonry block (CDWblock).
2. Compaction level minimum of 2 MPa and the curing regime applied (200 °C for 24 hours) were found to give satisfactory performances (satisfy compressive strength and creep performance). The performances of the CDWblocks were found at least equal to the concrete blocks commonly used in the United Kingdom (UK).
3. The volume stability of the CDWblock is affected by relative humidity (RH). Higher RH environment tends to cause higher expansion, and vice versa.
4. The volumetric movement of the CDWblocks due to environment moisture is not fully reversible, but highly reversible due to thermal exposure.
5. The compressive strength of the masonry unit recently tried using locally available construction demolition material, well meet the minimum Indonesian standard of 25 kg/cm^2.

ACKNOWLEDGMENT

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PROPERTIES OF COLD ASPHALT EMULSION MIXTURES UTILIZING AGGREGATE FROM CONSTRUCTION DEMOLITION

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ABSTRACT

Incidentally, due to a particular reason such as: natural disasters, war, building refurbishment and reconstruction, large amount of material from construction rubble may be available. When this material is crushed into various particle sizes, it can be used for many purposes in civil engineering industry. This paper describes a general review on cold asphalt mixes and laboratory experimental test results on the properties of Cold Asphalt Emulsion Mixtures (CAEMs) for road pavement that utilizes aggregate from construction demolition, with objective to evaluate its properties. The practical benefits of cold mixes are often ignored. They are simple to produce and suitable for low to medium traffic conditions; for construction in remote areas, and for small scale jobs such as reinstatement work. The types of materials used were: waste concrete as coarse aggregate and waste concrete block masonry as fine aggregate. These materials were crushed into the required particle size, with rice husk ash was used as the filler. The investigation was carried out in line with the Indonesian Specification for Dense Graded Emulsion Mixtures. A simplified mix design procedure for producing cold mixes which had previously been developed by the author was used. The materials were initially proportioned, then followed by coating test, and compaction on mixtures with variation of residual asphalt content of the emulsion. Finally the samples were cured 24 hours in room temperature in side the mould and 24 hours in oven at 40 °C, before testing. It was found that the optimum residual asphalt content was 12 %. This is attributed to the high absorption property of the waste aggregate. The compaction effort required to meet porosity requirement of 5-10% was 2 × (2×75) Marshall blows. Although the porosity obtained close to the upper limit, the stability of the samples was well above minimum of 300 kg (3 kN). Other properties evaluated such as degree of coating, asphalt film thickness, and water absorption, met the specified value.

Keywords: *cold, mix, construction, demolition, aggregate*

INTRODUCTION

Aggregates demand for civil engineering construction increases from time to time. Meanwhile there has been an increasing pressure to reduce the exploration of natural aggregates. This situation encourages the utilization of waste and secondary aggregate materials for construction industry.

An alternative material that can be used is material from demolition of building or road pavement scarifying / recycling (Craighill et al., 2006). For example, in the United Kingdom (UK), around 17% of the total waste arises from the construction and demolition industries (DoE, 1994). Although a large proportion of the waste created is recycled in some way, most of it is used for low grade purposes such as access roads within landfill sites and only 4% is used to replace primary aggregates (Humphreys et al., 1994).

In Indonesia, construction demolition materials are mostly used as fill material. There is limited access and availability to reports and research results on other the utilization of this material. This material is not yet widely available in Indonesia. It is usually available incidentally, due to natural disasters such as, earthquake, flood, tsunami, land slide, building renovation, etc. A systematic processing using a mobile aggregate crusher for the materials from demolished/heavily damaged construction need to be made available, as the materials can be used for various purposes, such as for fill materials, building block materials, and materials for lightly trafficked road pavement. It is a viable scheme for a post disaster management.

This paper describes a general review on cold asphalt mixes and laboratory experimental test results on the properties of Cold Asphalt Emulsion Mixtures (CAEMs) for road pavement that utilizes aggregate from construction demolition, with objective to evaluate its properties. The experiment was carried out at Civil Engineering Department Udayana University-Bali.

There are three main concerns on CAEMs, namely: high porosity of the compacted mixture, weak early life strength (as it contains water) and long curing time (evaporation of water/volatile content) required to achieve maximum performance.

The practical benefits of cold mixes are often ignored. They are simple to produce and suitable for low to medium traffic conditions, for construction in remote areas, and for small scale jobs such as road/pavement reinstatement work.

METHODS

Aggregate Grading

The aggregate grading was determined by adopting the mid point gradation of dense graded emulsion mixture type V, in line with Indonesia specification (MPW RI, 1991). The particle size distribution is shown in Figure 1.

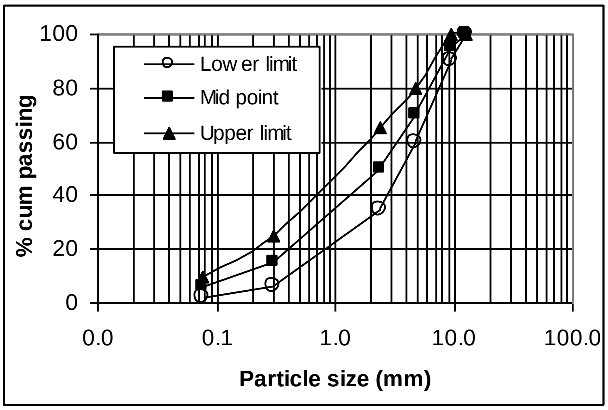

Figure 1. The aggregate grading of the CAEMs

Materials Used

The materials was taken from locally available waste concrete, and waste masonry wall. For coarse aggregate (larger than 2.36mm), crushed waste concrete was used. Waste masonry concrete block and waste clay masonry, was used for the fine aggregate (passing 2.36, retain on 0.075mm), and rice husk ash was used for filler (passing 0.075mm).

Referring to Figure 1, the coarse particle was 50%, the fine particle was 44 %, and 6 % filler (passing 0.075mm).The fine particles consist of 40% waste masonry concrete block and 60% waste clay masonry (by weight of fine aggregate), or 17.6% and 26.4% by weight of total aggregate.

Specification

The specification referred to for this investigation is the specification from the Ministry of Public Work Republic of Indonesia (MPR RI 1991), with main properties of the mixture as summarized in Table 1.

Tabel 1. Specifiation of Cold Asphalt Emulsion Mixtures (CAEMs)

Properties if Mixture	Mix Type V
Effective asphalt content	Min 6 %
Asphalt absorbed	1.7 %
Total residual asphalt content	Min 6.5 %
Total asphalt emulsion content (% thd berat total campuran)	Min 10.8 %
Soaked stability	Min 3 kN (300 kg)
Retain stability (% to dry stability after 48 jam capillary soaking)	Min 50 %
Porosity	5-10 %
Water absorption (% by weight of total mix)	Max 4 %
Asphalt Film Thickness	Min 8 micron
Coating	Min 75 %
Later thickness Minimum	25-75 mm
Utilization	Base & Surface

Mix Design

The design procedure used was based on the author's recommendation to overcome the impractical requirement of the determination of optimum water content at compaction on site and ensures the porosity of the compacted mixtures meet the specification. The retained stability is evaluated at optimum residual asphalt content only, which reduces the number of samples needed, and provides data on the ultimate strength of the CAEMs under full curing conditions (Thanaya, 2003).

Aggregate Proportion

Aggregate proportion was done by proportioning aggregates based on its particle size in line with the mid point of the aggregate gradation as shown in Figure 1.

Estimation of Initial Emulsion Content (IEC)

This can be carried out by using any available formula, such as below (Asphalt Institute, 1989):

$$P = (0.05A + 0.1B + 0.5C) \times 0.7 \quad (1)$$

where P is the % Initial Residual Asphalt Content by mass of total mixture, A the % of aggregate retained on sieve 2.36 mm, B the % of aggregate passing sieve 2.36 mm and retained on 0.075 mm, and C the % of aggregate passing 0.075 mm.

$$IEC = (P / X)\% \quad (2)$$

where IEC is the Initial Emulsion Content by mass of total mixture and X the asphalt content of the emulsion. The actual need of emulsion is largely affected by the type of materials used.

Coating Test

In this test, the dry aggregates that had been proportioned are evenly pre-wetted with various percentage of water (by mixing) before adding the estimated asphalt emulsion then mixing continued. The workability and degree of coating is observed. The objective is to obtain minimum 75 % asphalt emulsion coating onto the aggregates surfaces with sufficient workability.

Determination of Optimum Pre-wetting Water Content (OPWc)

After carrying out coating test, the OPWc is determined. At the OPWc the loose mixture should have sufficient workability and satisfactory coating. If at the OPWc, the loose mixture becomes rather sloppy, the loose mixture should be air dried while mixing, either by giving gentle air blows using a fan or a hair dryer (for lab experiment) before compaction. On site this can be done by laying and exposing the loose mixture to the environment.

Compaction

The compaction should be carried out when the loose mixture is neither too sloppy nor too dry. The compaction practicality should be assessed according to the compaction equipment used. Compactor with kneading motion (such as a gyratory compactor) can compact the loose mixture in a slightly sloppy condition, but impact type compactor such as a Marshall hammer, requires less sloppy loose mixtures to avoid bouncing (Asphalt Institute, 1997; Thanaya, 2003).

The porosity range targeted is wide: 5-10% (MPW RI, 1990; MPW RI, 1991) and compaction level was found to play significant role to meet porosity target (Zoorob and Thanaya, 2002). The compaction level should be tried (varied) until the density of the sample gives the required porosity.

Curing

This step consists of:

1. Design Curing Stage A; Oven Curing Compacted Samples for Dry Stability Test:
   This conditioning procedure consisted of keeping the samples for one day in their moulds after compaction. The samples are then extruded and kept for one day in an oven at 40 ^{o}C. They were then removed from the oven and stored for one day at room temperature.
2. Design Curing Stage B; Water Conditioning (capillary soaking) Samples for Soaked Stability Test:
   After having been subjected to oven curing as explained earlier in Design Curing stage A, the dry samples are water conditioned (capillary soaking). In this procedure half the thickness of each compacted specimen is soaked in water at room temperature for 24 h, the specimen is then inverted and the other half is soaked for a further 24 h. During soaking, the samples should rest on a bed of approximately 15 to 20 mm coarse sand. The samples are subsequently towel dried then tested for Water Absorption and Marshall Stability at room temperature. The Marshall Stability test results obtained are referred to as Soaked Stability values. At this condition the samples have not yet achieved full curing, i.e. still contain some amount of water.

Density and Volumetric Calculation

Density can be obtained from samples after undergoing Design curing Stage A. At this stage the sample still contains some amount of water. The sample wet density is determined as follow:
Sample Wet Density (D):

$$D = \frac{weight \;\; in \;\; air}{volume} = \frac{weight \;\; in \;\; air}{weight \;\; SSD \text{ - } weight \;\; in \;\; water} \quad (3)$$

Note: Weight SSD is the weight of sample after weighing in water then towel dried (BS EN 12697-6 2003)

Then the sample should be broken down and used for taking water content at testing. After that the dry density can be determined, by using the following formula:

$$D_d = \frac{100 + RBC}{100 + RBC + w} \quad (4)$$

where: D_d = dry density, RBC = residual bitumen content, w = water content at time of testing, D = wet density (at time of testing).

The SG_{mix} (max theoretical density) of mix is calculated using the following formula:

$$SG_{mix} = \frac{100}{\frac{\% a}{SG_a} + \frac{\% b}{SG_b} + \frac{\% c}{SG_c} + \frac{\% binder}{SG_{binder}}} \quad (5)$$

(% by weight of total mix)

Note: a, b, c, are aggregate fraction of mixtures (BS EN 12697-5 2002)

Porosity $(P)\% = \left(1 - \frac{Dry \; Density}{SG_{mix}}\right) \times 100\%$ (6)

(BS EN 12697-8 2003)

Variation of Residual Asphalt Content (RAC)

Using the compaction effort that had been tried and can give sufficient density hence can give the required porosity (5-10%), samples are manufactured with variation of residual asphalt content and cured according to the Design Curing Procedure stage A and B, followed by Marshall Soaked Stability Test.

Determination of Optimum Residual Asphalt Content (ORAC)

The ORAC is determined based on soaked samples, by optimizing all parameters especially stability and porosity with reference to the specification. All parameters are plotted into graphs against the residual asphalt content RAC.

Calculation of Asphalt Film Thickness (AFT) at ORAC

The Asphalt Film Thickness can be calculated using the formula below (Whiteoak 1991):

$$AFT = \frac{\% Binder}{100 - \% Binder} \times \frac{1}{SG.Binder} \times \frac{1}{ASA} \times 1000 micron \quad (7)$$

where ASA is the aggregate surface area (m2/kg) that can be determine with reference to Asphalt Institute (Asphalt Institute 1989). Calculation of ASA requires surface area factor (SAF) as given in Table 2. The ASA is calculated by multiplying the total percent passing each sieve size by the appropriate SAF, and adding up altogether (Table 3). Using the ASA with unit as shown in Table 3, the AFT value obtained had been found to be equal to a unit of mm, then to be converted to micron where 1 mm = 1000 micron. The minimum AFT targeted is 8 micron (MPW RI, 1991).

Table 2. Surface Area Factor

Particle/Sieve Sizes	Surface Area Factor (m2/kg)
Maximum size (all sizes grater than 4.75mm)	0.41
4.75 mm (No.4)	0.41
2.36 mm (No.8)	0.82
1.18 mm (No.16)	1.64
600 μm (No.30)	2.87
300 μm (No.50)	6.14
150 μm (No.100)	12.29
75 μm (No.200)	32.77

The Surface Area Factor shown in Table 3 should be used in accordance to the related sieve/aggregate particle sizes.

If different sieve sizes are used when sieving and proportioning the aggregates for the mixtures, when calculating the ASA, the total percentage of aggregates passing the related sieve size in line with those in Table 2, can graphically be estimated from the mixture's aggregate gradation graph. An example of ASA calculation for this case is given in Table 3.

Table 3. Calculation of aggregate surface area-ASA (Asphalt Institute 1989)

Sieve	*ASA* Calculation		
mm	Total Pass (%)*	SAF	*ASA* (m^2/kg)
a	b	c	d = b x c
19.0	100	0.41	0.4100
9.5	-	-	-
4.75	70	0.41	0.2870
2.36	50	0.82	0.4100
1.18	40	1.64	0.6560
600 μm	24	2.87	0.6888
300 μm	16	6.14	0.9824
150 μm	8	12.29	0.9832
75 μm	6	32.77	1.9662
		Sum	6.3836

* in line with particle size/sieve as in Figure 1.

Determination of Retained Stability and Ultimate Strength

The retain stability is determined at ORAC only. The retained stability is the ratio between soaked stability and dry stability (Min 50%).

The strength of CAEMs develops with time to achieve ultimate values, i.e. at full curing condition. This is the reason why it is necessary to cure CAEMs to full curing. In order to achieve full curing condition the specimens shall be left in their compaction moulds for 1 day at room temperature then extruded, and followed by several days in an oven at 40 ^{o}C (until a constant mass is achieved) . At this condition all water content within the samples should have been evaporated (full curing condition). Finally the samples shall be left to cool down at room temperature for one day. At the end of this curing procedure the specimens can be tested for its Marshall Stability.

Evaluation of Increase of Strength Gain

Increase of strength gain of the compacted mixtures was evaluated by curing samples indoor at room environment (28 °C and 65% relative humidity-RH) for 1, 2, 3, and 4 weeks. Three types of sample were produced, i.e. without cement, with 1 and 2 % cement. The type of cement used was ordinary Portland cement (OPC).

RESULTS AND DISCUSSION

Properties of Material

The materials properties are shown in Table 4. Referring to Table 4 the apparent SG of the materials is lower than the minimum 2.5 as specified by the Indonesian Government (MPW RI, 1991). It is appear to be realistic as the materials are from waste aggregates. Only the abrasion of the coarse aggregate meets the specification. The water absorption of the materials used is far exceeding the requirement, and the soundness as an indication to resistant to chemical attack is slighly higher than the specification as shown in Table 5.

Tabel 4. The specific gravity (SG) of aggregates from construction demolition

Waste Aggregate	SG		
	Bulk	SSD	App.
Coarse waste agg. from broken concrete: 50%	2,073	2,241	2,493
Fine waste agg. from masonry concrete block: 17.6%. and clay masonry: 26.4%	1,958	2,093	2,264
Filler from rice husk ash: 6%	2,148		
Residual asphalt	1.02		

Table 5. Other properties of aggregates from construction demolition

Properties	Coarse waste agg	Fine Waste agg	Spec
Abrasion	29,78 %	-	≤40%
Water abs.	8,133%	6,895%	≤ 3%
Soundness	13,11 %	-	≤12%

Optimum Pre-wetting Water Content and Degree of Asphalt Emulsion Coating

The Optimum Pre-wetting Water Content (OPWc) was 9,5% for obtaining satisfacory coating. This is in line with the water absorption properties of the materials used. The degree of asphalt emulsion coating onto the aggregate surfaces was very satisfactory (about 98% by visual observation).

Level of Compaction Effort

The level of compaction effort to meet the required porosity was twice heavy compaction using Marshall hammer, as shown in Table 6. It is similar to the previous work experienced by the author (Thanaya, 2003). This is because the mixture became stiffer during compaction process, as more asphalt emulsion droplet set/break.

Table 6. Stability and porosity of CAEMs in lne with compaction effort (at 12 % residual asphalt content)

Compaction Effort (marshall blow)	Soaked Stability (kN)	Porositas (%)	Spec (%)
2 x 50	6.306	11.013	5 - 10
2 x 75	7.381	10.478	5 - 10
2 x (2x75)	9.348	9.277	5 - 10

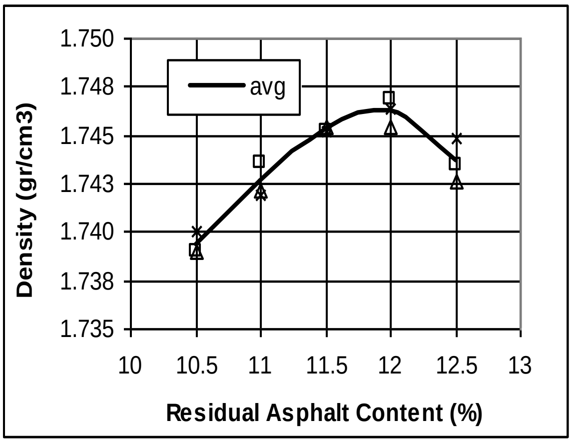

Figure 2. Density vs Residual Asphalt Content

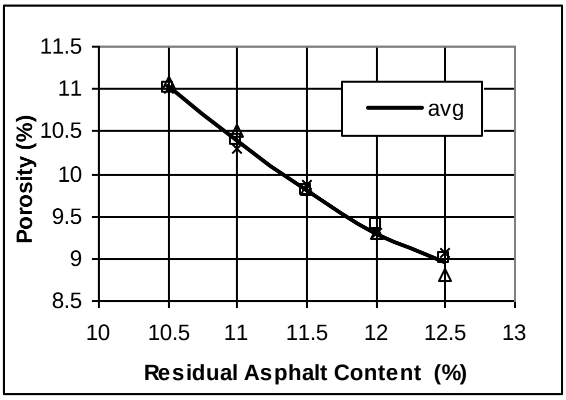

Figure 3. Porosity vs Residual Asphalt Content

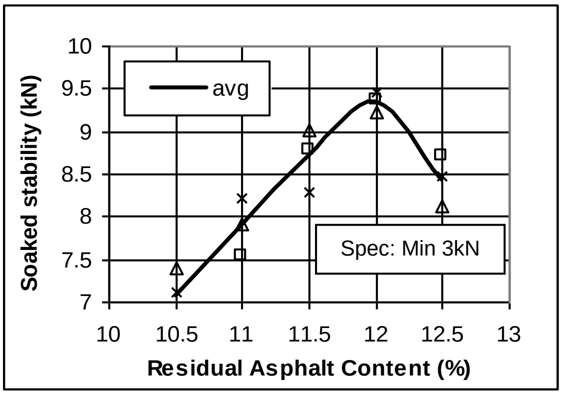

Figure 4. Soaked Stability vs Residual Asphalt Content

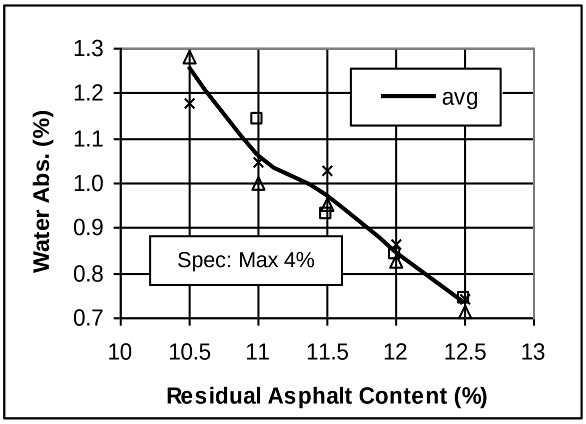

Figure 5. Porosity vs Residual Asphalt Content

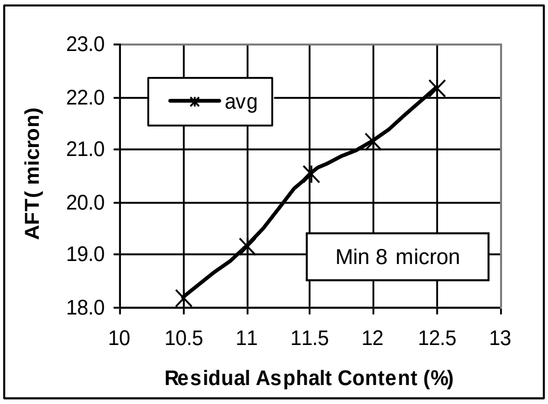

Figure 6. Asphalt Film Thickness vs Residual Asphalt Content

Porperties of the CAEMs

The Porperties of the CAEMs are shown in Figures 2 to 7, and in Table 7. Figure 7 and Table 7 summarize data in Figures 2 to 6. It is shown that water absorption and asphalt film thickness meet specification at all range of residual asphalt content. Referring to Figures 4 and 7, the maximum soaked stability and porosity are mainly used to determine the Optimum Residual Asphalt Content (ORAC) which is at 12 %.

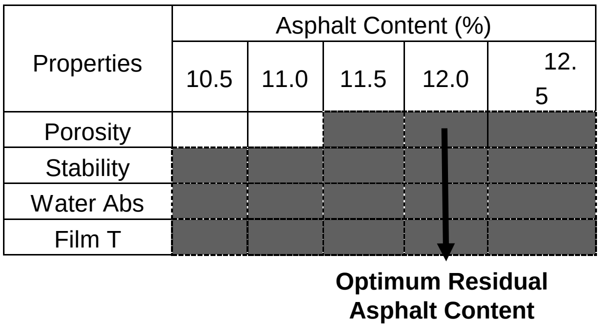

Figure 7. Diagrammatic Determination of Optimum Residual Asphalt Content

Tabel 7. Summary properties of the CAEMs mixture

Properties	Residual Asphalt Content (%)				
	10,5	11	11,5	12	12,5
Soaked stability (KN)	7.061	7.854	8.571	9.348	8.440
Porosity (%)	11.030	10.398	9.793	9.277	8.493
Water Abs. (%)	1.259	1.047	0.971	0.845	0.733
AFT (µm)	18.196	19.170	20.54	21.15	22.157
VMA (%)	29.1	29.4	29.7	30.0	30.5
VFB (%)	62.1	64.6	67.0	69.1	70.7

The above data show that except porosity, other parameters are easily met by the CAEMs. Although VMA and VFB are not specified, it was calculated for additional information. The value of VMA and VFB meet the general requirement as in hot asphalt mixtures.

The retain stability of the CAEMs at Optimum Residual Asphalt Content well exceeds the 50% requirement as shown in Table 8.

Tabel 8. Retain Stability at Optimum Residual Asphalt Content

Dry Stab (kN)	Soaked Stab (kN)	Retain Stability (%)	Spec
a	B	a/b x100%	
10.982	9.348	85%	Min 50 %

Meanwhile Table 9 gives stability data of the CAEMs at full curing condition. This table shows that when CAEMs can be brought to full curing condition, its strength (stability) is very satisfactory.

Table 9. Stability at full curing condition

Marshall blows	Porosity (%)	Stability at room temp ± 28ºC	Stability at 60ºC
2 x 50	11.013	8.350 KN	3.423 kN
2 x 75	10.478	9.035 KN	4.115 kN
2 x (2 x 75)	9.277	10.216 KN	5.540 kN

It is far exceeding the min 3 kN (at room temperature). It also exceeds stability of 2 kN (at 60ºC) as specified for hot asphalt mixture for road pavement with low trafficked load (MPW RI, 2002).

Increase of Strength Gain

When the compacted CAEMs is conditioned indoor at room environment (28 °C and 65% relative humidity-RH), in less than 1 week, it had met the minimum 3 kN stability, as shown in Figure 8. Addition of OPC can accelerate the increase of strength gain, especially during its early life time, at which the mixture is vulnerable to damages. If the graph is extrapolated to the curing duration less than a week, the minimum 3 kN stability required can be achieved a lot faster when incorporating OPC. After all, the increase of strength of the CAEMs is largely affected by temperature, which can evaporate the water content in the compacted mix faster. CAEMs had been known to be suitable in dry, and warm to hot climates.

Referring to Figure 8 after 4 weeks curing duration, the samples without cement had not yet achieved its ultimate strength as shown in Table 9. This meant that the sample would still increase its strength.

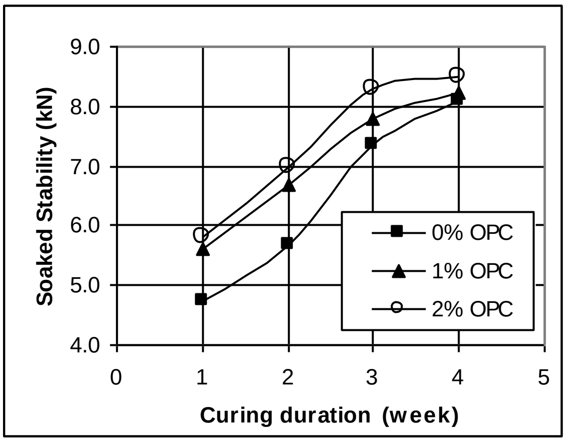

Figure 8. Soaked Stability vs Curing Duration

CONCLUSIONS

Referring to the results and discussion, it can be concluded as below:

1. The apparent specific gravity of the construction demolition materials used is lower than the 2.5 as specified by the specification.
2. The abrasion property of the coarse crushed concrete used was 29.78 %, which meet the min 40% specification.

3. The compaction level that gives the required porosity 5 -10 % was 2x(2x75) Marshall hummer.
4. The optimum residual asphalt content was 12 %, at which the properties of the CAEMs meet the specification.
5. Incorporation of 1-2 % cement can accelerate strength gain of CAEms at its early age.

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ADAPTIVE RE-USE OF JAVANESE TRADITIONAL HOUSE: A CONTINUITY AND CHANGE THE CASE OF DALEM NOTOYUDAN, YOGYAKARTA, INDONESIA

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ABSTRACT

Nowadays, adaptive re-use plays a more important role in conserving a number of historical buildings in Indonesian cities. It refers to renewing the use of building into a new function or in a 'creative use', in order to adapt the usage of the building in contemporary function through certain 'adjustment' or 'redevelopment' as minimum as possible. The concerns of adapting a new function are mainly on economic considerations. Bringing back 'economy' to old buildings has been the main drive behind adaptive re-use practices in many places, and now followed by other considerations, such as cultural, social and environmental values. Dalem Notoyudan is one of the Joglo types of Javanese Traditional House in the heart of Yogyakarta, the core city of Javanese culture. It is the seat of Prince Notoyudo, one of prince of Islamic Mataram Kingdom of Yogyakarta in 19th century, which at its heyday plays as city generator and as supporting part of the Sultan palace. At the present day, this house was nearly abandoned and limitedly maintained. Furthermore, it was worst after Java/Jogja Earthquake, at May 27, 2006. This paper is part of undergraduate thesis on adapting Dalem Notoyudan into a new function i.e., education facility. This paper will discuss adaptive re-use as one of architectural conservation, its principles, critical analysis, and design recommendations on continuing the glorious of a Javanese Traditional House by changing its function to meet our contemporary era.

Keywords: *Adaptive re-use, Architectural conservation, Javanese traditional house, Dalem Notoyudan*

INTRODUCTION

Adaptive re-use refers to renew the use of building into a new function or in a 'creative use', in order to adapt the usage of the building in contemporary function through certain 'adjustment' or 'redevelopment' as minimum as possible. The concerns of adapting a new function are mainly on economic considerations. Bringing back 'economy' to old buildings has been the main drive behind adaptive re-use practices in many places, and now followed by other considerations, such as cultural, social and environmental values.

PRINCIPLES OF ADAPTIVE RE-USE

According to (Craven, 2009; Chin and Binjuan, 2009) there are main principles of Adaptive re-use, mentioned as follows:

Authenticity

Adaptive re-use should maintain the authenticity of the original building. Changes can be made as minimum as possible, so that the architectural character of the original building can be maintained and safeguarded.

Strength (Retrofit)

Changes are made to strengthen and enrich the value of tradition or history of a building through structure retrofitting, old element differentiation and new construction addition can be made to support the exiting structure and not to destroy the old one.

Adaptability and Flexibility

Function of building can be adapted to the new function in this contemporary era and flexible to use in various function without loosing respect to the historical value of the building.

ADAPTIVE RE-USE AND ENVIRONMENTAL VALUES

Generally speaking, adaptive reuse is strongly inline with "spirit of safeguarding environment", which a property shall be used for its historic purpose or be placed in a new use that requires minimal change to defining characteristics of the building and its site and environment (Craven, 2009). Furthermore, in order to meet the new development, adaptive reuse committed shall be undertaken in such a manner that if removed in the in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

METHOD OF STUDY

Method of the study is utilizing Dalem Notoyudan as case study. It is a Javanese Traditional House in Yogyakarta which will be adapted its function, from a traditional dwelling into an educational facility (Tuition Center). To initiate the study, Measured Drawing is conducted as the main method of the study. The original plan of the building is re-drawn and the existing plan is measured and drawn using CAD (Computer Aided Design) software and then compared to gain the changes of the original building and the existing one. The result from the comparison is analyzed to gain design recommendation in the end of the study.

The analysis comprises of physical aspects of the building, including: plan, facades, interior, exterior, landscape, and details of the building. Analysis of adaptive re-use is utilizing the principles of adaptive re-use, i.e.; authenticity, strength (retrofit), and adaptability and flexibility.

Simultaneously, portraying student's behavior in a Tuition Center is also conducted in order to gain a comprehensive understanding on their activities during the tuition time. The analysis unit comprises of junior and senior high school student in a famous Tuition Center in Yogyakarta, namely Primagama Tuition Center.

DALEM NOTOYUDAN AS CASE STUDY

Dalem Notoyudan is one of Javanese traditional house, which have strong relation to Yogyakarta Palace. The first owner of this building is Sri Sultan Hamengku Buwono VI (Prince Notoyudo). Dalem Notoyudan comprises of 8395 m2 located in area of Notoyudan RT 83, Pringgokusuman,Yogyakarta. In the present day, Dalem Notoyudan is owned and inhabited by R.M. Haryo Banindro, S.Sr or is often called by citizen with the title Romo Hanin. This house has a complete type of Joglo Javanese Traditional house that comprises of Regol, Kuncung, Pendhapa, Tratag, Emperan, Pringgitan, Dalem Ageng, Pawon, and Patehan. After Java earthquake in May, 2006, there are several part of this house that has collapsed including kuncung and some structural parts in other parts of the building.

Since the end of 1970es Dalem Notoyudan was rented by YUB Senior High School until the year of 2008. Nowadays, this building is only used as the throne of Romo Hanin, which only utilize the part of its Dalem Ageng. The rest was abandoned and less maintained.

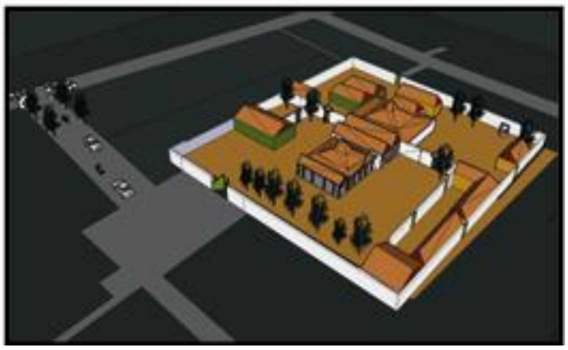

Figure 1.Original 3D Area of Dalem Notoyudan.
Source : Original Plan and Field survey, 2009

Figure 2. Existing Condition of Dalem Notoyudan.
Source : Field survey, 2009

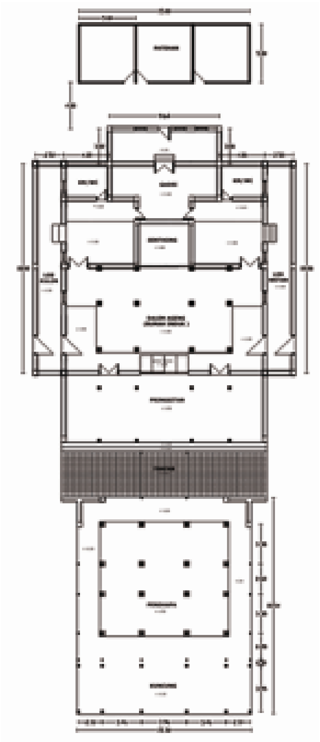

Figure 3. Original Plan of Dalem Notoyudan.
Source : Original Plan and Field survey, 2009

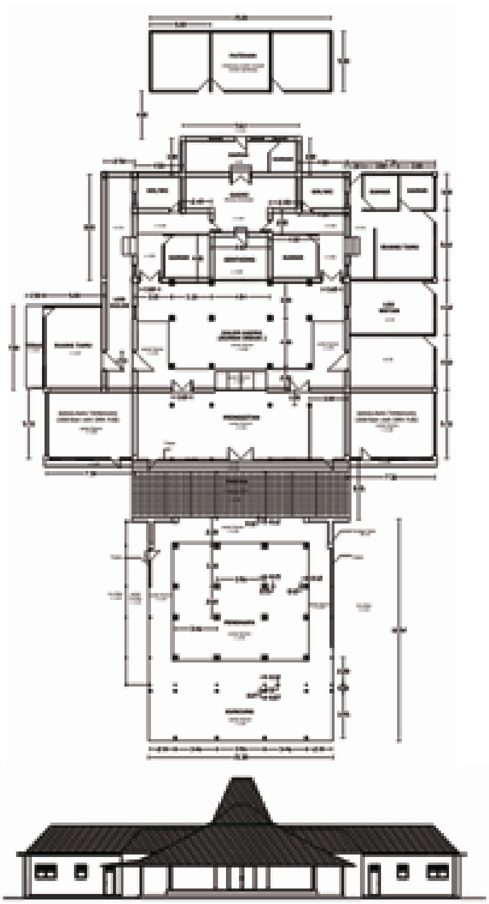

Figure 4. Existing Condition Plan of Dalem Notoyudan.
Source : Field survey, 2009

Figure 5. Existing Condition of Dalem Notoyudan.
Source : Field survey, 2009

ANALYSIS

Physical Analysis

Based on the measured drawing to original plan of Dalem Notoyudan and the existing condition shows a large changes, that is in the Kuncung, Dalem Ageng (addition: Los Wetan and Los Kulon), Pringgitan, and Emperan. The appearances of the building is not changed from its original, as well as the structural and material of the building. The landscape of the building has changed from open space (*Pekarangan*) into settlements. The landscape that remained is only in the front yard and streets to circulate the public settlements. The ornaments of the house has been deteriorated due to wood material were less resistance to tropical climate. In complete, below is the table of physical analysis, showing the degree of changes of Dalem Notoyudan:

Table 1. Continuity and Changes of Dalem Notoyudan (based on Original Plan and Existing Condition)

Element	Continuity and Change
Regol	No changes
Kuncung	Since Java Earthquake 2006, Kuncung has collapsed
Pendhapa	Small changes in wood structure, no formal changes
Tratag	Small changes in wood structure, no formal changes
Pringgitan	Small changes in wood structure, no formal changes
Dalem Ageng	No changes
Senthong	No changes
Los Wetan	Large changes (more spacious-than the original)
Los Kulon	No changes
Patehan	Functional changes from kitchen area into dwelling for servants and local inhabitants
Yard	Narrower in recent years due to new development to supply dwelling demand for rent houses.

Source : Author Analysis, 2009

ANALYSIS OF PRINCIPLES OF ADAPTIVE RE-USE

Authenticity

The re-use of Dalem Notoyudan is based on original plan of the house and has minimum in changes including the plan and the appearances of the building. The settlement that already exist is maintained since it's became an integral part of *Ngindung* system which already exist from the olden days. The addition construction is performed in the pekarangan area and undisturbed the harmony of the original building.

Strength (Retrofit)

Retrofitting of Dalem Notoyudan is performed in the structural part of the wooden structure using new material, such as steel.

Adaptability and Flexibility

The use of the Dalem Notoyudan is adapted into a new function using the existing space. For example, part of Dalem Ageng is utilized as administration and staff office as well as utilized as dwelling for the owner of the building.

Figure 6. Analysis of Adaptive re-use
Source : Author Analysis, 2009

Table 2. Analysis of Adaptive re-use

Code	Element	Analysis of Adaptive Re-use
1	Letjend Suprap-to street	One of Yogyakarta main street, parallel to Malioboro Street
2	Incoming Spand-rel	-
3	Al-Hikmah Mos-que	Religious Building (public)
4	Security Post	-
5	Community Hall	Various public activity held in this hall
6	Los Kulon Building	Once utilized as YUB high school, now abandoned, needs adaptation to be revitalized
7	Kuncung (Collapsed 2006, 68m2)	Originally used as loading area for the landlord. As part of the javanese traditional house, it is ap-propriate to be reconstructed/preserved.
8	Pendhapa (Roof Leaking, 210m2)	Originally used as community &guest hall, including to perform traditional art (*Wayang*, dances, etc). In this contemporary era, this should be adapted, since tremendous changes in our way of life.
9	Tratag (Roof Leaking, small broken structure, 70m2)	Originally used as trasition space to Dalem Ageng, need to be maintained and preserved.
10-11	Pringgitan (Leaking, small broken structure,100m2)	Originally used as platform for performing javanese puppet (*Wayang*), should be restored and preserved. In the last decades there are extention building in left and right side of the building, once used as class room of YUB High School.
12	Dalem Ageng (200m2)	Still use as main house for the landlord, once partly used as YUB High School. Need to be maintained and preserved for the sake of authenticity and strenght.
13	Senthong (170m2)	Use as private room (bedroom and sacred space for family), need to be maintained and preserved for the sake authenticity and strenght.
14-15	Los Wetan and Los Kulon (260m2)	Originally use as domestic space (dining room, storage, etc), once used as YUB High School classrooms. It needs to be maintained and adapted as new functions.
16	Patehan(75m2)	Originally use as kitchen, now rented for residentials. It needs to be maintained so that meet the requirements as residentials.
17	Settlement of Servants of the landlord (*Ngin-dung*)	Originally used as settlements for the servants, now public in general can rent it. It needs to be maintained and adapted as new functions.

Source : Author Analysis, 2009

DESIGN RECOMMENDATION

Based on physical and adaptive re-use analysis, followed is the design recommendation on the Adaptive Re-use of Dalem Notoyudan.

Figure 7. Design Recommendation

Figure 8. Design Recommendation

Table 3. Design Recommendation for Adapting Dalem Notoyudan as Tuition Center

Code	Element	Design Recommendation
1	Letjend Suprapto street	No changes
2	Incoming Spandrel	No changes
3	Al-Hikmah Mosque	Maintained and publicly use as religious buildings including for students of the Tuition Center
4	Security Post	No changes
5	Community Hall	Continuosly used as space for various public activity
6	Los Kulon Building	Recommended as warehouse, canteen, and photocopy center
7	Kuncung	Should be reconstructed and revitalized as multifunction gathering space.
8	Pendhapa	Should be repaired and strenghen the structure using light weight structure (steel structure), and use as art space for students to learn javanese performing arts, including wayang, karawitan and traditional dances.
9	Tratag	Should be revitalised as transitional space rather than car park (recent function).
10-11	Pringgitan	No changes, except for left and right of Pringgitan should be adapted as classrooms for Tuition Center.
12	Dalem Ageng	Should be preserved as residential area for the landlord, and partly used as office for Tuition Center.
13	Senthong	Should be preserved as bedrooms and sacred space for the goddess of the family.
14	Los Wetan	No changes, adapted as new function (classrooms for the Tuition Center).
15	Los Kulon	Should be maintained and continously used as domestic space for the landlord.
16	Patehan	Continously used as residential area.
17	Settlement of Servants of the landlord (*Ngin-dung*)	Continously used as residential area, especially for servants of the landlord

Source : Author Recommendation, 2009

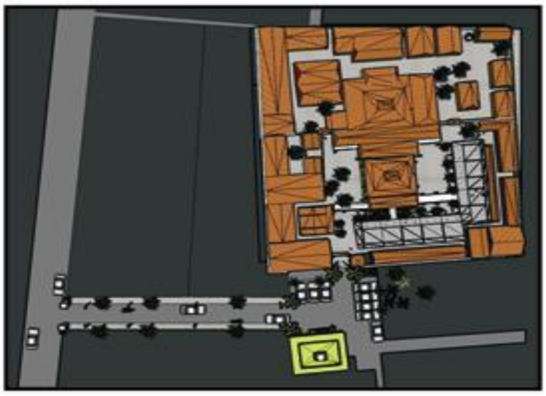

Figure 9. Design Recommendation

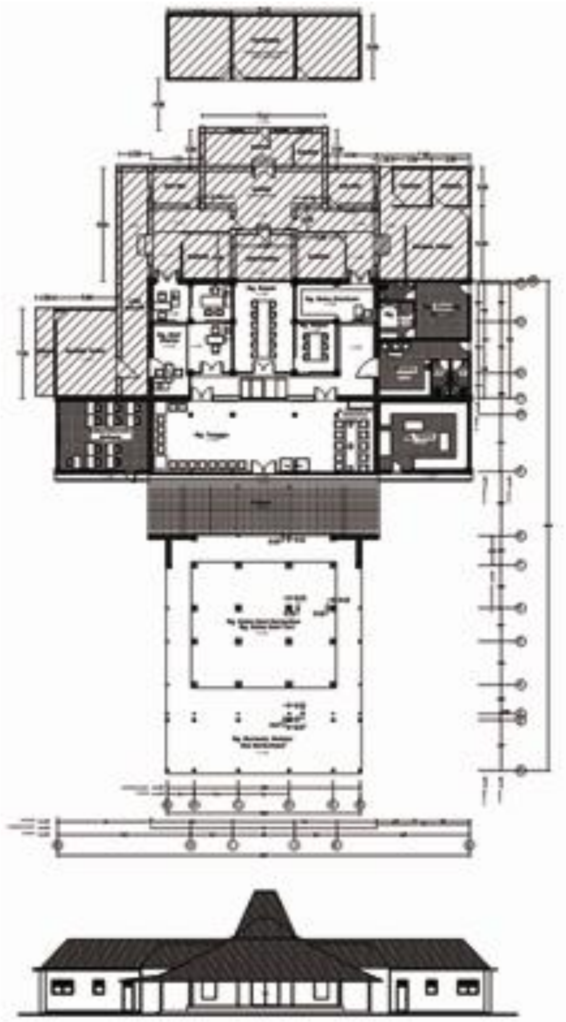

Figure 10. Design Recommendation

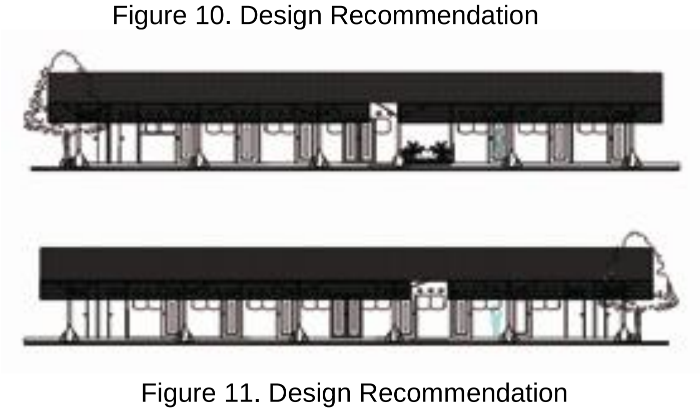

Figure 11. Design Recommendation

CONCLUSIONS

As one of the architectural conservation strategy, adaptive re-use should be critically implemented to avoid the loss of historical value of the building. In terms of environmental values, adaptive re-use can be one of the solution in maintaining existing buildings in Indonesian cities. In order to meet the new development, instead of demolishing original building, adaptive re-use principles offer reusing the existing into a new function in three critical principles, i.e. authenticity, strenght, and flexibility and adaptability. Those three are benefited in terms of cultural, economical and mainly environmental values. In brief, design recommendation in the case of Dalem Notoyudan can be implemented so that conservation of historical buildings in Indonesian cities can be more disseminated and implemented in the future.

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THREE IMPORTANT FACTORS OF EFFECTIVE SEISMIC RISK MANAGEMENT OF NON-ENGINEERED BUILDINGS

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ABSTRACT

Earthquakes have long been feared as one of nature's most terrifying and devastating events and non-engineered buildings always suffered most during this tragic event. To reduce the risk, factors of seismic risk management of this type of buildings need to be elaborated. Seismic risk management can be des-cribed as the systematic process of using administrative decisions, organisation, operational skills and capacities to implement policies, strategies and coping capacities of society and communities to lessen the impacts of seismic hazards and related environmental and technological disasters. This paper describes important factors of effective seismic risk management of non-engineered buildings that could be implemented in Indonesia. The description comes from some lessons learnt in many countries with significant seismic problems such as the United States of America, Taiwan, India, Algeria, Colombia, Nepal, and Peru. Some evidence of good practices employing seismic risk management from their seismic hazard, assessment, and response might be used as best examples for other countries with similar problems. The three important factors of effective seismic risk management of non-engineered buildings that could be implemented in Indonesia are (a) direct involvement of multidisciplinary stakeholders, (b) strengthening of local capacities, and (c) poverty consideration.

Keywords: *earthquake, seismic risk management, non-engineered buildings*

INTRODUCTION

An earthquake is a sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the Earth's surface. The National Earthquake Information Center (NEIC USA) locates about 50 earthquakes each day or about 20,000 a year (USGS, 2009). The infamous Indian Ocean Indonesian Aceh's Earthquake on 26th December 2004 (located off the West Coast of Northern Sumatra, Indonesia) was the 5th largest earthquake recorded in the world since 1900 (USGS, 2009). At the present time, scientists cannot predict precisely when and where an earthquake will occur (BSSC, 1995). Although earthquakes cannot be prevented, modern science and engineering provide tools that can be used to reduce their effects, based on the fact that much of the damage caused by earthquakes is predictable and preventable (USGS, 2009). Broadly speaking, predicting earthquakes may be difficult, but preparing for disaster is not.

Based on such field investigations from past earthquakes, the majority of damage caused by the ground shaking has been inflicted on buildings and houses, poor in design and construction, in both developing and developed countries. Most earthquake-related deaths and injuries have resulted from the collapse of such buildings. Almost all of them have been non-engineered buildings, particularly in developing countries (Mansouri et al., 2002 and Sarwidi, 2001). In 2000, the Indonesian Bengkulu earthquake affected 42,342 houses, damaging around 1,386 (IUDMP, 2000). In 2004, the Indian Ocean Indonesian Aceh earthquake (together with tsunami) caused around 127,000 buildings/houses to be completely destroyed (BAPPENAS, 2005b). While the Indonesian disaster manager was still sympathising with the Aceh survivors in a reconstruction process following the Aceh earthquake, a second severe ground shaking hit Yogyakarta and Central Java on 27 May 2006, and left 156,662 private houses totally destroyed and 202,031 damaged (BAPPENAS, 2006). Most of the collapsed or heavily damaged buildings and houses were non-engineered, masonry constructions, with or without a reinforced concrete frame, in particular, those built by medium-low income communities or medium-low cost housing. On the other hand, the few buildings that were constructed according to seismic codes were able to survive the earthquakes. This evidence is similar to the findings from other developing countries (Mansouri et al., 2002). As a result, earthquake disaster mitigation activities of non-engineered buildings should be strengthened immediately; there is no need to delay implementing comprehensive earthquake disaster management plans in these cities. These are the most critical challenges facing a community living in a high seismic hotspot. Tomorrow's risk is today's challenge.

Based on good practice in countries, the reduction of seismic risk can be achieved through an approach of seismic risk management. Adopted from Charette (2002), seismic risk management can be described as a systematic process of using administrative decisions, organisation, operational skills, and capacities to implement policies and strategies for society and communities to lessen the impacts of seismic hazards and related environmental and technological disasters. Seismic risk management should be seen as advanced preparation and anticipation of possible adverse future seismic events, rather than responding as they happen. Generally, seismic risk management is pro-active. Some countries have employed integrated seismic risk management, embracing multidisciplinary stakeholders, with successful results (SCEC, 2002; UNDP, 2004; DFID, 2004; EERI, 1999; and IDEA, 2005).

Thus paper elaborates factors of seismic risk management of non-engineered buildings which could be implemented in Indonesia. The description comes from some lessons learnt in many countries with significant seismic problems such as the United States of America, Taiwan, India, Algeria, Colombia, Nepal, and Peru. Some evidence of good practices employing seismic risk management from their seismic hazard, assessment, and response might be used as best examples for other countries with similar problems.

CONCEPT OF SEISMIC RISK MANAGEMENT

The view that seismic disasters are temporary disruptions to be managed only by humanitarian response, or that their impact will be reduced only by some technical intervention, has long been replaced by the recognition that they are intimately linked with sustainable development (UNDP 2004 and UN-ISDR 2002). Clearly, physical exposure itself as a result of development does not explain, nor automatically lead to, increased the risk. If urban growth in a hazard-prone location is accompanied by adequate building standards and urban planning that takes into account risk considerations, earthquake risk can be managed and even reduced. Therefore, seismic risk management should be factored into everyday decision-making in development planning; a shared responsibility and shared efforts are needed to reduce the impact of future earthquakes.

Obviously, recognition of seismic risks as part and parcel of development planning can address some seismic risk management problems in Indonesia. At the same time, the full range of technical, social, cultural, and political consideration is evolving, and links with different fields and various stakeholders introduce new challenges. Each multi-sector stakeholder apparently approaches the issue from a different perspective, brings new practices, and has certain aspirations, which need to be harmonised to create the right mixture of seismic risk management initiatives. At the moment, current advances in information technology provide timely access to, and ease in transmission of, information within the systems, and significantly increase the range of interactions among individuals, within organisations, and between sets of organisations in reference to a common event or problem (Comfort, 2002). Dissemination of good practices and results can also encourage more commitment to seismic risk reduction; however, what has been achieved is not systematically assessed, recorded, and monitored (ISDR, 2003). As a result, the outcomes from seismic risk reduction are not yet supported by hard evidence. Furthermore, "what works and what does not work, and why" are not adequately known for informed advocacy, policy decision, or strategic planning.

Seismic risks can be managed effectively in a number of ways. SCEC (2002) has developed a seismic risk management approach as advanced preparation, using a multidisciplinary method. There are three phases that influence the seismic risk management approach. Seismic hazard analysis corresponds with science, seismic risk assessment conforms to engineering, and finally, political and economic action accords with mitigation. The length or relative importance of each component phase may vary and the boundaries between each phase are not well defined, depending largely on the certain situation. Moreover, the seismic risk management approach developed by SCEC (2002) tends to divide into three phases: risk identification, risk assessment, and risk response, where risk documentation is embedded in each phase, explained in Figure 1.

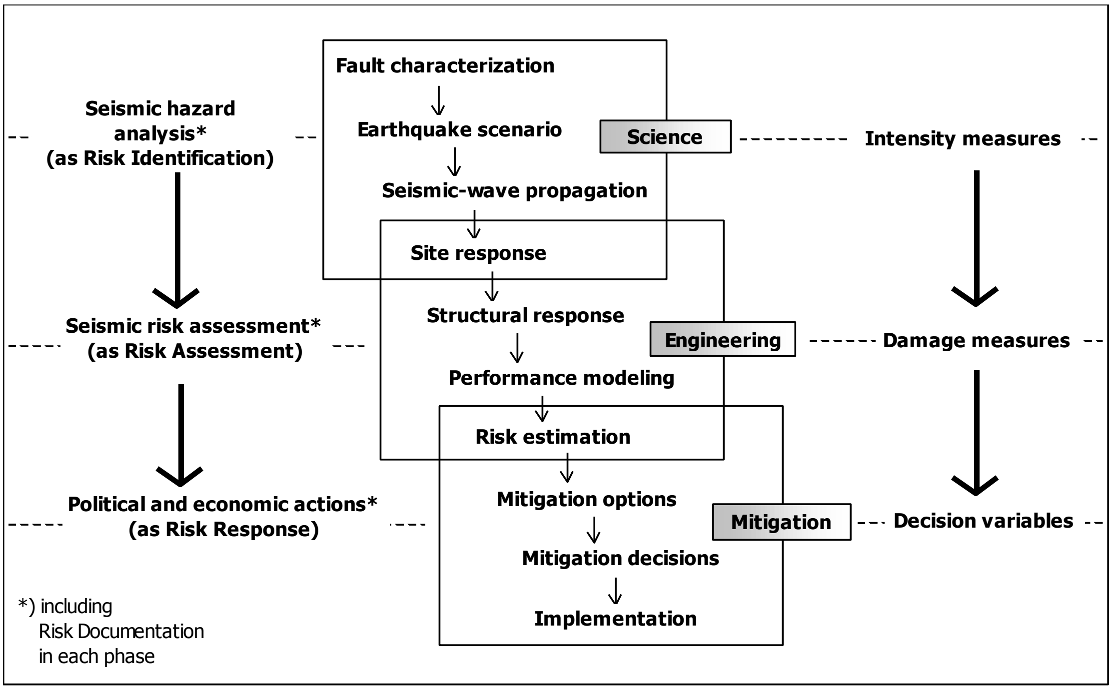

Figure 1. Seismic risk management approach (SCEC, 2002)

During the phase of seismic hazard analysis and seismic risk assessment, scientists and engineers seek methods and approaches that will reduce the levels of uncertainty associated with the causes of an event and the fragility and vulnerability of structures subjected to the event. Individuals become advocated of methods and approach which, when accepted, provide individual recognition and rewards. In addition, an important role for science and engineering is to improve knowledge about the mitigation of the effects of extreme events, effectively transferring knowledge and facilitating collaboration among users of the knowledge (Petak, 2002).

In general, there are two types of seismic hazard analysis, deterministic and probabilistic (Gould, 2003). In a deterministic analysis, an earthquake event of a specified magnitude is assumed to occur on the fault that causes the greatest damage to the subject building(s). This approach can intuitively be expected to generate a reasonably conservative “worst-case” scenario for loss. On the other hand, a probabilistic analysis accounts for the full range of possible earthquakes, their location, return period, size, and the propagation of the earthquake motion from the rupture zone to the site(s) of interest. This provides a return period curve with a more complete and ‘realistic’ evaluation of the potential earthquake losses.

In line with Figure 1, the next phase is political and economic actions as a seismic risk response, which corresponds with mitigation action. An effective mitigation plan anticipates actions that a community must take before a disaster strikes. Planning is one of the most important parts of any mitigation effort. Taking the time up front to make people aware of the earthquake risk to their community, making a plan of how to reduce that risk over time, and what to do in the event of an earthquake can make a tremendous difference in post-disaster recovery efforts.

It is clear from Figure 1 that seismic risk management needs risk “dimensioning”, and risk sizing takes into account not only the expected physical damage, victims and equivalent economic loss, but also social, organisational and institutional factors. The difficulty in achieving effective seismic risk management, in part, has been the lack of a comprehensive conceptual framework of seismic risk, facilitating its evaluation and intervention from a multidisciplinary perspective. Most existing indices and evaluation techniques do not express risk in words adequate for the diverse types of decision-makers, and they are not based on a holistic approach that invites intervention (IDEA, 2005).

According to the growing recognition mentioned above, although the risk management approach in Figure 1 shows distinctive steps, those activities in the seismic risk management approach enables an overlap between each step. This means that the activities in each step are not as clear-cut as are sometimes implied. In most cases, while different countries have implemented earthquake risk management movements that differ from each other in detail and degree, they are nevertheless the same in principle.

Lessons learnt from several countries emphasized that investment in seismic risk management is much more cost effective than expenditure on relief and rehabilitation (NDMD, 2004a). In other words, the expected cost of loss after an earthquake has occurred can be reduced using seismic risk management actions. Chen et al. (2003) mentions that expected loss during an earthquake can be cut down significantly through preventive activities before the disaster happens. Obviously, seismic risk management decisions must be made and implemented, particularly in high seismic areas around the world. Setting priorities for action is imperative, since the need for improvement will always vastly exceed the available resources (SCEC, 2002).

THREE IMPORTANT FACTORS OF SEISMIC RISK MANAGEMENT OF NON-ENGINEERED BUILDINGS

As extracted from many sources of literature, three important factors that drive successful and effective implementation of seismic risk management in various countries, particularly interrelated with non-engineered buildings. These are (a) direct involvement of multidisciplinary stakeholders, (b) strengthening of local capacities, and (c) poverty consideration. Evidence that the successful three factors have widely contributed in reducing seismic risk in countries such as the United States of America, Taiwan, India, Algeria, Colombia, Nepal, and Peru will be presented as follows.

Direct Involvement of Multidisciplinary Stakeholders in Seismic Risk Management

The enforcement and implementation of seismic risk management is not simple because seismic risk is interrelated with interdependencies among technical, organisational, cultural, and other types of systems affecting a community's capacity to both mitigate and respond to disaster. There is no longer a single actor, but many actors, involved in interdependent decisions that increase or decrease the threat of danger to the community (Comfort, 1999). Moreover, there is growing evidence that the partial perspective of disciplines among community members generate actions that are unsustainable (Petak, 2002). Thus, bringing a wide range of stakeholders together to cross both disciplinary boundaries and sectors in seismic risk management is a substantial key to sharing effort and responsibility before disaster strikes. How well they work together can determine the quality and outcome of the risk management process.

In general, multidisciplinary stakeholders involved in seismic risk management can be divided into two extreme groups: government and non-government agency. Both of them have specific and significant roles within their sphere of operation.

1. Involvement of Government Agencies

UNDP (2003) claims that the role of government, in order to reduce disaster, is very important. It is because governments as public institutions generally view the mitigation of extreme event consequences as an integral part of their responsibility to provide for public safety, which they see as occurring through their regulatory-controlled activities, which are in the "public interest". At the present time, many governments in the examples below have brought a new paradigm shift in their approach to disaster management, based on the conviction that investments in risk management as pro-active actions are much more cost effective than expenditure on relief and rehabilitation. They have the existence of an administrative structure responsible for seismic risk reduction as a structural entity with adequate budget allocation as evidence of their commitment to disaster management. In general, UNDP (2004) highlights that the lack of wider political commitment to disaster reduction is often stated as the main barrier to progress in implementation.

In the USA, earthquakes are the most costly natural hazard. In 1978, the US government created the National Earthquake Hazards Reduction Program (NEHRP) under the Federal Emergency Management Agency (FEMA) to improve the nation's understanding of earthquake hazards and to mitigate their effects (www.fema.gov). Since its creation, NEHRP has provided a comprehensive framework for efforts to reduce the risk from earthquakes. Besides NEHRP, in the area of seismic hazard, the U.S. Geological Survey (USGS) Earthquake Hazards Program is the world scientific leader in seismic-hazard studies (www.usgs.gov). In implementing the results of their activities to understand and mitigate the effects of earthquakes, US government agencies have actively collaborated with state geological surveys, emergency-response officials, earthquake engineers, local governments, and the public. This collaboration has resulted in dramatic improvements in earthquake preparedness and public safety in the United States.

Similar to the USA, the Government of Taiwan has established a National Center for Research in Earthquake Engineering (NCREE) to promote seismic hazard mitigation in an integrated and systematic approach (www.ncree.gov). Furthermore, the Government of India launched a 'National Programme for Capacity Building of Architects in Earthquake Risk Management'. The overall goal of the programme is sustainable earthquake risk reduction. The Government of India has brought about a paradigm shift in the approach to disaster management, namely that development cannot be sustainable unless disaster mitigation is factored into the development process (NDMD, 2004a). In Algeria, there are Seismological and Earthquake Engineering Centres (Belazougui, 2003). In Nepal, there were three municipalities which expressed their interest immediately after the Government of Nepal launched the 'Kathmandu Valley Earthquake Risk Management Project' in 1997 (ADPC, 2000).

At end, the existence of government agency(s) as a structural entity, which actively manages seismic risk, is the primary role in mitigating, directing, and organizing disaster response operations. This shows the high degree of political commitment of the government to disaster management, which is accompanied by a high level of commitment to implementation. The Government of the USA, for example, mentioned that between 1983 and 2001, only 129 people died in eight severe earthquakes, compared to 1,600,000 world-wide (SCEC, 2002).

2. Involvement of Non-government Agencies

While governments bear the primary responsibility with regard to safety and security, they cannot and should not shoulder these tasks alone. Non-government agencies, or the private sector, are a government's partner in reducing disaster. Private sectors include non-profit organisations, non-government organisations, and the business sector. Encouraging governments and private sectors to formally take account of disaster risk together in their decision-making might be a first step in raising the profile of disaster in corporate social responsibility, as well as promoting the responsibility of employers for human rights and environmental stewardship in and beyond the workplace, in order to prevent the accumulation of disaster risk (UNDP, 2004).

Indeed, the private sector has a role to play, in moving towards community resilience, that incorporates an awareness of disaster risk. Unfortunately, there are very few recorded examples of corporate social responsibility that have engaged with the disaster risk reduction agenda in developing countries (UNDP, 2004). There is great scope for encouraging the private sector to incorporate disaster risk issues into their corporate social responsibility planning. In the developed countries with significant earthquake problems, it is the professional engineers that have been at the forefront of earthquake reconnaissance studies (Jain, 1998).

There are a lot of non-government agencies in the area of Earthquake Engineering (EE) in the USA. Tremendous improvement has been achieved in order to manage seismic risk (EERI 2003), as described below:

1. Establishment of major EE research centres in the United States, such as PEER Center headquartered at the University of California at Berkeley, Multidisciplinary Center for Earthquake Engineering Research (MCEER) at SUNY Buffalo, and Mid-America Earthquake (MAE) Center at the University of Illinois, Urbana-Champaign. These three centres are funded by the National Science Foundation (NSF) with matching funds from other sources.

2. Establishment of several important experimental facilities to conduct EE research including, among others: Cornell University UCB, University at Buffalo (SUNY), University of Michigan, University of Minnesota, University of Nevada at Reno, University of Texas at Austin, University of Washington, Georgia Institute of Technology, Lehigh University, Ransellaar Polytechnic Institute.
3. Establishment of the Applied Technology Council (ATC) in 1971 and its first significant activity, ATC 3-06 "Tentative provisions for the development of seismic regulations for buildings," was a turning point, casting a framework for the next generation of seismic design code.
4. Establishment of California Universities for Research in Earthquake Engineering (CUREe) in 1988, and its reorganization to Consortium of Universities for Research in Earthquake Engineering (CUREE) in 2000.
5. Publication of reports from studies conducted at the above-mentioned research centres. Also, EE specific journals, including Earthquake Engineering and Structural Dynamics, Earthquake Spectra, Soil Dynamics and Earthquake Engineering, Journal of Earthquake Engineering, among others, have provided media to disseminate research and development.
6. Publications of books, monographs, and reports have greatly enhanced people's understanding of earthquakes, and performance of facilities. These include reports published by ATC, EERC, EERI, FEMA, SCEC, MAE, MCEER, NCEER, PEER, SEAOC, USGS, among others.

Furthermore, there is an Earthquake Engineering Centre in Algeria, which was founded in January 1987. Their missions and objectives are (a) to perform investigation and research activities in the field of seismic risk reduction, (b) to train its future researchers, (c) to build its specific research and testing laboratories, (d) to train and improve the knowledge of specialists in seismic design at the national level (seminar courses, conferences and symposia), (f) to educate and inform the public and the authorities, (g) to aid and assist the engineering offices and concerned institutions, and (h) to integrate hazard mapping and the results of vulnerability and risk investigations in development and the urban planning with mandatory implementations. In India, there is the National Core Group for Earthquake Mitigation, founded in 2003, with seven National Resource Institutions: (a) Centre for Environmental Planning and Technology, (b) Indian Institute of Technology Kharagpur, (c) Indian Institute of Technology Roorkee, (d) Jawaharlal Nehru Technical University, (e) Manipal Institute of Technology, (f) Maulana Azad National Institute of Technology, and (g) School of Planning and Architecture, New Delhi (NDMD 2004a)

Private sectors operate their business within the structure of the free market, where there is most often significant market competition. Their focus is on increased and improved sales of products and services, meeting customer needs while achieving an acceptable return on their investment. In contrast, governments operate within the structure of the political system and understand that extreme events often produce broad scale damage with losses having large socio-economic impacts or significant impacts on community resilience. Governments generally view mitigation of extreme event consequences as part of their responsibility to provide for public safety. The conflict here is between advocates for risk management through appropriate mitigation facilitated through government action and the notion of a free market maximisation of return on investments with minimum governmental regulation. There is a disconnection between the short term good of the business in private organisation and the long term good of the community. In other words, there is considerable controversy regarding how the government and the private sector can best implement seismic loss-reduction measures through regulatory policies, economic incentives, long-term investment, and public education (Bruneau et al., 2004). Apparently, the role of business sectors in seismic risk management still needs to be enhanced.

In summary, involvement of multidisciplinary stakeholders should embrace multi-target audiences to develop a sense of responsibility in seismic risk reduction in daily life. Some literature suggests that those parties are government officials, community leaders, businessmen, small and medium contractors, educators, foremen, researchers, scientists, and NGOs (IUDMP, 2001; CEEDEDS, 2004; SCEC, 2002; GREAT, 2001)

Strengthening of Local Capacities within Seismic Risk Management

Each risk scenario at the local level represents a unique configuration of hazards and vulnerabilities in the context of broader processes of development at the national and global levels. Yet ultimately, vulnerability and risk are manifested at the local level (UNDP, 2004). Local level community response remains the most important factor enabling people to reduce and cope with the risks associated with disaster. Local organisations play a pivotal role in overcoming local obstacles, in defining and shaping a regional level of risk management policy, in sharing and promoting further exchanges and knowledge between other localities or regional levels and between key agencies and individuals, and in supporting the development of national capacities. In general, strengthening of local communities can be achieved through three aspects: developing local leadership, conducting participatory approaches, and increasing public seismic awareness.

1. Developing Local Leadership

Local authorities are in charge of basic needs such as land-use planning, construction planning and control, including the protection of people on its territory. In addition, outsiders are rarely able to effectively contribute single-handedly to safety programmes in developing countries. It is rare to find outside experts with a good understanding of the local situation, who can work in developing countries for long periods of time. Hence, the best results are achieved when the problem is tackled by local experts, with outsiders providing a guiding role: developing local leadership is the key to success.

In developing local leadership in communities, a long-term commitment is needed, which is often beyond the funding and staffing cycles of many agencies. Perhaps, in developing countries, the greatest difficulty is avoiding the trap of communities becoming dependent on well-meaning external agencies. The application of appropriate technology is one approach that has been promoted as a way to overcome some of the problems associated with the implementation and long-term sustainability of development projects in the Third World. Appropriate technology should be able to satisfy the requirements for fitness for purpose in the particular environment in which it is to be used. It should also be maintainable using local resources, and it should be affordable (Vickridge, 1996).

Examples of the successful and long-term improvement of local communities do exist, but remain uncommon. The earthquake event in Northridge, California on 17th January 1994 is a good example. Response operations were immediately activated by the earthquake and carried out largely by experienced, well-trained, local emergency service organisations (Comfort, 1999). Improving local capacity to repair and strengthen their own houses using modern seismic features can be seen in the increasing number of house units in Maharastra, India. In 1995, the number of completed repaired or strengthened houses was around 38,000 units; in 1998 the number reached approximately 182,000 units, a tremendous increase (EERI, 1999).

2. Conducting Participatory Approaches

Capacity improvement at a local level, together with a participatory approach, might bring about other important things to strengthen local communities. For policy interventions seeking to include a participatory approach, preliminary discussions to help map the social relationships within the community are essential if the vulnerable (who are also the socially excluded) are to be reached and helped to build their own levels of resilience through participation. Building meaningful participation with vulnerable groups and individuals in development is not easy. Principle characteristics of social vulnerability are political marginalisation and social exclusion. Encouraging social integration and political participation to enhance resilience and other goals for quality of life is a major challenge to disaster and development policy (UNDP, 2004). The example of participatory process has been carried out by the Government of Nicaragua, who undertook a participatory process of local development planning within a disaster reduction approach. Disaster reduction was factored into a range of planning sectors, including infrastructure development, productive sectors, social sectors and environmental management (UNDP, 2004). Community participation has also been noted in the small Senegalese town of Rufisque (UNDP, 2004).

The participatory programme is itself a learning process. Key elements of success have included the realisation that risk profiles and participatory processes in each region are different, so strategies should rely on local decision-making and be flexible in approach and implementation. In addition, local plans should be linked with central institutions to access support and blend with national development policy, called bottom up vision The involvement of local stakeholders into disaster risk management and participation are also a key factor in maintaining local support and generating significant local outputs for disaster risk reduction, as well as motivating the acceptance of shared responsibilities and cooperation.

3. Increasing Public Seismic Awareness

The next factor to enhance local communities is public seismic awareness. Lack of public awareness to seismic risk tends to contribute to essential barriers in implementation of seismic codes within non-engineered building. SCEC (2002) highlights that public seismic awareness can be achieved primarily through public education. Creating a community of knowledgeable people through public education is essential to the development of 'resonance' or willingness to support shared action, when necessary, to sustain the goal of a responsible, civil society. In the USA, publications of books, monographs and reports using both hard copy and on-line systems have greatly enhanced community understanding about earthquakes and performance of facilities. These include reports published by ATC, EERI, FEMA, SCEC, MCEER, and USGS (EERI 2003). The citizens, elected officials, property owners, and other decision makers must be informed about the nature of the risks, their mitigation options, and the costs of action and inaction. In order to close the gap between existing knowledge and its implementation, public education is the best solution (SCEC, 2002).

A good example of a strong, earthquake resilient local community might be seen in Manizales City, Colombia. The success of the seismic risk management action was evident during the massive earthquake of 1938, which did not damage the city significantly. Similarly, the earthquakes of 1962, 1964, 1979, 1995, and 1999 caused only minor or moderate damage. Since the 1980s, the city has had a municipal disaster prevention system in place, based on municipal development and land-use plans, that incorporates disaster risk management as a strategic and political cornerstone. Disaster preparedness has become part of the city's culture. Prevention-related information and education activities are conducted regularly in schools. Drills are held periodically to ensure that awareness and alertness remain high. The mayor has a disaster risk advisor for interagency co-ordination and the city employs a team of professionals who work at scientific research centres. All residents who take steps to reduce the vulnerability of their homes receive a tax break as an incentive. A collective and voluntary housing insurance scheme has been promoted by the city. It is added to local bimonthly tax payments, with the aim of covering the tax-free lower socio-economic strata, once a defined percentage of taxpayers paying for the insurance has been achieved. Seismic micro-zonation has enabled the local administration to estimate the expected annual losses of its public buildings and insure them selectively. The city administration of Manizales has produced a disaster risk plan that aims to translate state-of-the-art theory into practice, transfer best practice from current experiences in other places, focus on local participation and sustainability, and build in local ownership (UNDP, 2004).

Conversely, specific to Indonesia, a survey about public awareness of earthquake and quake preparedness given to the community in the Minomartani residential area, adjacent to Yogyakarta City, reveals that the whole community tends to overlook the future earthquake risk. It seems that there is no public education of the grass-root community of seismic risk from government and private agencies (Chandra et al., 2004).

In summary, the strengthening of local capacities through improving their local leadership, participatory approaches, and public awareness is important to enhance resilient communities against future disaster. According to the World Disasters Report, UNDP (2004) claims 'effective and accountable local authorities are the single most important institution for reducing the toll of natural and human-induced disasters in urban areas'. Furthermore, providing a local lens allows a large number of small events to be catalogued, re-shaping perceptions on risk as a priority concern for development policy and contributing to a potentially genuine process of self-organization to reduce risk. This is an essential precursor to a bottom up decision making process for development policies, strategies, plans, programs and projects in disaster reduction (Yodmani, 2003) focusing on the local ownership of prevention projects. Sometimes, knowledge from a developed country is not fully suitable for the local situation, and the impact on policy and practice at a local level is dubious.

Poverty Consideration in Seismic Risk Management

UNDP (2004) reveals that, in global terms, disaster risk was found to be considerably lower in high-income countries than in medium- and low-income countries. Disasters affect the poor disproportionately. Poor people are often the most likely to be exposed to natural and non-natural hazards. “Disasters in medium- and low-income countries are an integral part of their poverty cycle. Poverty causes disasters, and disasters exacerbate poverty” (UNDP, 1994). It is true that the majority of the earthquake losses are concentrated in non-engineered buildings, which mostly belong to the poor, who often bear the greatest cost in terms of lives, and livelihood, and rebuilding their shattered communities and infrastructure (Sarwidi, 2001).

Poor people are often unable to obtain basic services because (a) institutions are not accountable, (b) local elites dominate the political process and control private sector resources, (c) corruption is widespread, (d) social relationships are inequitable, and (e) poor people lack experience with participation. Poverty levels, or the absolute number of poor and destitute persons, have increased continually, with dramatic effects in terms of increases in social risk and disaster vulnerability (UNDP, 2004).

The urban poor are often forced to make difficult decisions about risk. In low-and-middle income countries, city governments have often proved ineffective in regulating the process of urban expansion through land-use planning and building codes. Unregulated low-income settlements, where land values are lowest, often occupy the most hazard-prone locations, for example, in peripheral squatter settlements located in ravines, on unstable slopes or in flood-prone areas, or else in dense inner city slums.

Living in hazardous locations is sometimes ‘chosen’ if individuals seek opportunities not only to improve their own quality of life, but also to enhance the health and educational attainment of their children, for greater prospects for their children tomorrow. Poor or non-existent sanitation, high unemployment and underemployment, deficient health and education services, insecure land tenure, crime and violence, and other factors configure a panorama of everyday risk. For individuals caught up in the immediate concerns of daily survival, disaster risk management is often not a priority. Hence, everyday risks accumulate and prepare the way for disaster (UNDP, 2004).

The disaster impact largely depends on the kind of development choices countries have made previously. As countries become more prosperous, for example, they are often better able to afford the investments needed to build houses more likely to withstand earthquakes. At the same time, the rush for growth and the resulting urbanisation can trigger haphazard urban development, which increases the risk of large-scale fatalities during such a disaster. When populations expand faster than the capacity of urban authorities or the private sector to supply housing or a basic infrastructure, risk can accumulate quickly in informal settlements. The urbanisation process leads to the concentration of populations in risk-prone cities, and risk-prone locations within cities. This is true in megacities and in rapidly expanding small- and medium-sized urban centres in developing countries (UNDP, 2004).

Regression analysis of vulnerability indicators shows that, statistically, physical exposure and the rate of urban growth acted together in being associated with the risk of death by earthquake (UNDP, 2004). In other words, the risk of dying in an earthquake is greater in countries with rapid urban growth. Mass migration from rural to urban settlements has resulted in the growth of city slums; many located on unsafe land and built with environmentally inadequate construction techniques. Low building standards may reflect a lack of control and supervision in middle income areas and the lack of resources to build hazard resistant structures in low-income areas. It is a fact that, in many rapidly growing cities, earthquake risk considerations have not been factored into the building and planning process. In general, city governments have not been capable of regulating either building or settlement in a way that reduces risks (UNDP, 2004).

International experiences, including tragic lessons from the recent large earthquakes in Aceh on 26th Dec 2004 and Yogyakarta, on 27th May 2006, show that the growth of earthquake prone communities, following the global processes of development and urbanisation, commonly give rise to seismic risk unless proper countermeasures are taken to prepare for future earthquakes and to manage the risk. This is also true for countries of low and moderate seismicity, taking into account that the risk value depends not only on the hazard level, but also on the aggregate elements at risk and their vulnerability to probable seismic influence. The overcrowding and deterioration of inner city slum areas in Lima, Peru has been identified as a critical process of seismic risk accumulation in that city (UNDP, 2004).

This situation may be attributable to resource constraints in poorer countries. In 2001, in Indonesia, for example, only 7.2% of the population lived below 1$/day, but up to 55.4% lived below 2$/day (Timmer, 2004). The governments of such countries lack, not only the financial resources needed to shoulder the economic burden, but also the institutional and human resource capacities needed to deal quickly and comprehensively with disasters and emergencies. Also since the 1970s, but with increasing emphasis in the 1980s and 1990s, researchers from social sciences and humanities have argued that the impact of a natural hazard depends, not only on the physical resistance of a structure, but also on the capacity of people to absorb the impact and recover from loss or damage (UNDP, 2004).

In the area of seismic risk management, in order to protect poor people from the collapse of non-engineered buildings, which are prevalent among the medium to low income population, it is urgent to disseminate seismic codes which are (a) socially acceptable, (b) economically feasible, and (c) easily absorbed into local construction methodologies down through the grass root communities (Arya, 1994). In fact, earthquake resistance need not be expensive when incorporated into a sound design from the very beginning of the planning effort by a competent team; it usually only amounts to about 1.5% of the cost of construction (BSSC, 1995). Again, Maharastra, India, provides an example of good practice; there were over 500 model houses constructed in order to demonstrate cost-effective building techniques, use of local materials and seismic features in 1998 (EERI, 1999). One way for communities to encourage well-enforced seismic codes, and not add a monetary burden, is to provide tax incentives for more disaster-resistant homes. For example, if a homeowner reduces the chances of damage from an earthquake by installing a mitigation measure, then this taxpayer would receive a rebate on state taxes to reflect the lower costs for disaster relief (Kunreuther, 2000).

Finally, it can be assumed that the widespread persistence of collapse of non-engineered buildings in developing countries has a tremendously devastating impact on efforts to eradicate poverty at all levels. As a whole, the collapse of such buildings during an earthquake seriously undermines the result of development investment, and therefore remains a major threat and impediment to sustainable development and poverty alleviation.

In conclusion, based on the three essential factors captured from such good practices in seismic risk management mentioned above, this points towards the need for policy responses that begin to identify and then tackle the root causes of risk that are embedded within contemporary development practices — as an integrated part of sustainable development policy. Thus, the proper approach to the problem of seismic risk management should include consideration of all three contributing factors, particularly within the broader context of sustainable development. There is a strong sense that these factors are inter-linked. It is true that the length and importance of the three factors should be cornerstones and influence each other to ensure continuous movement and improvement of seismic risk management actions, particularly within non-engineered construction in developing countries (Figure 2), so that the approach is common but the solutions are local.

DISCUSSION: THE IMPORTANCE OF INTEGRATED SEISMIC RISK MANAGEMENT IN INDONESIA

Due to rapid economic growth and complex socio-economic and technical problems in developing countries, Corpuz (1990) highlights that earthquake-resistant construction in the high seismic regions is challenging because: (a) cities have experienced explosive urbanisation, (b) most of the population lives in informal housing and slums, which pose a relatively low standard of living, (c) seismic codes/standards have been poorly implemented, and (d) many buildings and other structures are very old and weak. Countries like Indonesia need effective solutions that are unique to their local needs. It is clear that many new residential buildings in cities are still widely needed to accommodate a large population. Thus, the increasing number of non-engineered buildings constructed with non-seismic resistance prepares the way to the next disaster.

Nepal and India, for example, as developing countries have initiated and incorporated seismic risk management activities together with a sustainable development process. These activities address seismic risk management as a pro-active rather than re-active approach. In contrast, currently, seismic risk management in Indonesia seems to be unsystematic and incomprehensive. Ngoedijo (2003) highlights that most development planning in government agencies is left to sectoral departments without intensive co-ordination and involvement with other sectors, even non-government agencies. It seems to be a lack of uniformity in policy approach regarding the various aspects of disaster and risk management. Aceh's and Yogyakarta's tragic events in 2004 and 2006 respectively, for example, illustrate the inadequacy of seismic risk management capability in major Indonesian cities.

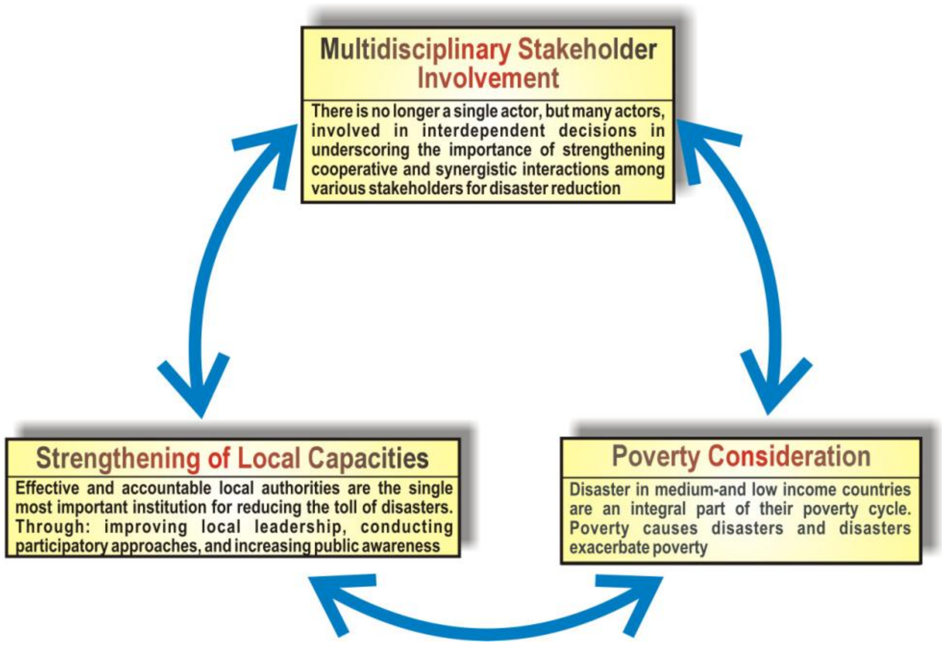

Figure 2. Three important factors of effective seismic risk management of non-engineered buildings

People do not implement seismic codes in their houses, probably because they do not recognise the existing local seismic risk and the importance of seismic codes or perhaps they are just being negligent. In general, communities consider implementing seismic codes through voluntary and regulatory approaches as well as by a combination of the two. Lay people who are living in high seismic areas attempt voluntarily to incorporate seismic codes in their homes if they have a high awareness about seismic risk; however, in most cases, they do not have any adequate information about seismic hazard and the importance of seismic codes in their areas to improve their awareness. At the same time, government agencies often do not have adequate resources to enforce seismic codes through regulation in actual construction. In addition, petty contractors, foremen, masons, and carpenters who build most residential buildings in grass root communities never implement seismic features because of a lack of training and information access. In certain cases, researchers and scientists often leave their research findings on a shelf, without any concrete implementation (IUDMP, 2000; CEEDEDS, 2004; and Jain, 1998). These indicate that a variety of community members have their own specific circumstances, play different roles and exercise varying interests about seismic code implementation. These facts suggest that the problem of implementation of seismic codes in actual construction is not simple, and may even be extraordinary to solve.

It is true that what is needed tends to be an integrative approach that bridges the disciplines of science, engineering, politics, economic, and organisational and institutional analysis (Petak, 2002). Therefore, establishing and improving integrated seismic risk management of non-engineered buildings, as a risk management tool for major cities, is extremely urgent in Indonesia. In addition, this would essentially contribute also to a reduction in poverty levels by enabling communities to be better prepared for facing the seismic risk in their city.

Based on the conviction that development investment that fails to appropriately consider disaster risks could increase vulnerability, recognition of seismic risks as part and parcel of sustainable development can address some of these five reasons and barriers presented above. Much work should be done to help to facilitate integration of the different fields and varieties of stakeholder, who introduce new challenges and opportunities. Naturally, all stakeholders, including governments, non-government organisations, volunteers, the private sector, and the scientific community, speak different languages and bring new practices which need to be harmonised. Dissemination of the successful implementation of practices and results can also encourage more commitment to seismic risk reduction; however, achievements are not systematically assessed, recorded and monitored. As a result, how much seismic risk reduction is paying off is not yet supported by hard evidence. Furthermore, "what works and what does not and why" are not adequately known for informed advocacy, policy decisions, or strategic planning (UN-ISDR, 2002). Therefore, it is critically important that a widely agreed framework should be developed to help harmonise and systematise the field of integrated seismic risk management in Indonesia.

CONCLUSIONS

Through in depth analysis of several references, three important factors that drive successful and effective implementation of seismic risk management in various countries, particularly interrelated with non-engineered buildings have been developed. These are (a) direct involvement of multidisciplinary stakeholders, (b) strengthening of local capacities, and (c) poverty consideration. It must be emphasised, however, that the three factors are not the ultimate solution to all problems related to the seismic risk management in the domain of non-engineered construction. Nevertheless, it is a tool or stepping stone which can be used to streamline individual, organisation, and agency involvement objectives, to make them more productive, efficient, and effective for all elements of shared responsibility and shared efforts to reduce seismic risk. The factors may be seen as a living document to be regularly reviewed and modified as issues emerge, knowledge expands, and capacities change. Furthermore, it is very important to disseminate the value of the factors and their conceptual framework as a tool benefiting all parties to achieve change permanently. Above all, the ultimate goal of this explanation is to save lives and prevent human suffering due to the collapse of non-engineered buildings during strong earthquakes in the future. These factors are very urgent to be implemented as it is true for Indonesia that there appears to be a notable absence in the frameworks of any attempts to reduce seismic risk of non-engineered buildings, for either national or local levels.

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COMPRESSIVE STRENGTH ASSESSMENT OF CONCRETE STRUCTURES FROM SMALL CORE BY POINT LOAD TEST

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ABSTRACT

To assess a compressive strength from existing concrete structures by core drilling are usually gathered with a diameter specimen of 100mm or three times of maximum coarse aggregate size and examined by uniaxial compressive strength (UCS). It is relatively difficult to gather a large sized core, and a pit place will be limited by main members. To get an alternative solution with smaller specimen, point load test (PLT) has been selected which is a simple test and widely accepted in rock materials research, but relatively new in concrete. The reliability of PLT is examined by extracting a lot of core drilled specimen from ready mixed concrete blocks with maximum coarse aggregate size, G_{max} of 20mm in representative of architectural structures and 40mm in representative of civil structures on the range of concrete grade from 16 to 50. Compressive strengths were classified into general categories, conversion factors were determined, and scattering characteristics were also investigated. The relationship between point load index (I_S and compressive strength of concrete core specimen (f'_{cc}) can be written as linear approximation as $f'_{cc} = k.I_S - C$.

Keywords: *Strength assessment, standard specimen, small core, point load index, linear approximation*

INTRODUCTION

One of the reliable tests for assessing in-situ strength of concrete is coring. Coring may prove expensive and the holes have to be backfilled, but the resulting data are usually accepted as the best evidence of the condition of the concrete in place. It is established in JIS A1107 (1993) that a core drilled specimen diameter of 100mm or three times of maximum coarse aggregate size from a concrete structure member should be taken for performing strength evaluation. Small cores are often used as substitutes for large cores to test concrete strength. They have the advantages of being easily drilled and cut, minimum damage to structures, and a lower capacity machine is needed (Ruijie, 1996).

The main parameter for characterizing a concrete in engineering practice is compressive strength. Ibragimov (1989), the maximum aggregate size is considerable as played role for affecting the properties of concrete. The standard laboratory test ussualy requires a standard specimens, so indirect test are needed. The PLT is intended as an index test for the strength classification of rock materials, but it may also be widely used to predict other material strength parameter. It is an attractive alternative method, because it can provide similar data at a lower cost, a simple preparation of specimen, and possibility on field application.

ISRM (1985), in order to estimate UCS indirectly, index-to-strength conversion factors are developed. Richardson (1989) conducted a point load tests of cast specimens with various diameters. Zacoeb et al. (2007) showed a strong correlation between point load index of core drilled specimen (I_S) and compressive strength of concrete core (f'_{cc}). Ishibashi et al. (2008) investigated the influence of *h*/*d* ratio and maximum aggregate size (G_{max}) on concrete core specimen by using PLT. Many research works had been conducted to acknowledge with regard to PLT and resulted in widely used and other parameters. However, more experimental works helps to substantiate the existing correlation.

FINITE ELEMENT ANALYSIS

Broch, et al (1972) started with a simple formula taking an idealized failure plane of diametric core sample as shown in Figure 1. From this figure can be taken into account as conceptual model for derivation on point load index equation as:

$$I_S = \frac{P}{d^2} \tag{1}$$

where, I_S : point load index (MPa)
P : load (N)
d : diameter of specimen (mm)

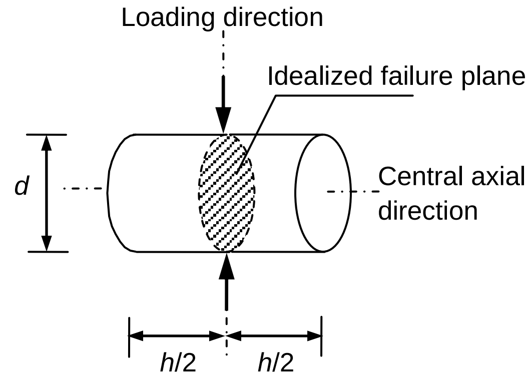

Figure 1. Specimen diametric of PLT on cores

By taking the circular area of the core into account, an argument can be made that Equation 1 should be written as:

$$I_S = \frac{4P}{\pi d^2} \tag{2}$$

The user of this test soon noticed, that the results of a diametric test were about 30% higher than those for an axial test using the same specimen dimensions. Broch et al (1972) and ISRM (1985) suggested acknowledge this difference by applying a size correction and introducing the equivalent core diameter of D_e. Hence, the Equation 2 can be re-written as:

$$I_S = \frac{P}{D_e^2} \tag{3}$$

The variations of I_S with specimen size and shape lead to introduce a reference index $I_{S(50)}$ which corresponds to the I_S of a diametrically loaded rock core of 50mm diameter (Broch et al.1972). Accordingly, initial I_S values are reduced to $I_{S(50)}$ by size correction factors determined from empirical curves as a function of d.

It is indicated that the considerably larger shape effect should be avoided by testing specimens with specified geometries. ISRM (1985) proposed a new correction function which accounts for both size and shape effects by utilizing the concept of equivalent core diameter (D_e). This function, known as geometric correction factor F is given by:

$$I_{S(50)} = FI_S \tag{4}$$

where F : the geometric correction factor

$$F = \left(\frac{D_e}{50}\right)^{0.45} \tag{5}$$

The unique point load index can be obtained by applying a size correction for the specimen as point load index of I_S varies with core specimen diameter of D_e. The size-corrected point load index of $I_{S(50)}$ for each specimen is defined as the value of I_S that would have been measured on a standard specimen diameter of D_e = 50mm. In the case of specimen diameter of D_e other than 50mm, size correction must be calculated by using of Equation 5.

LABORATORY WORKS

The concrete block for core specimen extracting were sized of 300mm x 300mm x 600mm made from ready-mixed normal concrete with typical slump range value from 8 to 12cm for most application as workability control and divided into two groups as shown in Table 1. For curing, all concrete block specimens were covered with plastic sheets and the humidity was set for about a week. Commonly in Japan, for architectural structures such as building construction is using the maximum coarse aggregate size, G_{max} of 20mm. While for civil structures such as pier, abutment, bridge deck and check dam is using the maximum coarse aggregate size, G_{max} of 40mm.

Table 1. Group of concrete block

Group	G_{max} (mm)	Grade	Cement Type
I	20	16	OPC (Ordinary Portland Cement)
		21	
		24	
		36	
		50	
II	40	16	PBSC (Portland Blast-Furnace Slag Cement)
		21	
		24	
		30	

Core specimen diameter of 125, 100, 50 and 35mm were extracted from the above mentioned concrete block with the electric core pulling out machine. The wet type that used by flowing some water during the core drilled process is applied, and the extraction speed was assumed to be about 4cm/min. The direction of extraction is considered as the direction of concrete placing as vertical direction in assumption of practical work in construction. The situation of core specimen extraction is shown in Figure 2.

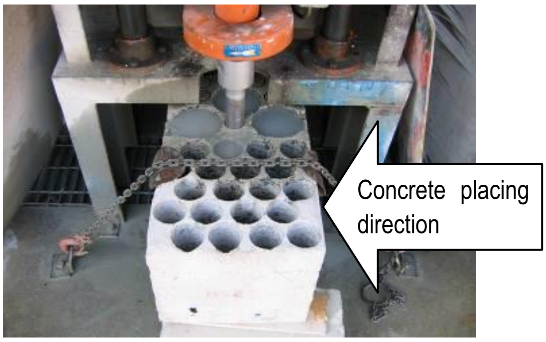

Figure 2. Core specimen extractions

The core specimen with *h*/*d* ratio of 1.5 and 2.0 were selected as core specimen of PLT in this study. In order to establish a specific *h*/*d* ratio, core specimens were cut both ends with a concrete cutting machine to become a fixed height (*h*). The total number collection of each specimen is shown in Table 2.

Table 2. Total number of core specimens

Group	Grade	*d* (mm)	*h*/*d*	Total
I	16	35	1.5	135
			2.0	135
		50	1.5	105
			2.0	99
	21	35	1.5	90
			2.0	90
		50	1.5	60
			2.0	60
	24	35	1.5	66
			2.0	66
		50	1.5	59
			2.0	58
	36	35	1.5	123
			2.0	126
		50	1.5	111
			2.0	108
	50	35	1.5	67
			2.0	66
		50	1.5	73
			2.0	72

Table 2 (Continued)

II	16	35	1.5	126
			2.0	126
		50	1.5	85
			2.0	87
	21	35	1.5	154
			2.0	138
		50	1.5	82
			2.0	79
	24	35	1.5	113
			2.0	113
		50	1.5	87
			2.0	86
	30	35	1.5	157
			2.0	172
		50	1.5	113
			2.0	108

The specimen in PLT is taken and loaded between two hardened steel cones. The system consists of a small hydraulic pump, a hydraulic jack, a pressure gauge and interchangeable testing frame of very high transverse stiffness. Spherically truncated, conical platens of the standard geometry shown in Figure 3 are to be used with the cylinder area of 14.52cm^2. The platens should be of hard material such as tungsten carbide or hardened steel so that they remain undamaged during testing (ISRM, 1985).

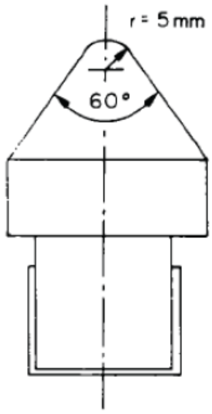

Figure 3. Point load cone platen

The core specimen in this study is gradually loaded by activating the hand pump until failure and determined this load as *P*. The point load index of I_S was calculated by using Equation (3) and for core specimen diameter of 35mm was corrected to the standard core diameter as point load index of $I_{S(50)}$ for core specimen diameter of 50mm by using Equation (4). The examination is conducted by using PLT machine with oil pressure cylinder type and maximum load capacity of 98kN as shown in Figure 4.

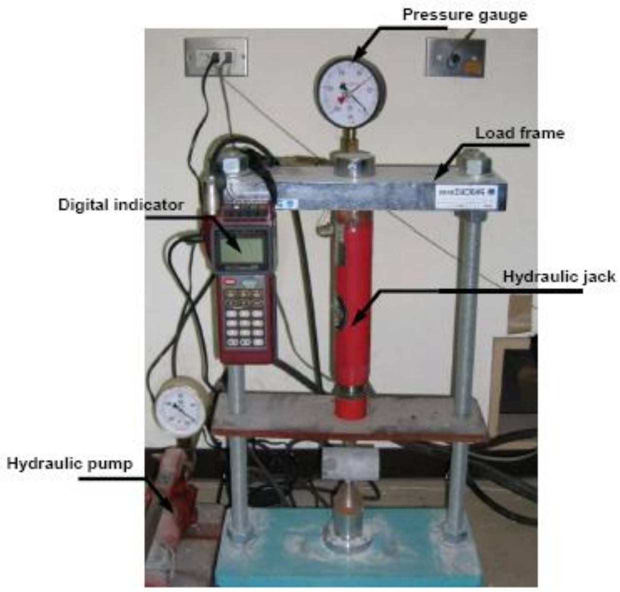

Figure 4. Setup of PLT

RESULTS AND DISCUSSION

Compressive Strength

From a concrete block is extracted a core specimen with diameter of 100 mm as minimum requirement and 125mm as three times of maximum coarse aggregate size (JIS A1107, 1993), cut both ends of the core with a concrete cutting machine, end face polished, processed it to become specific *h*/*d* of 2.0 and examined by UCS test. The mean value of compressive strength of concrete core, f'_{cc} is shown in Table 3, and assumed these values as reference on this study.

Table 3. Compressive strength

Group	Grade	Age (Days	f'_{cc} (MPa)
I	16	161	15.6
	21	337	35.4
	24	73	31.5
	36	177	42.9
	50	78	51.5
II	16	188	21.6
	21	173	22.4
	24	532	34.4
	30	118	32.2

Point Load Index

The mean values of PLT were computed for both diameter sizes as shown in Table 4. Scattering characteristics were also investigated by mentioning of *CoV* (coefficient of variation). The *CoV* is the degree to which a set of data points varies. When assessing precision, the lower of *CoV* percentage, the better of precision between replicates. For Group I, the level of *CoV* is almost same or less than that on actuality of ready-mixed concrete product (Saga, 2008) from 10 to 15%. It can be stated that the test results are satisfy enough. For group II, the *CoV* is bigger than the requirements (except for concrete grade of 30).

Table 4. Point load index

Group	Grade	*d* (mm)	*h*/*d*	I_S (MPa)	*CoV* (%)
I	16	35	1.5	2.27	11.4
			2.0	2.32	13.3
		50	1.5	1.87	10.7
			2.0	1.93	10.8
	21	35	1.5	3.24	11.4
			2.0	3.31	12.4
		50	1.5	2.57	9.7
			2.0	2.61	11.1
	24	35	1.5	3.21	12.4
			2.0	3.28	13.1
		50	1.5	2.71	8.1
			2.0	2.77	9.3
	36	35	1.5	3.61	11.9
			2.0	3.69	13.5
		50	1.5	3.06	10.4
			2.0	3.02	10.9
	50	35	1.5	3.95	8.1
			2.0	4.05	9.6
		50	1.5	3.27	8.2
			2.0	3.34	8.9
II	16	35	1.5	2.20	26.1
			2.0	2.30	31.9
		50	1.5	1.85	18.7
			2.0	1.95	18.1
	21	35	1.5	2.52	23.0
			2.0	2.55	24.3
		50	1.5	2.12	21.0
			2.0	2.00	18.0
	24	35	1.5	2.90	26.3
			2.0	2.92	27.0
		50	1.5	2.31	18.2
			2.0	2.43	18.2
	30	35	1.5	2.80	24.7
			2.0	2.85	19.7
		50	1.5	2.43	8.5
			2.0	2.47	7.6

For Group I, the level of *CoV* for *h*/*d* of 1.5 is smaller than *h*/*d* of 2.0. It can be stated that *h*/*d* ratio of 1.5 is better than *h*/*d* of 2.0 for making a PLT specimens from core drilled extraction.

While for core specimen diameter, *d* is better using 50mm than 35mm, because the level of *CoV* is also smaller. Beside this reason, it is also fulfilled with the standard core diameter requirements of 50mm. For all groups, it is possible and acceptable for using a core diameter of 50mm and *h*/*d* ratio of 2.0 as PLT specimen with results in the range of *CoV* from 8 to 18%. Application of PLT for small diameter of core specimen is not suggested for d/G_{max} ratio below 1.25, considering the *CoV* results for G_{max} of 40mm and *d* of 35mm are larger than 20%.

Correlation between Point Load Index and Compressive Strength

Point load index of core specimen diameter of 50mm, $I_{S(50)}$ is determined as standard value. Hence, the value of different core specimen diameter, $I_{S(35)}$ should be corrected in order to show a relationship with $I_{S(50)}$ by using Equation (4) and (5). By correcting the point load index of $I_{S(35)}$ and assuming as standard core specimen diameter of 50mm, will add the number of data for analysis of point load index $I_{S(50)}$. The new result for this combination is shown in Table 5 corresponding with the compressive strength of concrete core (f'_{cc}) for each grade.

Table 5. Point load index and compressive strength

Group	Grade	f'_{cc} (MPa)	I_S of *h*/*d*	
			1.5	2.0
I	16	15.6	1.86	1.93
	21	35.4	2.57	2.61
	24	31.5	2.71	2.77
	36	42.9	3.07	3.03
	50	51.5	3.27	3.34
II	16	21.6	1.85	1.95
	21	22.4	2.12	2.00
	24	34.4	2.31	2.43
	30	32.2	2.43	2.47

The correlation between point load index, $I_{S(50)}$ and compressive strength of concrete core, f'_{cc} for both of groups is shown graphically in Figure 5 and 6. It is clearly evident to show the correlation by proposing a second order of polynomial and linear regression, respectively. It is proven by showing the square value of correlation coefficient which judges the effectiveness of a second order of polynomial approximation curve for *h*/*d* = 1.5 is thought to be similar for *h*/*d* = 2.0. Linier regression also showed the same trend of effectiveness except for group II.

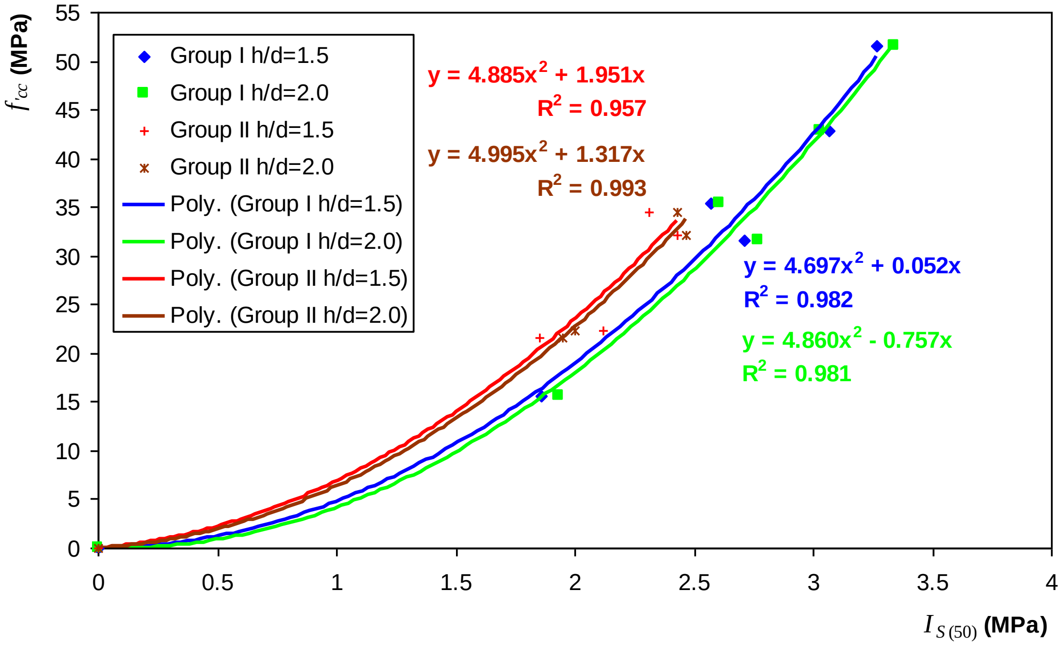

Figure 5. Second order of polynomial regression

JIS A5308 (2003) gives the compressive strength range of ready-mixed concrete in field application from 18 to 45MPa. Hence, the application of PLT for estimating in-situ strength of concrete structure should be confirmed in this range. So, the correlation was limited to this range for core specimen diameter of 35 and 50mm as shown in Figure 7. When using the linear regression as shown in Figure 6, the approximation line does not intercept in the origin point. However, Figure 7 shown that the fitted curve will pass through the origin which aims to establish the relation of the whole area would be overestimated. It is preferable to using linear approximation than other modes in order to minimize the standard for the assessment of risk.

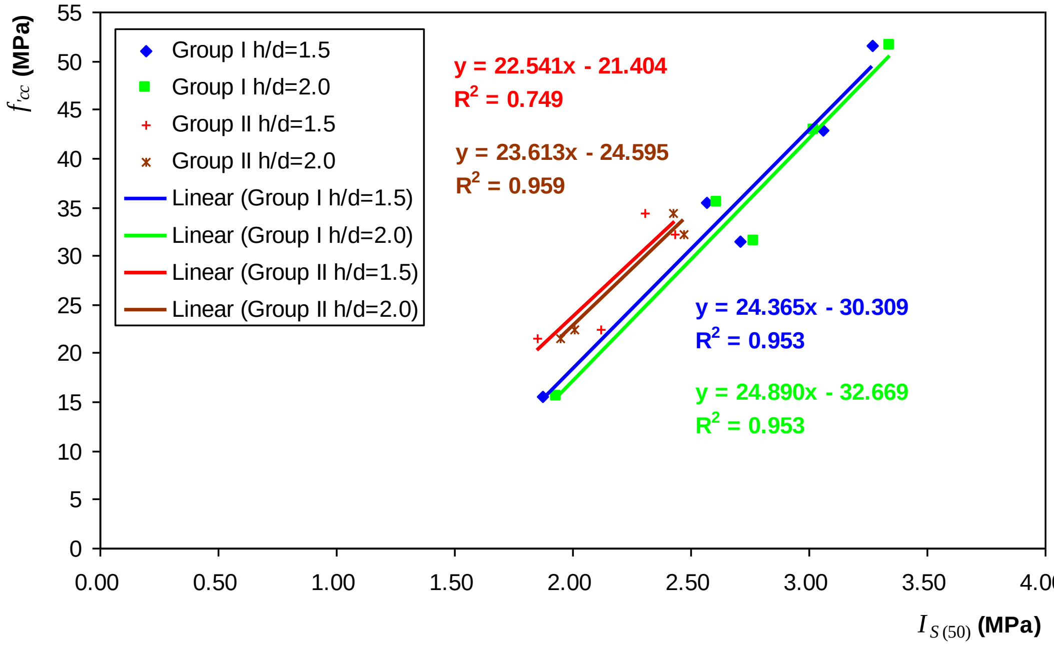

Figure 6. Linear regression

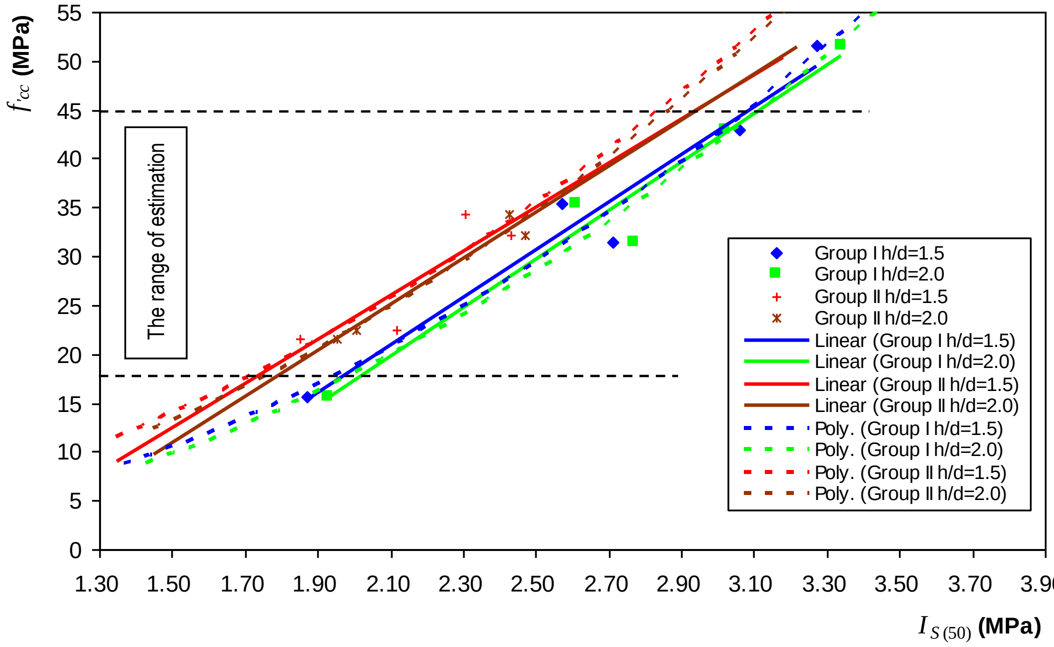

Figure 7. Linear approximation for $I_{S(50)}$ to f'_{cc}

The New Geometric Correction Factor

By considering the Equation (4) and (5) were proposed for rock specimen, so it is not suitable for concrete regarding the issue of homogeneity. The previous section already mentioned that maximum coarse aggregate size in concrete will affect the results of point load index. A new correction factor of F is proposed by following the format of previous Equation as:

$$I_{S(50)} = \left(\frac{d}{50}\right)^{X} I_S \quad (6)$$

The value of X can be generated by using data from group I for core specimen diameter of 35mm. The selection of this data was considered more reliable by showing a lower CV. The solution is simple, because the nature of linear approximation as the origin. The exponent value of X is calculated as 0.53 with coefficient of correlation is 0.982. Finally, the expression geometric correction factor for concrete core specimen is given by:

$$F = \left(\frac{D_e}{50}\right)^{0.53} \quad (7)$$

Table 6 shows the absolute relative error between experimental and estimation values for point load index of $I_{S(35)}$ to become standard point load index of $I_{S(50)}$ by using Equation (8). The results are satisfied enough by showing a value of absolute relative error less than 5% in the case of d of 35mm and G_{max} of 20mm.

Table 6. Experimental and estimation of $I_{S(50)}$

f'_{cc} (MPa)	h/d	Point load index (MPa)			Error (%)
		$I_{S(35)}$	$I_{S(50)}{}^{a}$	$I_{S(50)}{}^{b}$	
15.6	1.5	2.27	1.88	1.87	0.53
	2.0	2.32	1.92	1.93	0.52
31.5	1.5	3.24	2.68	2.57	4.28
	2.0	3.31	2.74	2.61	4.98
35.4	1.5	3.21	2.66	2.71	1.85
	2.0	3.28	2.72	2.77	1.81
42.9	1.5	3.61	2.99	3.06	2.29
	2.0	3.69	3.06	3.02	1.32
51.5	1.5	3.95	3.27	3.27	0.00
	2.0	4.05	3.35	3.34	0.30

*)a = estimation
b = experimental

Recalculation procedure is conducted by using a new Equation (8) for correcting point load index of core specimen diameter of 35mm and performing linear regression analysis to propose a formula of compressive strength estimation for equivalent core diameter of 50mm as $f'_{cc} = k.I_S - C$ as shown in Table 7. The coefficient of correlation, R^2 also shows an improvement in strong relationship between $I_{S(50)}$ and f'_{cc}.

Table 7. Formula of estimation

Group	h/d	Formula of Estimation	R^2
I	1.5	$f'_{cc} = 24.4I_S - 30.3$	0.953
	2.0	$f'_{cc} = 24.9I_S - 32.7$	0.953
II	1.5	$f'_{cc} = 20.8I_S - 16.7$	0.928
	2.0	$f'_{cc} = 22.3I_S - 22.0$	0.979

In consideration with the standard compressive strength that used as linear approximation for index-to-strength conversion factor k is shown in Figure 8. The k value is calculated by divided the compressive strength (f'_{cc}) with point load index (I_S). While C is constant depend on the linear regression equation.

CONCLUSIONS

Based on this study, it can be concludedthat an approximation curve showed a strong correlation between point load index (I_S) and compressive strength (f'_{cc}) for core diameter of 35 and 50mm with height and diameter ratio of h/d = 1.5 and 2.0. In addition for reference index $I_{S(50)}$, it can really deal with a linear approximation. Considering the issue of homogeneity that concrete is composite material, a new correction factor is proposed for core specimen diameters differ from 50mm as

$$F = \left(\frac{d}{50}\right)^{0.53}$$

To estimate a concrete compressive strength can be conducted with proposed equation as $f'_{cc} = k.I_S - C.$
There is a prospect that PLT can be applied as indirect method to estimate a compressive strength on concrete structure. Application of PLT for in-situ concrete compressive strength estimation should be confirmed in the range of compressive strength of ready-mixed concrete product from 18 to 45MPa. Considering the maximum coarse aggregate size of G_{max} in concrete, new criterion is proposed by determining the minimum value of d/G_{max} ratio should not less than 1.25.

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Urban/Rural Environmental and Settlement

EVALUATION OF AGRICULTURAL LAND TO ANTICIPATE DROUGHT DISASTER IN GUNUNGKIDUL REGENCY, YOGYAKARTA SPECIAL PROVINCE

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ABSTRACT

Agriculture makes the highest contribution to the Gross Regional Domestic Products of Gunungkidul Regency, Yogyakarta Special Province, i.e. 35.4%; however, the productivity of agriculture in this region is still low. The characteristics of its physical environment become a factor that hinders the development of agriculture. On the other hand, the precipitation is relatively high, and compared to the water demand it is still a surplus. This potential requires further study in order to make it optimally useful and to increase the productivity of agriculture. This research is aimed to analyze the land characteristics, land capacity and conformity, critical factors of land, commodity and productivity of crops agriculture. The interpretation of ASTER imagery becomes the main source of data. The primary data are collected using the field survey method and semi-structured interview. The sampling technique used in this research is the area random sampling in each unit of land. Other secondary data are in the form of statistical and spatial data collected from related institutions. The data analysis uses Land Classification and Land-use Planning and Geographic Information System. The result shows that the land capacity in Gunungkidul Regency is dominated by Class II (30.0%) and Class VI (35.6%). Non-critical lands are 59.17%, mostly in the area of Wonosari, and 40.42% of very critical lands are mostly found in Karsts Hills. The Karsts area is categorized as naturally critical, and it requires land conservations. The conformity of lands in Gunungkidul is 55.7% of lands are appropriate (N), while 44.3% of lands are inappropriate; most of them are in Karsts areas where the soil layer is thin and they have water crises. The common commodities of foodstuff crops planted by the inhabitants of Gunungkidul Regency are non-irrigated rice, irrigated rice, corns, cassavas, soybeans, and peanuts. There are 3 (three) types of land use based on the planting calendar in Gunungkidul Regency, which include rice fields, dry lands, and fallow lands; most of them are planted with dry-season crops or left fallow in dry seasons and planted with non-irrigated rice in rainy seasons.

Keywords: *agriculture, land resources, droughts, Gunungkidul*

INTRODUCTION

Gunungkidul Regency is a region with the potential as well as problems in making the efforts to achieve food stability. Agriculture makes the highest contribution to the Gross Regional Domestic Products, i.e. 35.4% (BPS, 2006); however, the productivity of agriculture in this region is still low. Drought or clean-water supply is the typical problem which hinders the development of agriculture (Widodo, 2007). The physical characteristics of its environment, particularly the physiographic and geologic ones, represent very deep groundwater aquifers as well as the land's low capacity to absorb and preserve water. *Dinas KIMPRASWIL DIY* (The Settlement and Regional Infrastructure Agency of DIY Province) (2006) reported that the precipitation in Gunungkidul Regency is high and goes beyond the water demand. This potential requires further study of the optimal use of rainwater in order to increase the productivity of agriculture.

The need to improve the productivity of agriculture has certain limitedness. The ability to maintain productions depends on the effectiveness of biological cycles and the conformity to the carrying capacity of environment. The sustainability of agricultural-productivity improvement will be endangered if the carrying capacity of environment is exceeded. This matter requires an evaluation study concerning the capacity, conformity, and criticality of agricultural lands as one of the bases to design the strategies for the empowerment of agricultural land carrying capacity in order to anticipate droughts. The ability and effectiveness of the strategies to anticipate droughts based on land evaluation will be the assets to achieve agricultural-productivity improvement.

DEVELOPMENT OF AGRICULTURE BASED ON LAND EVALUATION

Everything that human do to use and manage their natural and environmental resources has a significant influence on the implementation of sustainable development. Before using natural resources, which are the basic assets of development, human should learn such characteristics as uneven distributions, interactions and interdependences, and renewable or non-renewable classifications (Katili, 1983).

The limitedness of agricultural land resources will strongly influence the survival pattern and strategy of households. The study conducted by Kurniawan (2003) in Tirtohargo Village, Kretek Sub-district, Bantul Regency of DIY indicated that there were some types of responses as the survival strategy in agricultural activities, i.e. non response, growth response, satisfier response, and withdrawal response. The mostly-chosen responses were the growth response and satisfier response. Farmers conducted the growth response by adopting agriculture modernization, such as agriculture intensification. The land factor also highly affected the agricultural activities, in which each land has different conformity to certain agricultural commodity.

The potential of a region to develop agriculture generally depends on the physical characteristics of the environment, which include the climate, soil, topography, area profile, hydrology, and certain terms of use (Faculty of Geography UGM, 2005; Widodo, Prinz, D., Malik, A.H., 2005). The conformity of the physical characteristics to the terms of use or commodity will inform that a land is potential to develop. In this context, land resources require an analysis or evaluation of capacity and conformity. The use of land for agriculture also requires an evaluation of capacity potential. Unused lands or lands used for other sectors also require an evaluation of agricultural-land development.

After the land capacity is determined, the development of agriculture requires a study to identify the appropriate types of commodity. Land conformity is influenced by the factor of quality and land characteristics. Land quality represents the complex characters of land, while land characteristics mean the measurable and calculable parameters that can determine the land quality (Sitorus, 1985).

The development of agriculture in the context of environmental aspect is also studied in the following researches. Santosa (1998) conducted a study of land evaluation for the development of foodstuff crops agriculture in Bayat Sub-district, Klaten Regency in Central Java. The result showed that each landscape had varied conformity to the crops. This research was limited to proposing recommendations to develop commodities; other factors, such as water resources supply and applicative development programs were not considered.

Budi and Budi (2002), in their research during the dry season of year 2000 in the irrigation service area of Pondok Basin, Ngawi, East Java, stated that the efficiency of water use was positively correlated to the improvement of irrigated-rice productivity. Plenty water consumption caused lower productivity instead. This research is remarkable to develop in order to identify the approaches for water use efficiency which is highly relevant for drought-sensitive areas.

Land conservation for foodstuff crops productivity has also been studied by Ratnada and Yusuf (2003) in Imogiri Sub-district, Bantul, DIY, focusing on farmers' behavior towards land conservation. The result indicated that the farmers' behavior towards the efforts of land conservation for irrigated rice-field agribusiness system was in the average level. This behavior was influenced by the following factors: farmers' motivation to gain success, farmers' knowledge of land conservation, farmers' activeness in searching for information about land conservation, and intensity of land conservation extensions. Farmers' behavior towards land conservation turned out to bring a strong and positive influence to agribusiness productivity and revenue. This research implicitly recommended the significance of land conservation efforts in order to improve foodstuff crops productivity as well as the importance of farmers' active involvement in the efforts.

Maulana (2004) studied the influence of land size, cultivation intensity, and productivity on the growth of irrigated-rice production in Indonesia from 1980 to 2001. The result indicated that cultivation intensity played an important role, while land size and productivity tended to decline. This phenomenon showed that the fluctuation of total product use did not significantly influence the growth rate of production; in other words, there was a productivity leveling off. The recommended strategies to improve production were to develop agriculture research and technology, to control land-use change, and to develop infrastructure. Further research with narrower area will therefore be relevant to explain the three efforts in a more detailed and implementable description.

The aforementioned researches indicate that the variation of land carrying capacity and influencing factors are different for each region. They are caused by the difference in the aspects of inhabitants, environment, and natural resources as well as the management of each region. Therefore, the policy making and priority of development programs should consider the situation, condition, characters, and potential of the region, which are reflected by the carrying capacity if its environment. On the other hand, existing researches on agricultural land carrying capacity as well as concepts have not considered the factor of physical land carrying capacity, such as land damage, land conformity, and land capacity. This research is conducted to reduce the aforesaid weaknesses by using a comprehend-sive analysis.

CAPACITY, CONFORMITY, AND CRITICALITY OF AGRICULTURAL LAND IN GUNUNGKIDUL

Gunungkidul Regency is geologically divided into 9 (nine) geology formations. Kepek Formation is the dominant formation that occupies 71.7% of the total area size. Kepek Formation with its layered limestone rocks as the major rocks is difficult to develop into an intensive agricultural region. From the nine formations, only Wuni and Alluvium Formations can be developed into intensive agricultural regions because their major rock compositors enable the creation of thick soil layers. The compositors of Wuni Formation consist of volcanic bricks, tuff, sandstone, and siltstone combined with limestone, while Alluvium Formation consists of miscellaneous material sediment.

The biggest river in Gunungkidul Regency is Oyo River, which forms Oyo Sub Watershed from Opak Oyo Watershed system. Oyo River is the main river bordering the northern part of Wonosari Basin that has its upper reach at the ecosystem of Baturagung Hills and Massive Panggung. This river flows during all seasons; hence, in the dry season, it still flows although the debit is very low. The main function of Oyo River and its tributaries is to be the source of irrigation water for the agricultural lands along Oyo Watershed and of water supply for domestic demand including for the area of Wonosari Basin. The role as domestic water supply is more dominant than as irrigation source for dry agricultural lands in this region. The irrigation system of this region is mostly dry irrigation. The distribution of groundwater zones in Gunungkidul Regency in described as follows (Figure 2):

1. Groundwater zone in Baturagung Hills; the Hills consist of volcanic rocks (conglome-rate, shale, bricks, and tuff) so that there are no aquifers in this zone. The groundwater is of local type, and if it comes from flowing sources then it must be due to cracks or contacts among rocks. The groundwater in this zone has only little potential.
2. Groundwater zone in Gunung Sewu Hills; the groundwater reserve in this zone is abundant, but the depth can reach more than 100 m because it is part of an underground river system. Naturally, the Karsts area of this region has some caves, and some of the caves have an underground river that flows all year long and becomes a water resource for the inhabitants. However, the unusual depth makes the use of groundwater/ underground river water still low. This situation leads to drought vulnerability when the dry season comes to this Sewu Mountain Range.
3. Groundwater zone in Wonosari Basin; the depth can be divided into three areas, i.e.:
4. area with shallow groundwater (< 15 m), area with medium-depth groundwater (15 – 25 m), and area with deep groundwater (> 25 m). The groundwater potential in this zone is medium up to good.
5. Groundwater zone in Oyo Valley; the flow of groundwater to Oyo River comes through the layers of marlstone or the contact between marlstone and sandstone. The

groundwater depth is varied between 15 – 25 m. the groundwater potential in this zone is medium.

6. Groundwater zone in Massive Panggung; there are no aquifers, except the local ones. Groundwater flows through rock cracks and becomes spring in some areas. The groundwater potential in this zone is low.

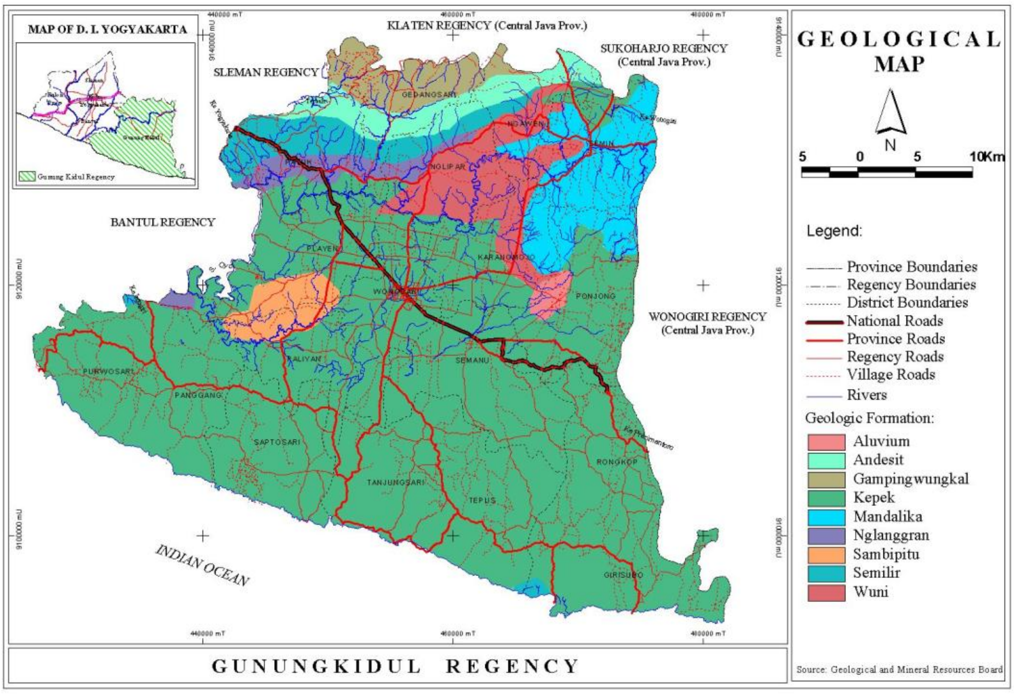

Figure 1. Geological Map of Gunungkidul Regency (developed from *Dir. Geologi & Sumberdaya Mineral,* 2006)

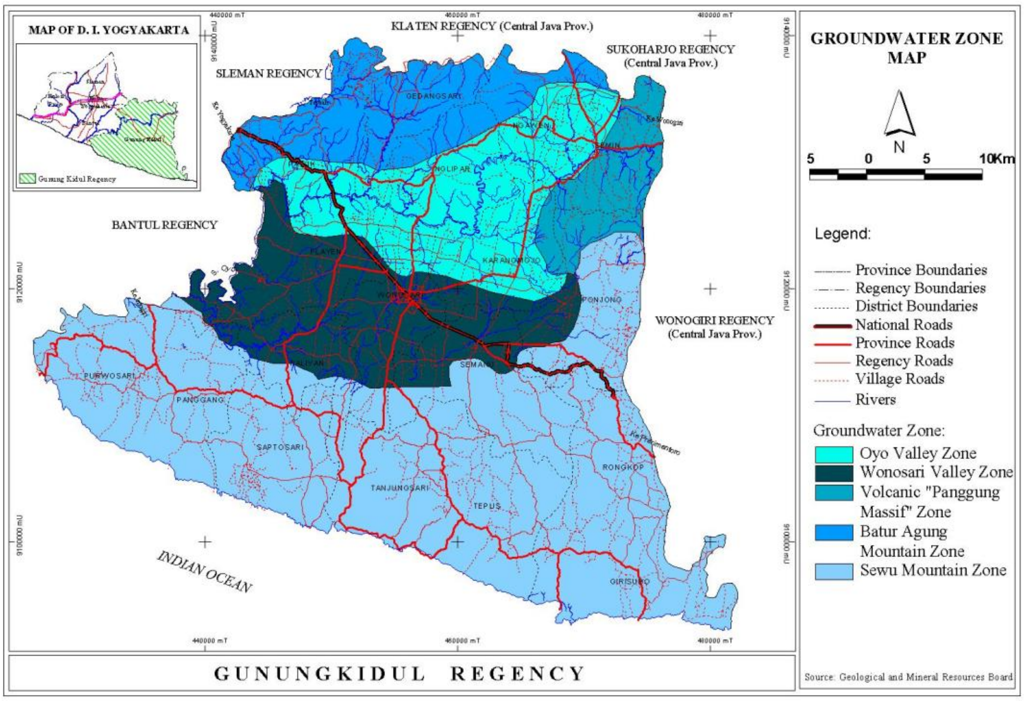

Figure 2. Map of Groundwater Zones in Gunungkidul Regency (Developed from *Dir. Geologi & Sumberdaya Mineral,* 2006)

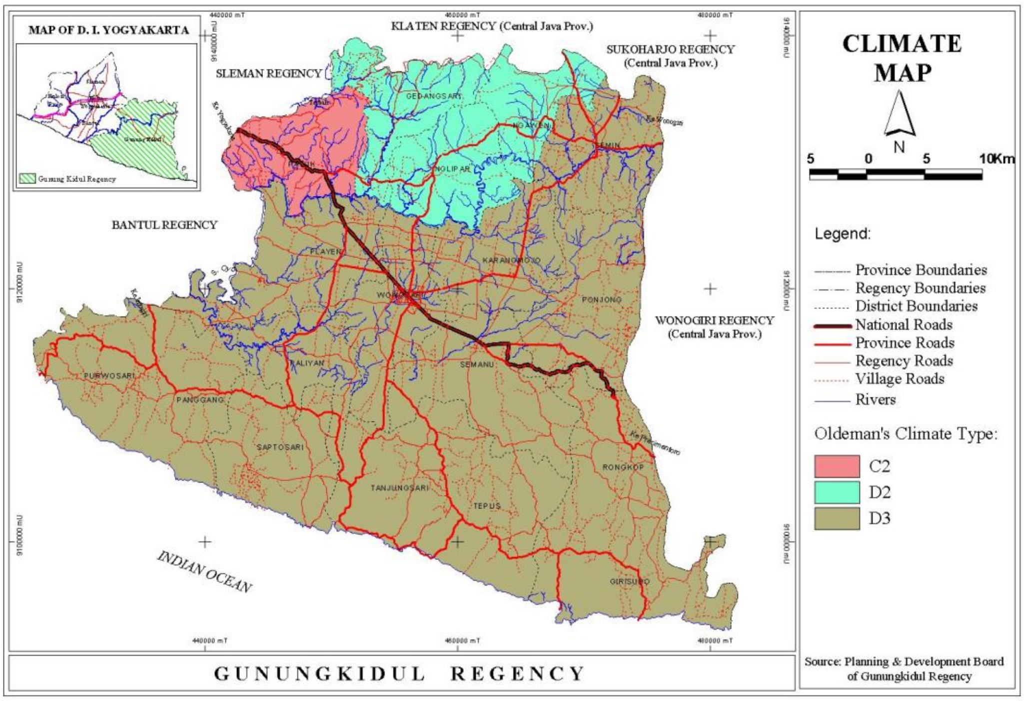

Figure 3. Climate Map of Gunungkidul Regency (Developed from *BAPPEDA Kab. Gunungkidul,* 2006)

Figure 3. Climate Map of Gunungkidul Regency (Developed from *BAPPEDA Kab. Gunungkidul,* 2006)

Scarce groundwater areas are spread throughout the northern part of Gunungkidul, such as Gedangsari Sub-district, Ngawen Sub-district and Patuk Sub-district, which consist of tertiary volcanic sediments in the form of volcanic bricks, sandstone, flakes, tuff, agglomerate, andesitic, basaltic, clay, and solid lava flow. The southern part of Gunungkidul Regency can also be classified as scarce groundwater because the groundwater/ underground rivers are too deep.

The highest annual average precipitation in Gunungkidul Regency occurs in Playen station, which is 2434 mm/year. Meanwhile, the lowest annual average precipitation occurs in Semin station, reaching 1632 mm/year. The average precipitation in this region is considered high, i.e. 1858 mm/year. According to the climate classification, most parts of this research area have Oldeman Type D3 climate, i.e. there are 3 – 4 consecutive wet months and 5 – 6 consecutive dry months. Type D3 climate includes Semin, Wonosari, Karangmojo, Ponjong, Playen, Paliyan, Tepus, Panggang, Purwosari, Saptosari, Semanu, Tanjungsari, Rongkop and Girisubo Sub-districts. Gedangsari, Ngawen, and Nglipar Sub-districts have Oldeman Type D2 climate, i.e. there are 3 – 4 consecutive wet months and 2 – 4 consecutive dry months. Meanwhile, Oldeman type C2 climate, i.e. there are 5 – 6 consecutive wet months and 2 – 4 consecutive dry months, occurs in Patuk Sub-district. The distribution of Oldeman climate can be seen in Figure 3.

Five consecutive wet months are considered optimal to grow irrigated rice. If it is less than three consecutive wet months, irrigated rice cannot be grown without additional irrigation. Three or four consecutive wet months can grow irrigated rice, but irrigation water is still required. If there are 2 – 4 consecutive dry months, farmers should be alert when planting crops due to water availability. If there are 5 – 6 consecutive dry months, additional irrigation is required to grow crops. According to Oldeman climate classification, the area of Semin, Gedangsari, Playen, Wonosari, Karangmojo, Ponjong, Paliyan, Ngawen, and Nglipar Sub-districts can be planted with irrigated rice, but additional irrigation is required when water scarcity occurs. Meanwhile, because Patuk Sub-district has five consecutive wet months, additional irrigation is not required. All these areas of Oyo Watershed can be cultivated with dry-land crops. In the region where 5 – 6 consecutive dry months occur, additional irrigation is needed. This situation occurs in Semin, Gedangsari, Playen, Wonosari, Karangmojo, Ponjong, and Paliyan Sub-districts. To cultivate crops in 2 – 4 consecutive dry months, irrigation is still required in order to anticipate water scarcity in such sub-districts as Ngawen and Nglipar. On the other hand, the sub-districts lying in Karsts areas, such as Tepus, Panggang, Saptosari, Semanu, Tanjungsari, Rongkop and Girisubo, can only use the land to plant non-irrigated rice or as rain-dependent rice field in a once-a-year period; after that, it can only be used as a dry land with such crops as cassava or corns.

The conservation area in Gunungkidul Regency functions mainly to protect Karsts areas and critical lands. Meanwhile, the cultivation area is mostly used as dry lands, reaching 56.886 % of the total land use in the research area, as seen in Table 1. The existing dry lands represent an adaptation of land use conducted by inhabitants in the research area considering that this region is vulnerable to droughts.

The subsequent land characteristic is land capacity. The physical components of land that are used to determine the class of land capacity in this research include: Surface Slope; Soil Sensitivity to Erosion; Level of Soil Erosion; Soil Depth; Texture of Soil's Upper Layer; Texture of Soil's Lower Layer; Soil Permeability; Soil Drainage; Gravel/Stone Content; and Flood Hazard.

The classification of land capacity follows the criteria from Faculty of Geography UGM (2005). Besides, the analysis unit is based on the landform, assuming that the slope, soil, gravel/stone content, and flood hazard characteristics for the regions of the same landform will be similar to each other. Considering that landform is made by nature, which represents a process of climate, major rocks, and slope functions, the physical components of land are then found in landform. The classification of land capacity is conducted by testing the values and characters of soil and location on a set of criteria for each category through a selection process (Sitorus, 1985). The values are tested on the criteria of the best land class. Not meeting the requirement, they will be tested on the lower class' criteria, and so on, until a class where all the criteria are met is found. Table 2 shows the criteria.

Based on the characters and limiting factors, lands can be classified into division, from division to class, from class to subclass, and finally management unit. The classes of land capacity are presented in Table 3.

Table 1. Distribution of Land-Use Types in Gunungkidul Regency

No.	Land Use	Size (km^2)	Percentage (%)
1.	Lake/pond	1.33	0.090
2.	Homogenous forest	153.76	10.352
3.	Non-agricultural industry	0.09	0.006
4.	Mixed garden	0.85	0.057
5.	Cemetery/graveyard	0.02	0.002
6.	Land waterworks	7.71	0.519
7.	Plantation	0.02	0.002
8.	Settlement	380.19	25.596
9.	Irrigated rice field: 1x rice	14.86	1.000
10.	Irrigated rice field: 1x rice + dry-season crops	28.93	1.948
11.	Irrigated rice field: 2x rice/year-more	4.54	0.306
12.	Irrigated rice field: rain-dependent	14.41	0.970
13.	Bush	31.83	2.143
14.	Damaged lands	1.57	0.106
15.	Infertile lands	0.29	0.020
16.	Dry lands/non-irrigated fields	844.96	56.886
	TOTAL	1485.36	100.000

Source: GIS Analysis (2009)

The analysis is conducted using LCLP (*Land Classification and Land-use Planning*) software. This software is chosen because it is able to classify land capacity correctly and to minimize human error. Moreover, this software is open to modifications of other types of modeling. The process starts with the making of criteria of land capacity according to Faculty of Geography UGM (2005). The aforementioned parameters are the processed using Geographic Information System (GIS) through the steps described in Figure 4.

The analysis shows that the land capacity in Gunungkidul Regency is dominated by Class II and Class VI. Class II occupies 30.0 % of the area size, and class VI has 35.6 % of the size as seen in Table 4 and Figure 5. This land capacity class merely reflects the land's physical condition without considering the condition of groundwater and surface-water reserves; therefore, the modified model for agriculture should be completed with analysis of land conformity for agriculture.

Table 2. Criteria of Land Capacity Classification

Inhibiting/Limiting Factor	Class of Land Capacity							
	I	II	III	VI	V	VI	VII	VIII
1. Surface Slope	A	B	C	D	A	E	F	G
2. Sensitivity to Erosion	KE_1,KE_2	KE_3	KE_4,KE_5	KE_6	(*)	(*)	(*)	(*)
3. Level of Erosion	e_0	e_1	e_2	e_3	(**)	e_4	e_5	(*)
4. Soil Depth	K_0	K_1	K_2	K_2	(*)	K_3	(*)	(*)
5. Texture of Upper Layer	t_1,t_2,t_3	t_1,t_2,t_3	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	(*)	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	t_5
6. Texture of Lower Layer	t_1,t_2,t_3	t_1,t_2,t_3	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	(*)	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	t_5
7. Permeability	P_2,P_3	P_2,P_3	P_2,P_3,P_4	P_2,P_3,P_4	P_1	(*)	(*)	P_5
8. Drainage	D_1	d_2	d_3	d_4	d_5	(**)	(**)	d_o
9. Gravel/Stone	B_0	b_0	b_1	b_2	b_3	(*)	(*)	b_4
10. Flood Hazard	O_0	O_1	O_2	O_3	O_4	(**)	(**)	(*)
11. Salinity (***)	G_0	g_1	g_2	g_3	(**)	g_3	(*)	(*)

Source: Arsyad (1989)

Table 3. Relationship between Classes of Land Capacity and Intensity/Type of Land Use

Class of Land Capacity		Intensity and Type of Land Use Increase								
		Natural Conservation	Forest	Shepherding			Planting			
				Limited	Medium	Intensive	Limited	Medium	Intensive	Very Intensive
Obstacles/ hazards increase; conformity and land-use options decrease	I									
	II									
	III									
	IV									
	V									
	VI									
	VII									
	VIII									

Source: Arsyad (1989)

Critical lands in Gunungkidul Regency are determined by analyzing the types of land use according to land capacity. A land is categorized as critical if an unconformity occurs between the land capacity and land use. The level of land criticality is based on the unconformity between the land use and class of land capacity, which has levels in the limiting factors. The higher the class of land capacity (approaching VIII), the more the limiting factors it has; therefore, the level of land criticality is higher if the land use does not conform to it. The result of land criticality analysis is presented in Table 5.

The ratio of non-critical land to critical land in Gunungkidul Regency reaches almost half of the area size. In general, there are 59.17% non-critical lands and 40.42% seriously-critical lands. Non-critical region is dominated by the area of Ledok Wonosari, while the critical lands are mostly found in Karsts Hills, which are supposed to have preserving function. This area is considered naturally critical, and it requires land conservation. The spatial distribution can be seen in Figure 6.

Table 4. Distribution of Land Capacity Classes in Gunungkidul Regency (GIS Analysis 2009)

No.	Land Capacity	Size (km^2)	Percentage (%)
1.	Class I	97.38	6.6
2.	Class II	445.65	30.0
3.	Class III	280.85	18.9
4.	Class IV	2.74	0.2
5.	Class V	129.28	8.7
6.	Class VI	529.48	35.6
TOTAL		1485.36	100.0

Table 5. Distribution of Land Criticality Classes in Gunungkidul Regency (GIS Analysis 2009)

No.	**Land Criticality**	**Size (Km^2)**	**Percentage (%)**
1.	Non Critical	878.92	59.17
2.	Potentially Critical	0.29	0.02
3.	Slightly Critical	2.55	0.17
4.	Averagely Critical	3.15	0.21
5.	Quite Seriously Critical	0.10	0.01
6.	Seriously Critical	600.35	40.42
TOTAL		1485.36	100.0

The existence of critical lands in a region will negatively impact the environment quality, including the physical and biotic environment as well as the culture of its inhabitants. Most critical lands in this watershed are not caused by human interference; they exist due to the natural factor of landform compositors of this area. The critical lands will show an apparent impact on the physical environment, whereas the biotic and cultural environment will adapt to the existing condition.

Land criticality is generally caused by the topographic condition, i.e. hills with steep or very steep slope and thick rock layers exposed to soil surface that is relatively water-proof and difficult to weather. This condition will trigger abundant, fast surface runoff when it rains, making erosion process occur intensively. This can be seen by the plenty number of trenches or erosion valleys in the whole area of critical lands. The relatively massive and resistant condition of rocks causes low weathering process and slow soil formation.

Consequently, this region has thin soil layers and is lack of plant nutrients. Moreover, it can cause poor groundwater content or groundwater scarcity, particularly in dry seasons. Droughts may occur because rocks cannot preserve sufficient groundwater. The steep slope, plenty number of rock exposes stuck on the thin soil layer, and high surface runoff will certainly trigger a landslide in the form of soil mass movement, rock fall, or slope-reform fall. All these natural phenomena will accelerate the process of land degradation, which will reduce the quality of physical environment in general.

Thin soil layers, lack of plant nutrients, and insufficient groundwater in the rock compositors make vegetation difficult to grow well. As a result, these critical lands look dry and infertile, without forests, and can only grow bushes in the rainy season. This condition makes land use as a manifestation of human adaptation to their physical environment relatively less intensive. The dominant land uses are dry lands in sloping areas with terracing system and very sparse settlement in a scattered pattern. In conclusion, critical lands with all their characteristics do not give sufficient benefits to land-use efforts nor sufficient productivity as planting media.

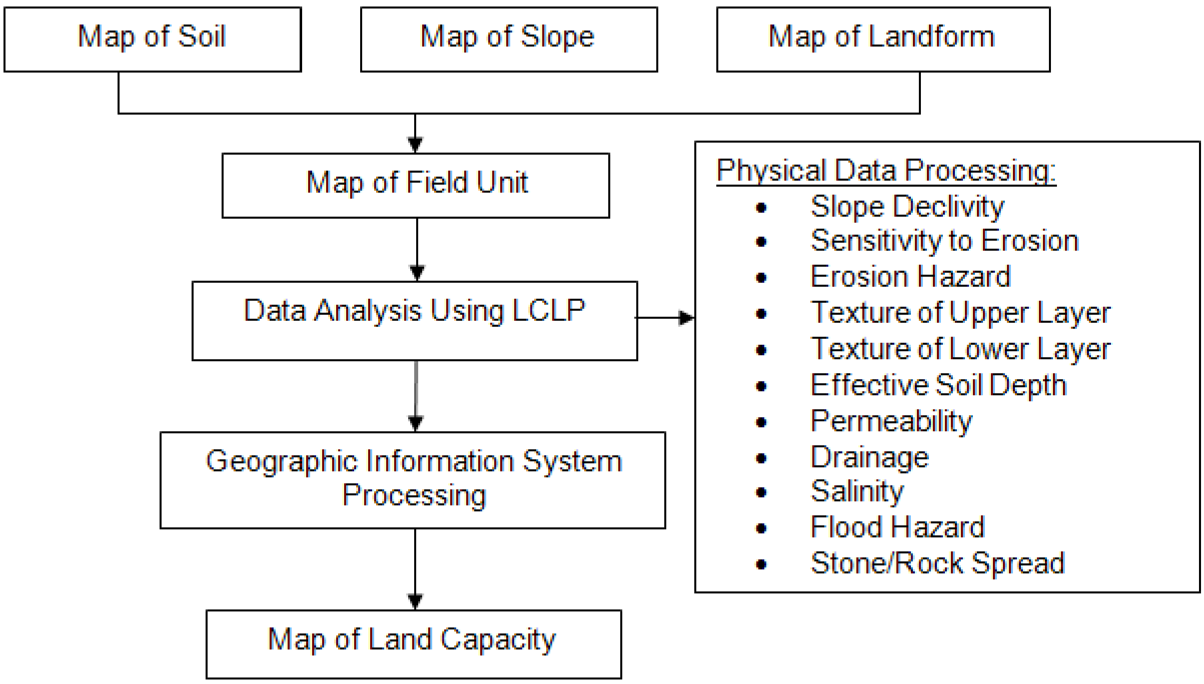

Figure 4. Stages of Land Capacity Data Processing

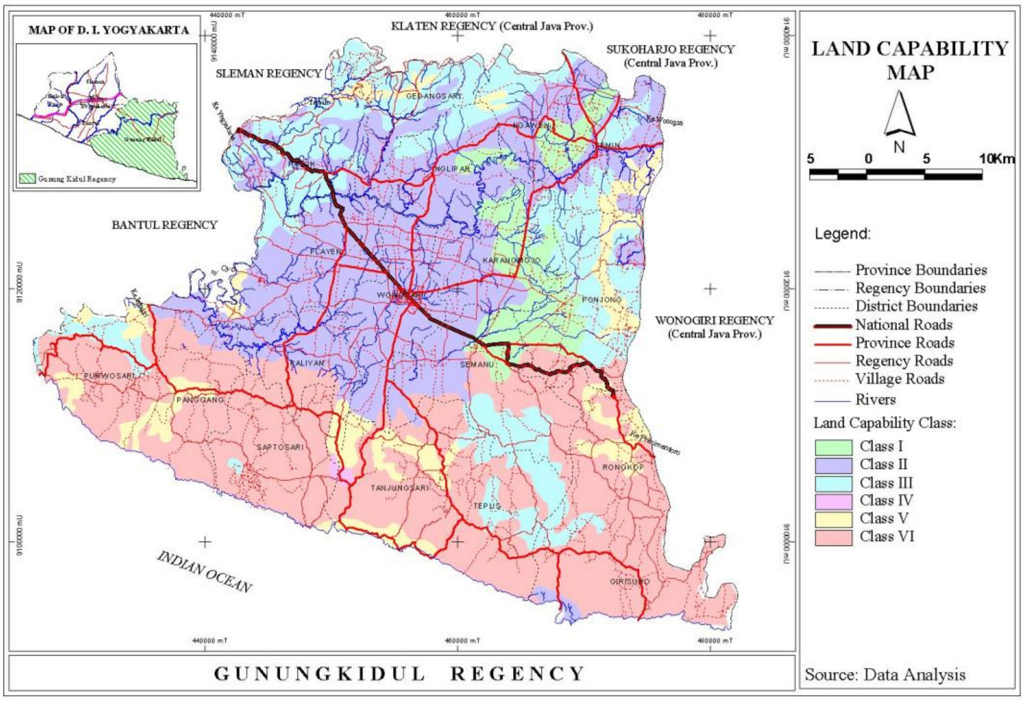

Figure 5. Map of Land Capacity in Gunungkidul Regency (Developed from *GIS Modelling, 2009*)

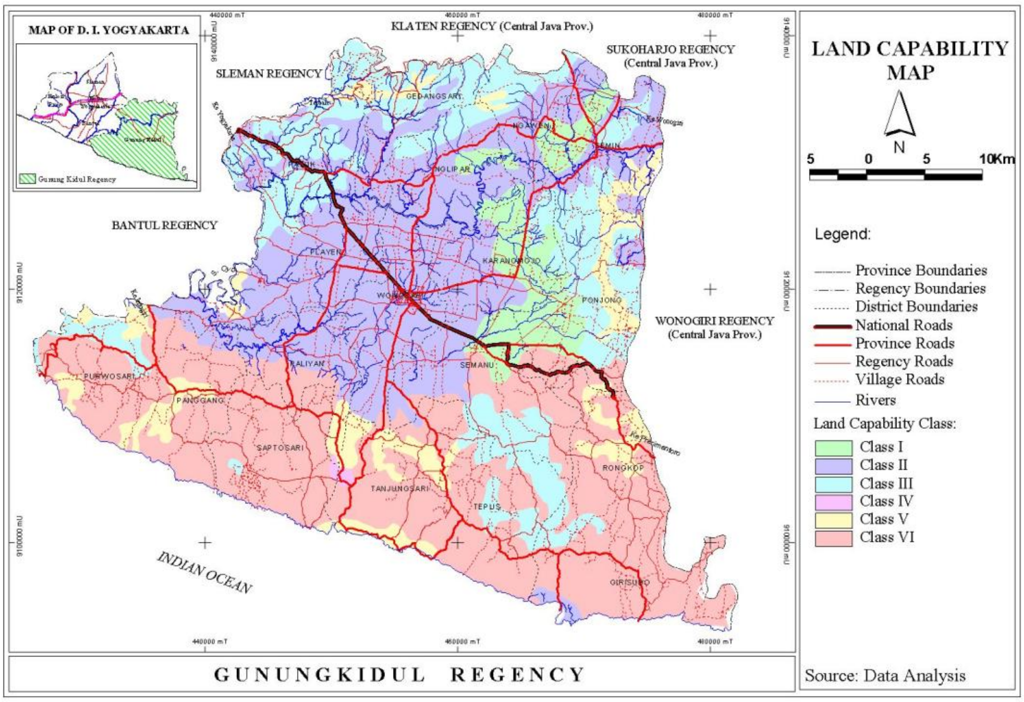

Figure 5. Map of Land Capacity in Gunungkidul Regency (Developed from *GIS Modelling, 2009*)

Based on the aforementioned description, the following land problems are identified:

1. Erosion occurs in almost all areas with different intensity, from the lightest to the heaviest, in the form of splash, string, channel, and trench.
2. Landslide occurs in all areas, including in the watershed, with different intensity, from the lightest to the heaviest, and different types, i.e. soil slide, soil creep, reformed-mass slide, rock slide, rock fall, and rock collapse.
3. Critical lands are identified in most areas.

4. Land damage due to uncontrolled mining activity is discovered.

Land evaluation is a process of land resource assessment for specific purposes using a tested approach or method. The result of land evaluation will provide information and/or directives for proper land use. Land conformity is the compatibility level of a tract of land for a specific use. The land conformity can be assessed for the existing condition (actual land conformity) or after an improvement (potential land conformity).

Actual land conformity is the land conformity gained from land's biophysical characteristics or land resource data before the land is supplied with the required inputs to overcome problems. The biophysical data includes soil characteristics and climate in relation to the growth requirements of the evaluated plants. Potential land conformity represents the land conformity to be achieved when improvement efforts are conducted. The evaluated land can be a conversion forest, abandoned or non-productive land, or agricultural land that has unsatisfying productivity but is still possible to improve if the commodity is replaced by a more appropriate plant.

The evaluation method used for dry agricultural land in this research is the matching method provided by LCLP (*Land Classification and Land-use Planning*) software. The result is then surveyed to find out the actual condition in the research area. The result of matching logic in Gunungkidul Regency is presented in Table 6.

Table 6. Distribution of Land Conformity Class in Gunungkidul Regency

No.	Land conformity	Size (km^2)	Percentage (%)
1.	S 1	97.38	6.6
2.	S 2	726.5	48.9
3.	S 3	2.74	0.2
4.	N 1	129.28	8.7
5.	N 2	529.48	35.6
Total		1485.36	100.0

Source: GIS Analysis (2009)

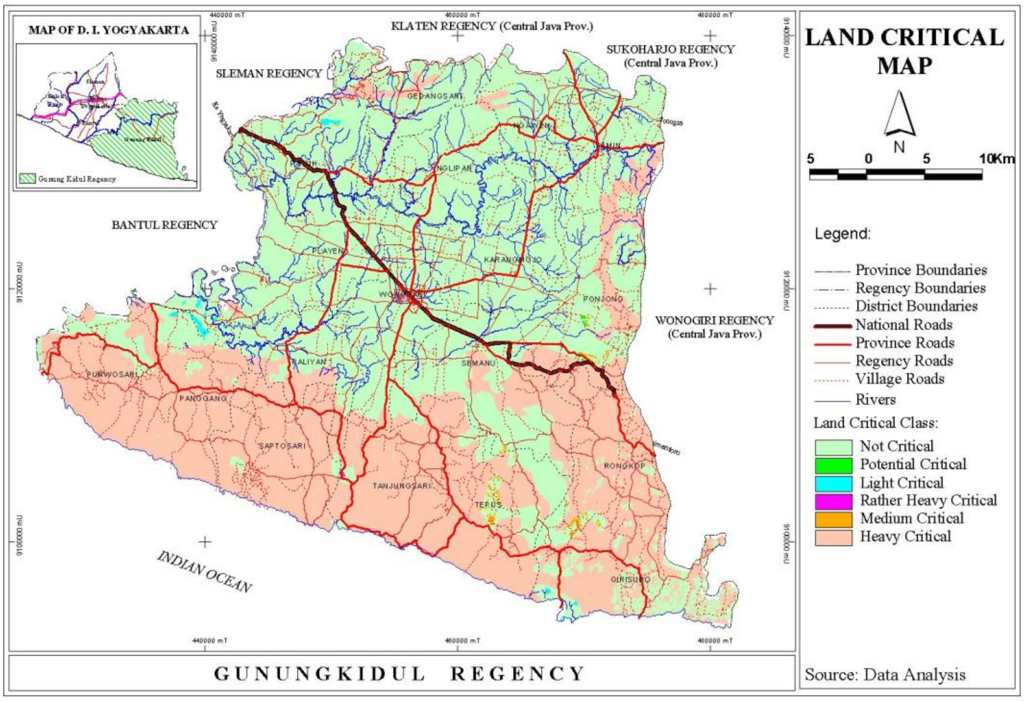

Figure 6. Map of Land Criticality in Gunungkidul Regency (Developed from *GIS Modelling, 2009*)

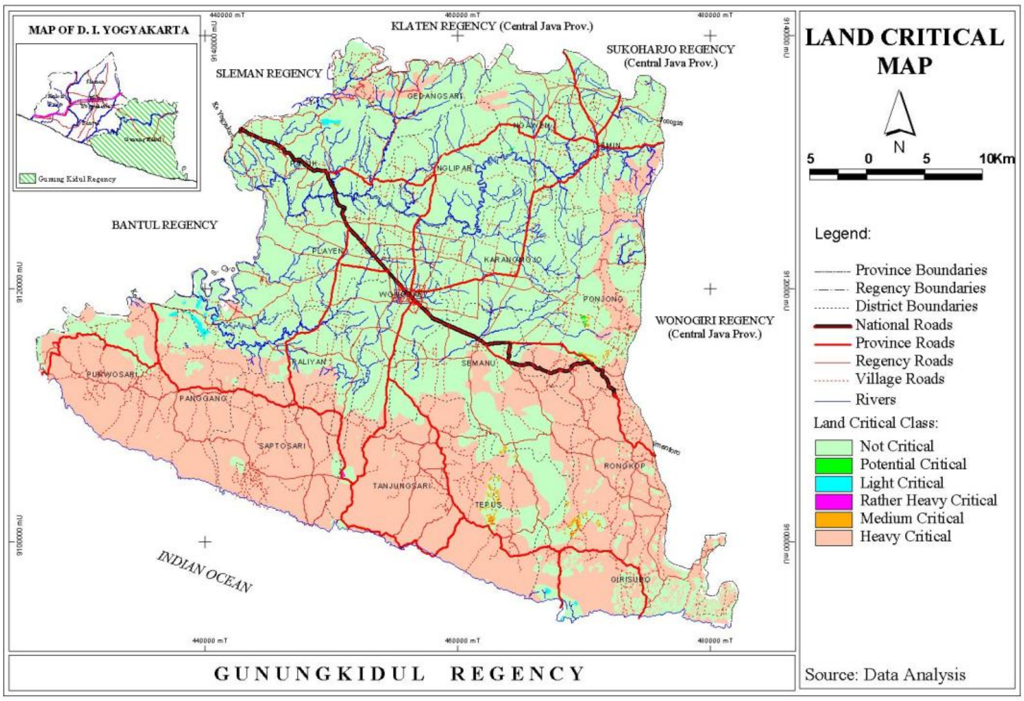

Figure 6. Map of Land Criticality in Gunungkidul Regency (Developed from *GIS Modelling, 2009*)

The data indicates that Appropriate Class (S) dominates 55.7% of the whole area, while

the inappropriate Class covers 44.3%. Inappropriate Class for agriculture are mostly located in Karsts area that has thin soil layer and water scarcity.

The field survey shows that the agricultural region in Gunungkidul Regency is planted with dry-season crops or left fallow in dry seasons and planted with non-irrigated rice in rainy seasons. Some specific parts of Ponjong region that have a technical irrigation system can be planted with rice all the year. The complete planting calendar in the sample locations is shown in Table 7.

According to the planting calendar, there are three (3) types of land use discovered in the research area, i.e. Rice Field, Dry Land, and Fallow Land. The type of rice planted in rain-dependent rice fields is Seherang, while irrigated rice fields are planted with IR64 and Bagendit types. Dry lands are mostly planted with such various crops as cassava, corns, soybeans, and peanuts. In several locations, there is a period of fallow condition due to irrigation water scarcity because almost all of the locations count on rainwater as the source of irrigation water except in some parts of Ponjong Sub-district that have river water as the source of technical irrigation system.

CONCLUSIONS

According to the result and analysis, the following conclusions can be made:

1. The dominant land use in Gunungkidul Regency is cultivation area for dry lands, covering 844.96 km^2 or 56.886 %.
2. Land capacity in Gunungkidul Regency is dominated by Class II (30.0 %) and Class VI (35.6 %).
3. There are three (3) types of land use according to the planting calendar in Gunungkidul Regency, i.e. rice field, dry land, and fallow land in which most of them are planted with dry-season crops or left fallow in dry seasons and planted with non-irrigated rice in rainy seasons.
4. 55.7% of Gunungkidul Regency land has Appropriate Class (N) and 44.3% has Inappropriate Class, which dominate Karsts Area where the soil layer is thin and water is scarce.
5. Gunungkidul Regency has 59.17% critical lands dominated by the area of Ledok Wonosari and 40.42% seriously critical lands found mostly in Karsts Hills.

Table 7. Planting Calendar in Sample Locations

No.	Coordinate		Month											
	X	Y	1	2	3	4	5	6	7	8	9	10	11	12
1.	456899	9124773	S	S	T	T	T	T	-	-	-	-	-	S
2.	455780	9129066	S	S	T	T	T	T	-	-	-	-	-	S
3.	453153	9128943	S	S	T	T	T	T	-	-	-	-	S	S
4.	471948	9131013	S	S	T	T	T	T	-	-	-	-	-	S
5.	467777	9119227	S	S	S	S	S	S	S	S	S	S	S	S
6.	454070	9108733	S	T	T	-	-	-	T	T	-	-	S	S
7.	448115	9114662	S	S	T	T	T	-	-	-	-	-	-	S
8.	449738	9119079	S	S	S	S	S	S	-	-	-	-	-	-
9.	451541	9123412	S	S	T	T	T	-	-	-	-	-	-	S

Source : Result of Field Survey 2009
Note : S: Rice field, T: Dry Land, - : Fallow Land

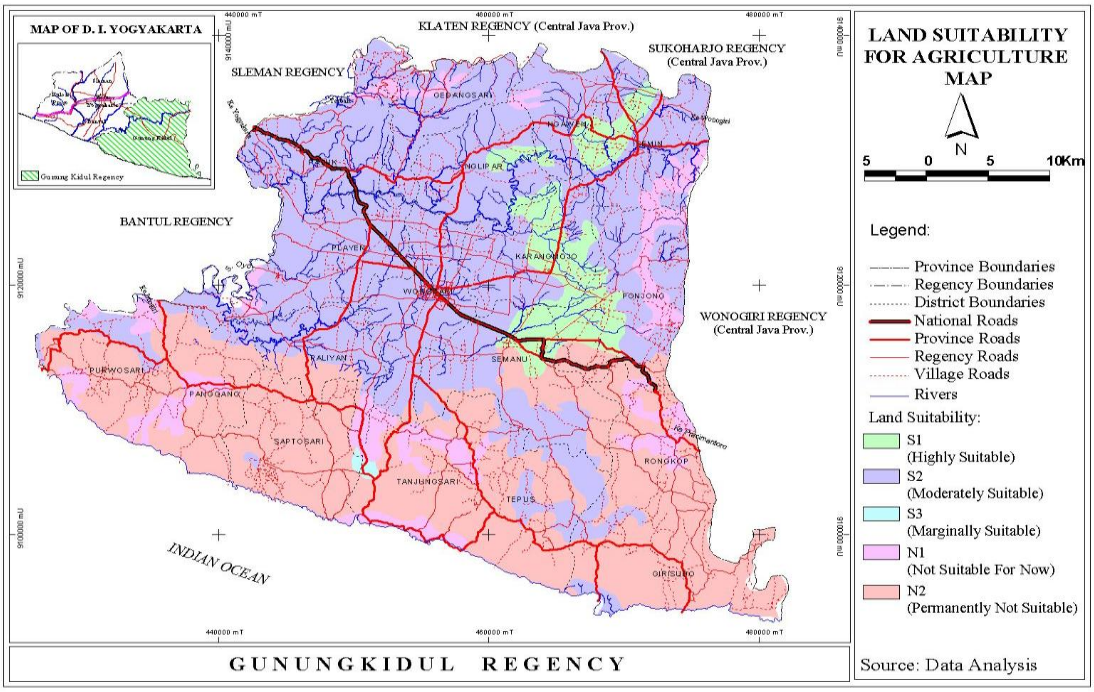

Figure 7. Map of Land Conformity for Agriculture in Gunungkidul Regency (Developed from *GIS Modelling, 2009*)

RECOMMENDATIONS

1. The development of agriculture in Gunungkidul should prioritize dry-land agriculture and continue making efforts to optimize irrigation management.
2. A further research is required to discover a variety of prime seed for each commodity that conforms to each land class.
3. A further research is required to study the development of Karsts region by taking into account the environmental conservation.
4. A further research is required to analyze the development of non-crops agriculture for the sake of people's wealth.
5. A further research is required to evaluate the development of nature-based non-agricultural business while taking into account the environmental conservation.
6. A more detailed research is required to analyze each land type, land capacity class, and land conformity class.

ACKNOWLEDGEMENT

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SHORELINE CHANGE MODEL USING THE EPR METHOD AND THE SIMULATION OF COASTAL VULNERABILITY IN SAMBAS DISTRICT-WEST KALIMANTAN

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ABSTRACT

Potential threats to the coastline increase from year to year because of global climate change that increases the temperature of the earth and sea level rise. West Kalimantan has a long coastline of 982 km. Potential length of this beach should be maintained in order not to decrease. District of Jawai and Jawai Selatan is one of the coastal areas, which suffered severe erosion. This study aims to model the pattern of coastline changes and the index of coastal vulnerability to current conditions and future conditions using physical parameters such as waves, tides, bathymetry, land cover and sea level rise (SLR). This research is conducted using satellite image map data is processed with ArcGIS 9.3, Erdas and Autocad. Shoreline changes were analyzed by End Point Rate method. From the results of the shoreline change analysis obtained information that the length of the beach erosion from Jawai Selatan to SB Nilam is about 4 km and the eroded area is 9557.546 m^2. Sambas coastal areas in the district Jawai Selatan until the district Jawai are susceptible to the existing conditions (first scenario). Vulnerability score on shoreline occupied criteria "High", where erosion rate on average per year is about 6 m. In the second scenario with tidal elevation is 3 m, wave height is 3 m, and SLR is 0.5 m, obtained results of a vulnerability index is generally dominated by the conditions of very high vulnerability. In the third scenario with tidal elevation is 4 m, wave height is 4 m, and SLR is 1 m, obtained results of a vulnerability index is generally dominated by the conditions of very high vulnerability.

Keywords*: shoreline changes, coastal vulnerability index, recent condition and future model analysis*

INTRODUCTION

The coast in Jawai Selatan until Jawai is low-lying area and the topography is quite flat. Prior to 1989, Coastal area of Jawai Selatan was vegetated by mangrove tree and since 1998 had damaged. In 2009, there are several indicators of coastal damage in district Jawai and Jawai Selatan, such as collapse of many coconut tree and shoreline retreat.

Erosion problem in Jawai and Jawai Selatan is due to the fishpond conversion, sand mining and position of breakwater which is too close from the shoreline that can cause serious consequences of rapidly increasing erosion behind the breakwater.

Therefore, it is important to investigate the shoreline changes, erosion rate per year and how these condition affect the vulnerability of coastal area in district Jawai and Jawai Selatan.

OBJECTIVES

This study aims to identify and model the pattern of coastline changes between 1992 until 2006. The result can be used to predict the shoreline changes for the future.

The second objective is to identify the index of coastal vulnerability againts current conditions and future conditions using physical parameters such as waves, tides, bathymetry, topography, land cover and sea level rise (SLR). This study is expected to provide valuable input to local government in overcoming the problem of coastal vulnerability and coastal hazards.

STUDY AREA

The study area is located on the Jawai Selatan coast to SB Nilam coast of Sambas district Pontianak. The coast length between Jawai Selatan and SB Nilam is about 31 km. The topography in this area is flat and constitute low-lying area.

Characteristic of Jawai Selatan coast comprised of sandy beach and mangrove trees can be found in Ramayadi beach, whereas in Jawai coast is dominated by sandy beach.

In Jawai Selatan, the fishpond is already damage due to mismanagement of fishpond and occurs erosion behind breakwater. The location of study can be seen in Figure 1.

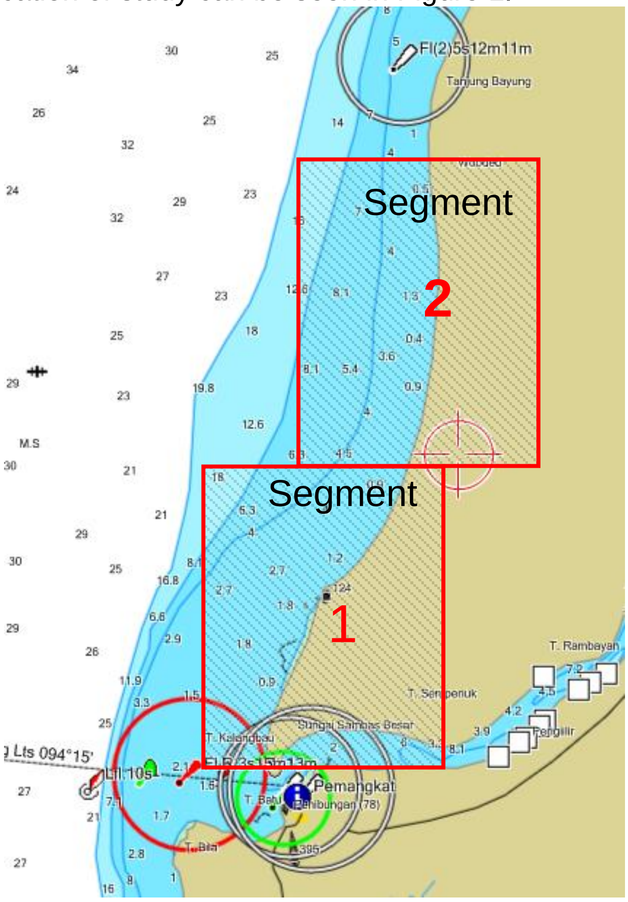

Figure 1. Study Area

METHODOLOGY

The method of this research is using remote sensing to extract shoreline position from satellite image using software Erdas. Shoreline change can be analyzed using Autocad based on the End Point Rate (EPR) method. Coastal vulnerability index (CVI) can be analyzed using ArcGis 9.3 based on the equation that was proposed by Gornitz et al. (1991).

Remote Sensing

Detection of shoreline change can be analysed using remote sensing method. Remote sensing require satellite image data to identify shoreline position. In this research, there are two satellite image data, namely between 1992 and 2006.

The software used for satellite data processing to obtain the position of the coastline is Erdas. The flow chart for processing satellite data using Erdas can be seen in Figure 2 (Alesheikh et al., 2007).

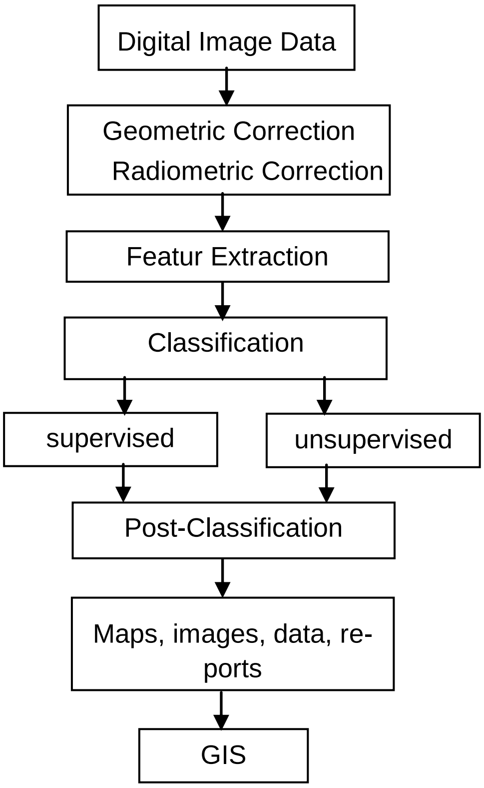

Figure 2. Steps of image satellite processing

EPR Method

The next step is analyse the shoreline position from the result of remote sensing process. EPR method is used to calculate the rate of shoreline change based on two shoreline position that have been extracted from satellite images.

EPR method is based on the concept of empirical equation shows that Shoreline changes in the future can be determined from the linear relationship between the Shoreline positions and times in the past or in previous years. EPR method can be written in the following equation (Li, et al., 1999).

$$Y = MX + B \qquad (1)$$

where Y = position of the coastline changes in year n (the desired end of the year),
m = rate of erosion / year = $(Y_n - Y_1) / (X_n - X_1)$,
X = year used as a bench mark (the early years of the start of the calculation),
B = point coordinates are used as a bench mark in the early years of the start of the calculation.

The Eq. 1 can be modified as follows

$$m_{EPR} = (Y_n - Y_1) / (X_n - X_1) \qquad (2)$$

where the EPR intercept is

$$B_{EPR} = Y_1 - m_{EPR} \cdot X_1 = Y_n - m_{EPR} \cdot X_n \qquad (3)$$

because the line end point can be added at the opposite point of recent point (X_n, Y_n), hence the equation can be rewritten into

$$Y_{EPR} = m_{EPR} \cdot (X - X_n) + Y_n \qquad (4)$$

Coastal Vulnerability Index

Vulnerability is defined as a specific condition that can increase the likelihood of danger or disaster resulting damage and loss. Coastal vulnerability index is intended to predict vulnerability due to coastal hazard (Szlafsztein, 2005).

The CVI is calculated by using some physical parameters of topography, coastal erosion rate per year, the slope of the shore base, rising sea level, wave height and tidal elevation (Abuodha and Woodroffe, 2006).

Table 1. Matrix for determination of coastal vulnerability index (CVI) from Gornitz (1991)

	Very low	Low	Moderate	High	Very high
Variable/ Score	1	2	3	4	5
Topography (m)	≥ 0.1	20.1 – 30.0	10.1-20.0	5.1-10.0	0 – 5.0
SLR change (m/tahun)	≤ -1.0	-1.0 - 0.9	1.0 – 2.0	2.1 – 4.0	≥ 4.1
Shoreline change (m)	≥2.1	1.0 – 2.0	-1.0 - +1.0	-1.1 - -2.0	≤ -2.1
Tidal range (m)	≤ 0.99	1.0 – 1.9	2.0 – 4.0	4.1 – 6.0	≥ 6.1
Annual max wave height (m)	0.0 – 2.9	3.0 – 4.9	5.0 – 5.9	6.0 – 6.9	≥ 7.0

The parameter of CVI can be modified according to the situation and condition (Cambers, 2001). The CVI can be obtained using the following equation

$$\text{CVI} = \sqrt{\frac{a.b.c.d.e.f}{6}} \qquad (5)$$

There are three scenarios of data input for coastal vulnerability index on the beach Sambas that can be shown in Table 2.

Table 2. Three scenarios of data input for coastal vulnerability index

	Scenario 1	Scenario 2	Scenario 3
Tide level	2 m	3m	4 m
Wave height	2 m	3 m	4 m
Sea level rise	0.1 m	0.5 m	1 m

RESULTS AND DISCUSSION

Coastline Change

Figure 3 show the pattern of shoreline change between 1992 and 2006, and the prediction of shoreline change in the future can be known.

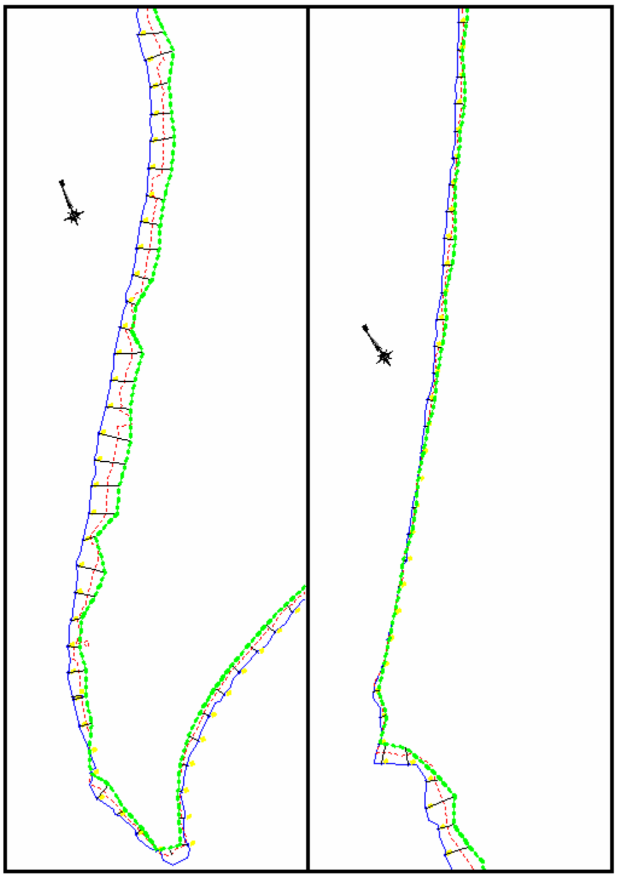

Figure 3. Shoreline change from 1992 to 2006 in Segment 1

From the shoreline change analysis using remote sensing can be seen that between the Ramayadi beach (sub distric Jawai Selatan) to Sentebang beach (sub district Jawai) had experienced a severe erosion of the coastline changes in average 6.642 m / year. Coastal areas in the district Jawai had became a place of sand mining, but it was banned and dismissed by the local government since 1997.

From the results of the shoreline change analysis are obtained information that the length of the beach erosion from Jawai to SB Nilam is about 4.6 km in segment 1 with an area undergoing erosion about 9557.546 m^2. In segment 2, the length of erosion is about 4.3 km with 11310 m^2 of land area.

The process of sedimentation in segment 1 has the length of sedimentation about 20.6 m and land area has experienced erosion about 133 $m^2$1, while in the segment 2 the length of sedimentation is about 5630 m with erosion of land area about 2798 m^2. Location of sedimentation process starting from coordinates 282005,148207 (in UTM format) to coordinates 281865.2173, 155155.0894.

Sediment process occur in coastal area along the coast in the sub district Jawai, from the village Nyirih to the beach in the villages SB Nilam is because there are mangrove trees that grow there.

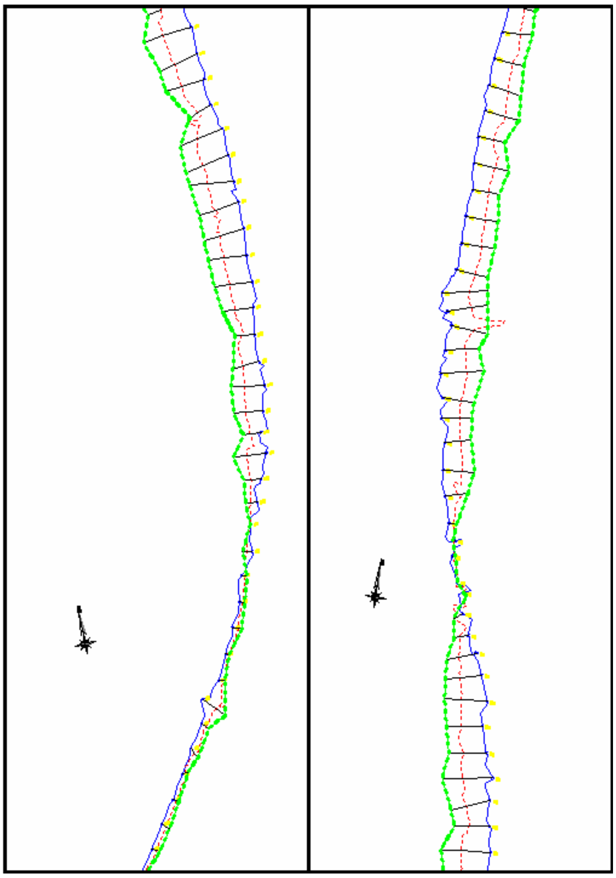

Figure 4. Shoreline change from 1992 to 2006 in Segment 2.

Erosion and sedimentation rates along the coast between Jawai Selatan and Jawai are varying depending on the interaction of waves, currents, defense building (such as breakwater, jetty, etc), mangrove plants, and land use (such as fishpond, sand mining, etc). Rate of erosion in segment 1 and segment 2 can be seen in Table 3.

Table 3. Rate of erosion minimum-maximun in segment 1 and segment 2

	Erosion (m/year)		Sediment (m/year)	
	Min	Max	Min	Max
Segment 1	0.11	12	0.002	0.98
average	5		0.34	
Segment 2	0.02	17	0.2	18
average	10.4		11	

Modeling of Coastal Vulnerability Index

Coastal vulnerability index (CVI) is the most common worldwide method to determine coastal vulnerability. However, the CVI should not be regarded as a constant value because it can change with time and require a simulation of some data to get a more realistic vulnerability.

Scenario 1 has data H= 2 m, tide level = 2 m and sea level rise = 0.1 m. The scenario 1 is simulated as as daily condition or existing condition.

In Figure 5, can be shown the coastal vulnerable index is dominated by moderate and high value. The land area of coastal is dominated by moderate vulnerability value where this area has flat topography and low-lying area, generally.

CVI has high vulnerability value on the shoreline due to along the shoreline has experienced a very severe erosion. Along the coastal regions have a very low vulnerability index which are found in high topography, such as rocky coastal.

Figure 6 shows the scenario 2 with wave height = 3 m, tidal elevation = 3 m, and SLR = 0.5 m, the CVI, is generally dominated by very high for both shoreline and coastal land. Sea level rise of 0.5 m or 50 cm is predicted for the year 2050 (Lewsey, C. 2002).

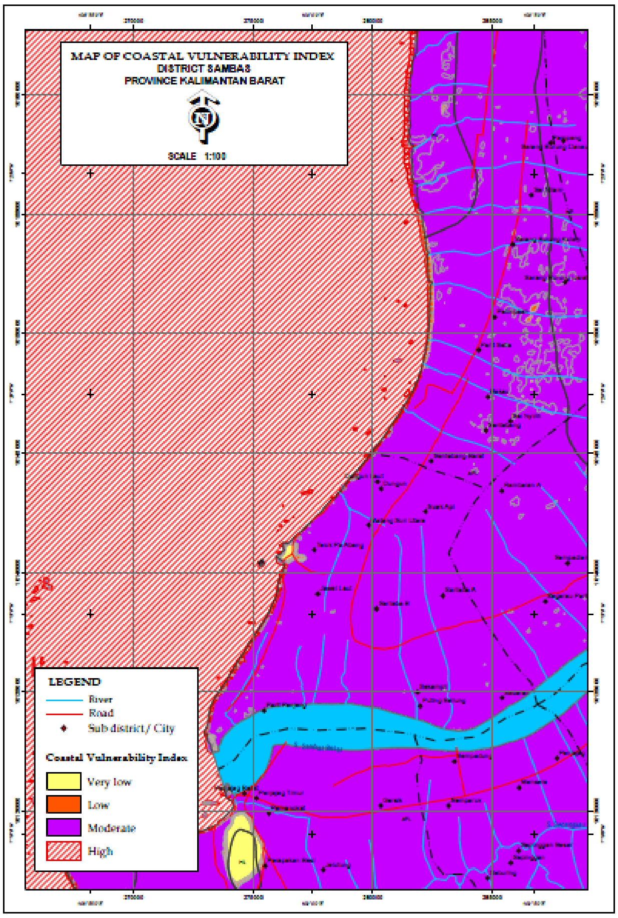

Figure 5. Scenario 1.

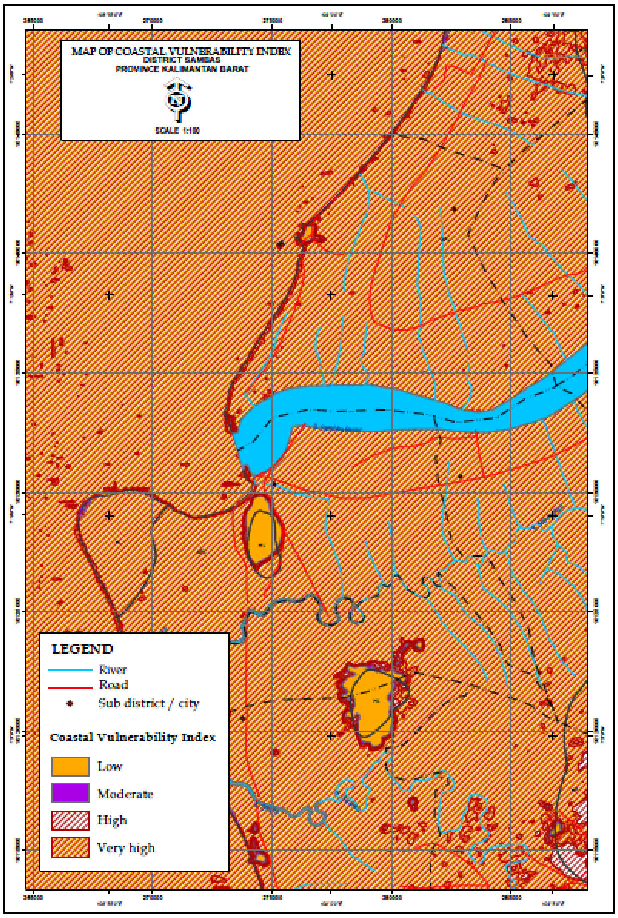

Figure 6. Scenario 2

In Figure 7 is for scenario 3 with wave height = 4 m, tidal elevation = 4 m, and SLR = 1 m, where the CVI score generally dominated by very high both shoreline and coastal land. There are only three CVI value in scenario 3, namely moderate, high and very high. This scenario simulated for the year 2100 where the sea level rise increased to 1 m or 100 cm (Lewsey, 2002).

Scenarios 2 and 3 are very useful and important to analyze the impact of storm surge attacks that have effects such as sea level rise on coastal areas. Storm surge is the event of sea level rise due to high winds and constant storms accompanied by heavy rains and could damage coastal areas.

From the simulation results of both the scenario 2 and scenario 3, the topographical condition in the coastal region along the coast from Jawai Selatan until Jawai is very flat and low-lying land, so very vulnerable to the threat of large waves and tidal fluctuations.

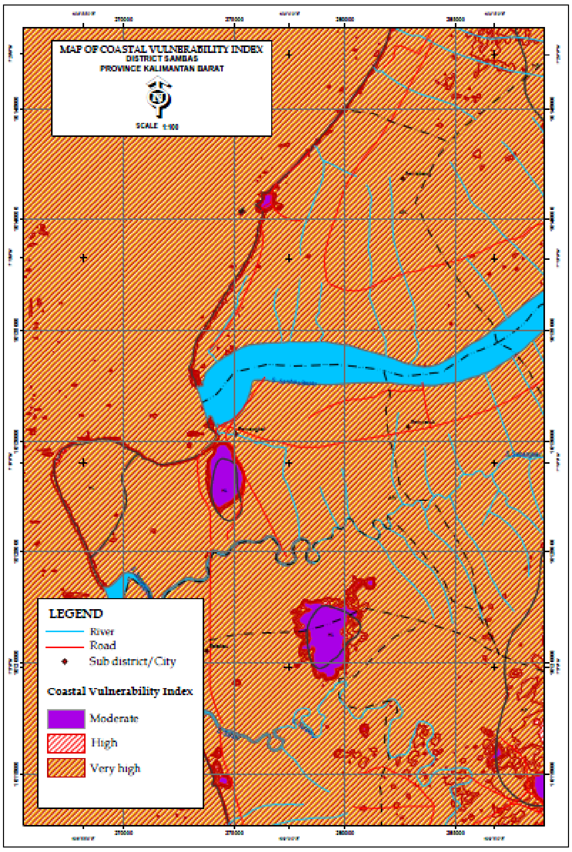

Figure 7. Scenario 3.

Verification

In Figure 8, can be seen that this area is the former location of fishpond that have been damaged.

Figure 8. Field verification

Figure 9 shows that condition of shoreline between beach in Jawai Selatan and Jawai had experienced erosion. Many coconut trees that had collapse and indication of coastal erosion can be seen clearly.

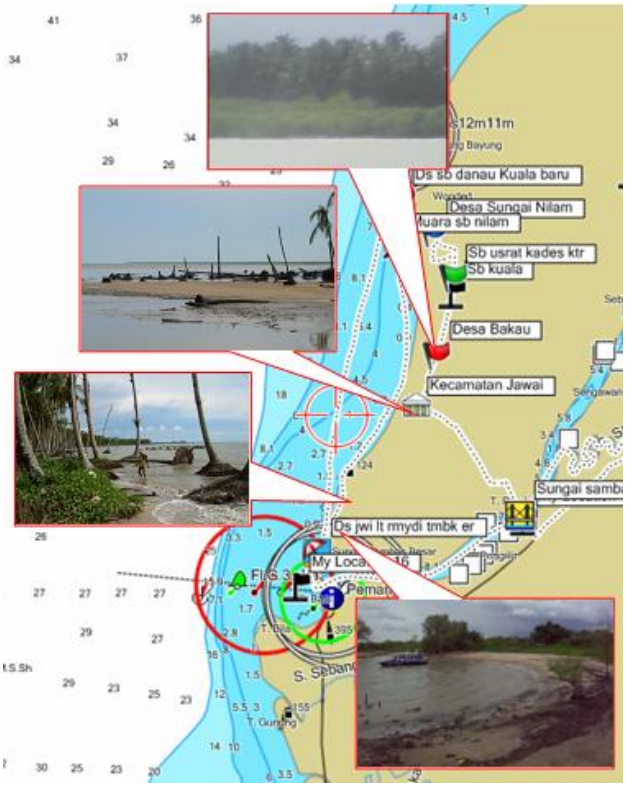

Figure 9. Field verification

There are two main factors cause erosion in Jawai Selatan. First, land conversion of coastal area to fishponds. Fishpond can cause a large void that susceptible from wave attack. Second, position of breakwater is too close to fishponds area that can cause erosion quickly due to the wave diffraction. Breakwater position should be located more far from shoreline (offshore breakwater) to reduce diffraction effect. Offshore breakwater is more adequate and more safely to protect fishpond from erosion because it can create salient and tombolo behind the structure.

From the results of studies in the field, the beach will be safe from erosion if there is a mangrove plant that can reduce wave energy and increase the supply of beach sediment transport

Mangrove trees can be found starting from the village along the coast Nyirih (Jawai district) to the beach in the village of SB Nilam.

CONCLUSIONS

From the results of this research, there are several conclusions that can be given as follows.

1. From the results of the shoreline change analysis obtained information that the length of the beach erosion from Jawai Selatan to SB Nilam is 3985.04 m (4 km) and the eroded area is 9557.546 m^2 in segment 1. In segment 2, the length of erosion is about 4.3 km with 11310 m^2 of land area.
2. Shoreline erosion is very strong with 5 to 6 m/year of average erosion rate for segment 1 and 10 m/year for segment 2. The rate of sedimentation is 0.34 m/year and 11 m/year for segment 1 and segment 2, respectively.
3. Sambas coastal areas in the sub district Jawai Selatan until the sub district Jawai susceptible to the (scenario 1). Sambas coastal region was quite vulnerable to the existing conditions, although CVI value is dominated by the moderate vulnerability, while the shoreline was in danger condition with CVI value is high vulnerability.
4. In the second scenario with tidal data = 3 m, wave = 3 m, and sea level rise = 0.5 m, obtained results of a vulnerability index is generally dominated by the conditions of very high vulnerability. On along the coast, the criteria of vulnerability index changed to "very high vulnerability ". Sea level rise 0.5 m is predicted for the year 2050.
5. In the third scenario with tidal data = 4 m, wave = 4 m, and an increase in sea level = 1 m, obtained results of a vulnerability index is generally dominated by the conditions of very high vulnerability. Sea level rise of 1 m was predicted for the year 2100.

This scenario aims to detect coastal vulnerability in the future.

6. The shoreline retreat in Jawai Selatan due to breakwater too close to the shoreline, can be overcome by removing the breakwater into the sea with a certain distance from the shoreline to grow salient and tombolo. Furthermore, the combination of Breakwater and mangrove plant, are expected to increase the supply of sediment to the eroded beach areas

ACKNOWLEDGEMENTS

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HEALTH RISK FROM AIR POLLUTANTS: AN EPIDEMIC IN WESTERN JAVA

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ABSTRACT

Complain from irritation of skin, cough, bad odor, and nausea was suffered by 100 % of a village (KSW) inhabitant, in Western Java. The location of KSW being upon a hill, just across factories along the coast, so that the people of this KSW blame the factories for emitting gaseous pollutants, which cause them to suffer the mentioned symptoms. The health problem was happened for the second time, before study was done to evaluate the relationship of air pollutants and these health effects. The study used a case-control retrospective epidemiologic method and relative risk measured as odd ratio. Stack emission dispersion predicted using the Gaussian model. Dispersions were described using isopleths. The stack samples were evaluated against emission standards, and Carbon monoxide (CO) was 458 µg/Nm^3, the standard being 100 µg/Nm^3. Predicted concentrations for all pollutants in KSW were all below national ambient standards, as expected, since stack samples were taken in accordance to the factories' permit and after the symptoms receded. The people at the time of study were healthy and no longer suffer any symptom, but the leaves of coconut trees within the KSW were brown and show a typical sulfur dioxide poisoning. the study confirms that there was relationship of the health effects with air pollutants exposure from the industrial sources.The KSW inhibitants who were exposed to ambient air pollutants more likely suffered eye irritation; cough; breathing annoyance; and skin itchiness : 17712 times; 3.14 times; 173.65 times; 128.35 times as compared to KC inhibitants who were not exposed. It was recommended that the factories on one hand, should reduce their emissions, and on the other hand, a continuous ambient air pollution monitoring device should be installed to be able to evaluate better the ambient air quality. It was clear that there is need to use more powerful epidemiologic study methods, designed specifically for areas with lack of sufficient data to measure accurately the air pollutants health risk estimation.

Keywords: *epidemic, air pollution, case-control study, isopleths.*

INTRODUCTION

Air pollution comes from many sources. Industries are major source of air pollution. They emit air pollutants, namely nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2) and particulate matter (PM). Exposure to ambient air pollutants has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function and continuing to restricted activity/reduced performance, visits to the hospital emergency department, admission to hospital and death. There is also increasing evidence for adverse effects of air pollution on the cardiovascular system as well as the respiratory system (WHO, 2006).

Cilegon has historically been the home of heavy industry, because it is a major coastal industrial city in Banten province, Indonesia. One of industrial site in Cilegon is in Gerem Districts. Emissions from these industrial sources in this area have created concerns about elevated health risks in residential neighborhoods adjacent to the industrial site, i.e KSW.

In assessing human health effect due to inhalation of ambient air, the health outcome is directly related to air concentration of the pollutants. Understanding the magnitude and nature of human exposure is clearly the first step in assessing the likelihood of adverse health effects that could result from contact with environmental pollutants. Undertaking this type of research requires identification of the key sources and constituents of ambient air pollutants of health concern, such as NO_x, CO, SO_2 and PM.

However, the emitted pollutants dispersión path from these industrial sources and local ambient air quality data were not available. But complain from irritation skin, cough, bad odor and nausea was suffered by 100% of KSW inhabitant. The location of KSW being upon hill, just across the industrial site for emitting gaseous pollutants, which cause them to suffer the mentioned symptoms. It happened for the second time, before study was done to evaluate relationship of air pollutants and these health effects.

In this paper, we present further investigation of the possible relationship of the health effects suffered by KSW inhabitants with air quality exposure from the industrial sources. The main objective of the study was to relate and estimate the environmental exposure to health outcome and the health risks of air pollutants exposure. This study expected to give important contribution in air quality management, in particular, contributing evidence regarding to the associations the health effects of air pollution. Furthermore, as a learning tool for the communities to improve their awareness regarding to potential harmful of ambient air pollution.

METHODS

Area of Study

Cilegon is located in Banten province, Western Java, Indonesia. It comprises of coastal-low land area stretch from East to West with average height around 0 – 50 meter above sea level and slightly rising around 50 meter to the South. Daily temperature is about 31.4 °C and 25.4 °C at night time. The climate is wet tropical with average daily rainfall of 1000-15000 mm, 78% humidity, and average wind speed range to 3.7 m/sec until 4.8 m/sec.

Figure 1. Banten province site map

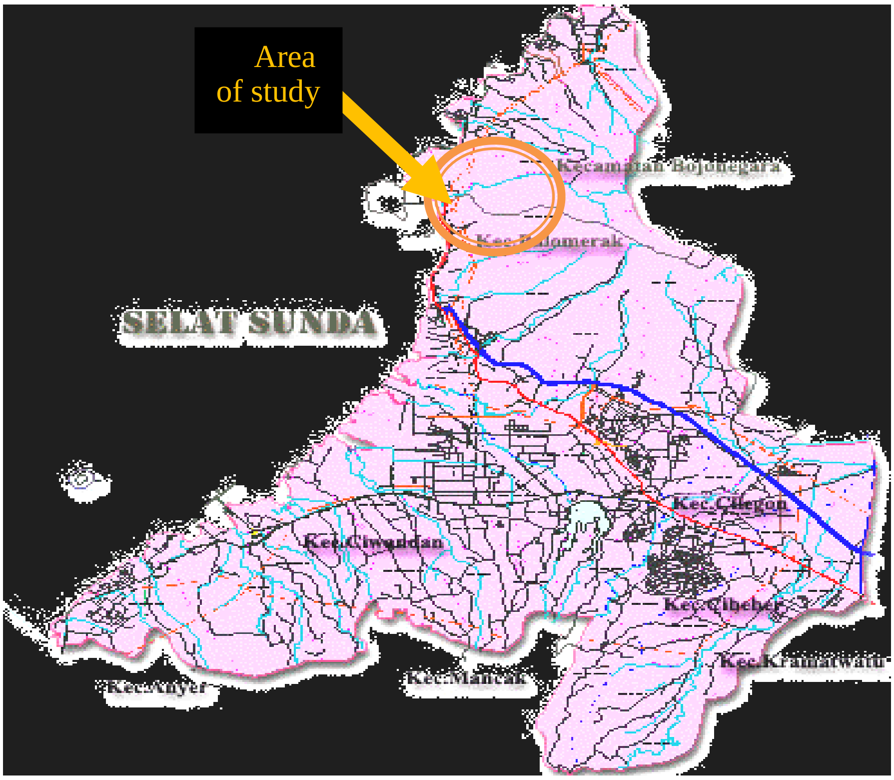

Figure 2. Area of study

Health Risk Assessment

To investigate the possible relationship of health effects with ambient air exposure, the epidemiology design strategy was observational study which observed exposure status in subject without assignment. The research was conducted with retrospective data and without following individual subjects for change in disease status. The basic observational design was Case-Control Study to identify factors that may contribute to a medical condition by comparing subjects who have that condition (the 'cases') with patients who do not have the condition but are otherwise similar (the 'controls').

Table 1. Matrix 2-by-2 of Case-Control Study

Variables	Case	Control
Exposed Factor	a	b
Unexposed Factor	c	d

Source : Soemirat, 2005

In case – control study, there were two comparable groups which have similar social-economic level. As a result, there would be data that is summarized in contingency matrix 2-by-2 as illustrated in Table 1. The comparable groups consist of exposed group (defined as the cases) and unexposed group (defined as the controls).

The cases were residential neighborhoods adjacent to the industrial site resided in Gerem Districts, to be precise, the cases were KSW inhabitants with total population 929 inhabitants, who complained skin irritation, cough, bad odor and nausea. The controls were KC inhabitants, were the neighborhoods of KSW with total population 272 inhabitants and still part of Gerem Districts.

The data was obtained from questionnaire and interviewed face to face. The questionnaire collected data on education level, sanitation facilities, variables related to socio-economic status and history of health.

$$n = \frac{N}{(1 + N(e^2))}$$

Where :
N= Population number
n = Samples number
e = 1 - Confidence Interval

Quantification of exposure – disease relationships from this case-control study was used Odds Ratio (OR). The OR is a relative measure of risk, defined how much more likely it is that someone who is exposed to the factor under study will develop the outcome as compared to someone who is not exposed. It was estimated indirectly by comparing disease frequency for the exposed population and unexposed population.

Mathematical equation for calculating OR :

$$OR = \frac{a_1 \times b_2}{a_2 \times b_1}$$

Air Dispersion Model

There were no data concerning air pollutants concentration in ambient air, as well as the dispersión path of pollutants emitted from these industrial sources. Therefore, modeling air concentration at receptor in a community is a crucial step in assessing potential risk to human health. Gaussian Dispersion Model was used to to predict the dispersión of air emissions from these industrial sources .

Model Description

The Gaussian dispersion model assumes any release from source disperse in a steady-state manner from the time of release until the time it reaches a receptor. It's for describing the mixture of air pollutants in the atmosphere at the vertical and crosswind direction of the source as a result of turbulence. The Gaussian dispersion models calculates the concentration χ at any receptor with the equation as follows :

$$\chi_{(x,y,z;H)} = \frac{Q}{2\,\pi\, u\, \sigma_y\, \sigma_z} \exp\left[-\frac{y^2}{2\,\sigma_y^2}\right]\left\{\exp\left[-\frac{(H-z)^2}{2\,\sigma_z^2}\right] + \exp\left[-\frac{(H+z)^2}{2\,\sigma_z^2}\right]\right\}$$

Where :

x	=	Air pollutants in mass per volume
Q	=	Pollutant emission rate in mass per time
U	=	Wind speed at point of release
σy	=	The standard deviation of the concentration distribution in the crosswind direction , m, at the downwind x
σy	=	The standard deviation of the

concentration distribution in the vertical direction , m, at the downwind x

π = The mathematical constant pi equal to 3,1415926..

H = The effective height of the centerline of the pollutant plume

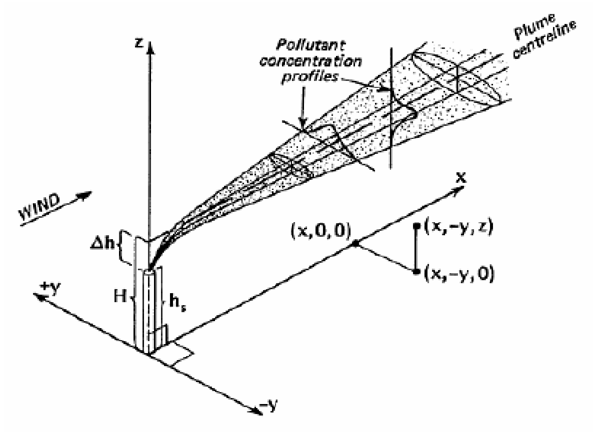

Figure 1. The Gaussian Dispersion Model Illustration (Source : Tuner 1994 in Budisulistiorini, 2007)

Dispersion Modeling Input

1. Location Input

A receptor grid for off-site receptor was set – up using Cartesian grid with a 100 m grid spacing out to distance of 1,5 km from the center of the industrial site. The distance from the stacks to the receptor was ± 1,5 km.

2. Emission Input

The industrial facilities modeled were located in the eastern of Gerem District. The distance between the source and the receptor 1.5 km repectively. The terrain within 1.5 km of site is relatively flat. The stack emission and the meteorology parameter were obtained from the emission monitoring data and evaluated against emission standard. The main parameters that measured from the stack were hydrocarbon as CH_4, CO, NO_2, SO_2, and PM. Table 2 summarizes the source parameter used in the modeling analysis.

3. Meteorological input

The meteorological parameters for The Gaussian Dispersion Model, in particular consists of wind speed, wind directions, temperature, and local atmospheric condition. They were obtained from the Meteorology and Geophysic Agency Kabupaten Serang for six months periode, from July 2002 to December 2002.

The wind direction and speed data were classified according to speed and direction, then summarized in the form of a polar diagram called windrose. It shows the direction from which the wind was blowing, the length of various segments of the spokes show the percent of time the wind was of the designated speed.

Table 2. Source parameter used in modeling

No	Parameter	Unit	Magnitude	Emission Standard
1	HC as CH4	mg/Nm3	18	35
2	CO	mg/Nm3	458	100
3	NO2	mg/Nm3	75	300
4	SO2	mg/Nm3	80	250
5	PM	mg/Nm3	259	50
6	Height	m	40	
7	Stack Diameter	m	1.20	
8	Stack Temperature	°C	217.8	
9	Exit velocity	m/sec	4.7	
10	Pressure	mmHg	75. 979	

Table 3. Frequency distribution of wind speed in July – December 2002

Wind Direction	Wind Speed (m/sec)				Total	Average wind speed
	(1-2)	(3-4)	(5-6)	(7-8)		
N	77	36			113	2.14
NE	1	2			3	2.83
E	10	9	4		23	2.98
SE	5	2		1	8	2.75
S	6	5	1		12	2.67
SW	2				2	1.50
W	12	6			18	2.17
NW	4	1			5	1.9
Calm 0-1 m/sec					184	

Table 4. Percentage distribution of windspeed in July – December 2002

Wind Direction	Wind speed (m/sec)				Total
	(1 - 2)	(3 - 4)	(5 - 6)	(7 - 8)	
N	42	20			62
NE	0.5	1			1.5
E	5	5	2		12
SE	3	1		0.5	4.5
S	3	3	0.5		6.5
SW	1				1
W	7	3			10
NW	2	0.5			2.5
Calm 0-1 m/sec					100

4. Modeling Output

All modeling output was collected in plot files that contained geographical coordinates (i.e., X and Y coordinates) for each receptor, applied in Microsoft Excell. The modeled air concentrations were expressed as µg/m^3. Result of this dispersion model was contour map of concentration distribution of pollutant released from a point source (isopleths).

RESULTS and DISCUSSIONS

Windfield Pattern and Emission Concentration

The modeled wind field (from Tables 3 and 4) represent a typical wind patterns during the July – December 2002 episode, respectively. It can be seen in polar diagram in Figure 4. From the diagram, most often (62 % of time) the wind was from North with average windspeed 2.14 m/sec.

The stack samples were evaluated against emission standards. Concentration of CO and PM were greater than the emission standards. CO concentration was 458 µg/Nm^3, the standard being 100 µg/Nm^3, and factory emitted more PM, 259 µg/Nm^3, as compared to the emission standard of 50 µg/Nm^3.

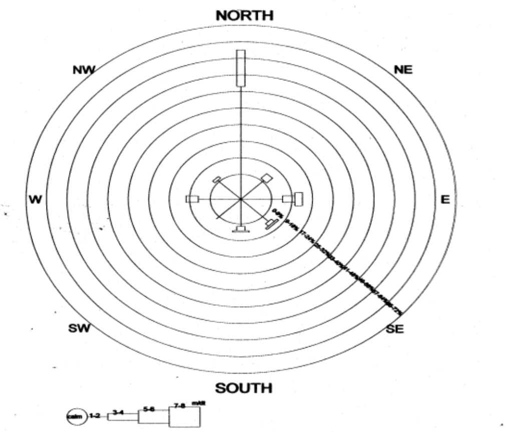

Figure 2. Windrose diagram during July – December 2002

Modeling Results

The input for the dispersion model consists of emission information, meteorological data and receptor information. These input were entries to the dispersion model which was a mathematical simulation of chemistry and physics of atmosphere (Siram, 2006).

Table 5. Predicted concentration of pollutants

Parameter	KSW (µg/Nm3)	KC (µg/Nm3)	Ambient Air Quality Standard
SO2	170.745	58.338	365
NO2	150.158	120.680	150
CO	969.009	395.400	10000
HC	44.230	35.990	160
PM	356.230	331.960	230

Table 5 summarizes the predicted concentration for all pollutants at receptors (KSW and KC). Predicted concentrations for all pollutants both in KSW (1.5 km from the source) and KC (2.0 km from the source) were all below ambient standards, except for PM. These were as expected, since samples were taken in accordance to the factory's permit.

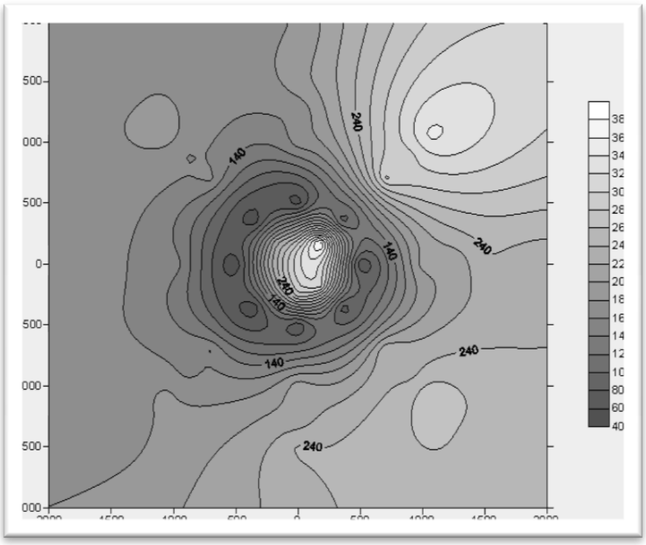

Figure 3. The prediction of particulate dispersion

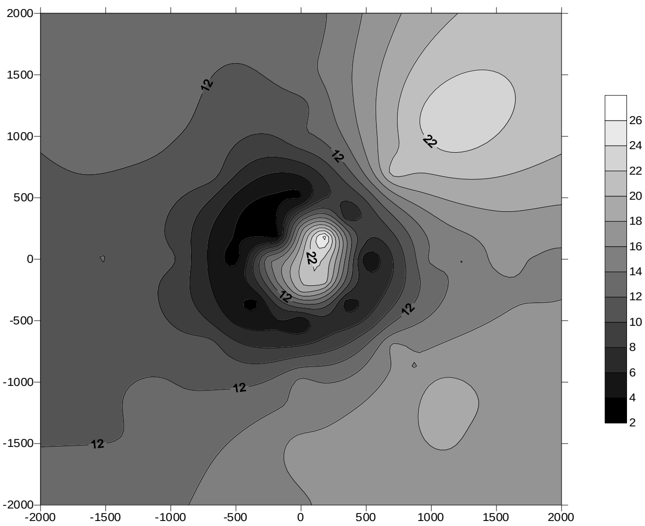

Figure 4. The prediction of hydrocarbon dispersion

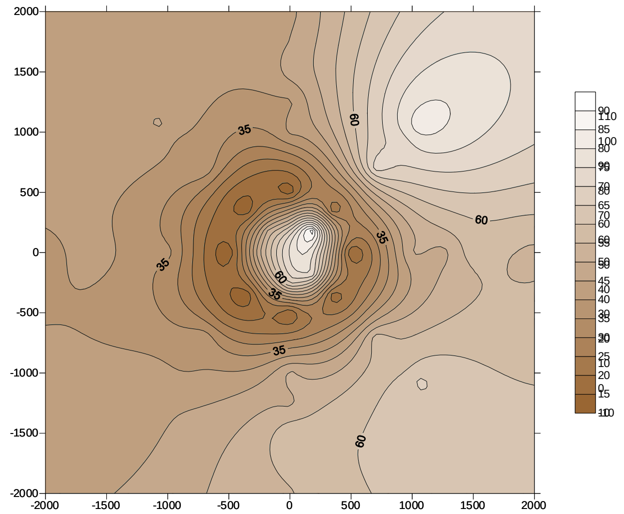

Figure 5. The prediction of NO_2 dispersion

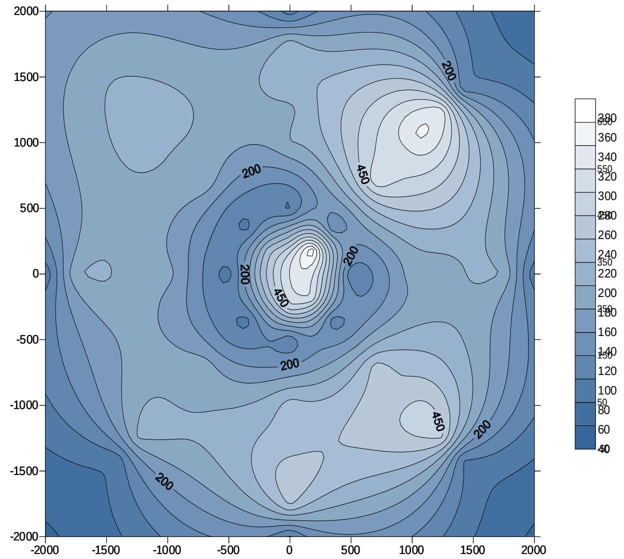

Figure 6 The prediction of CO dispersion

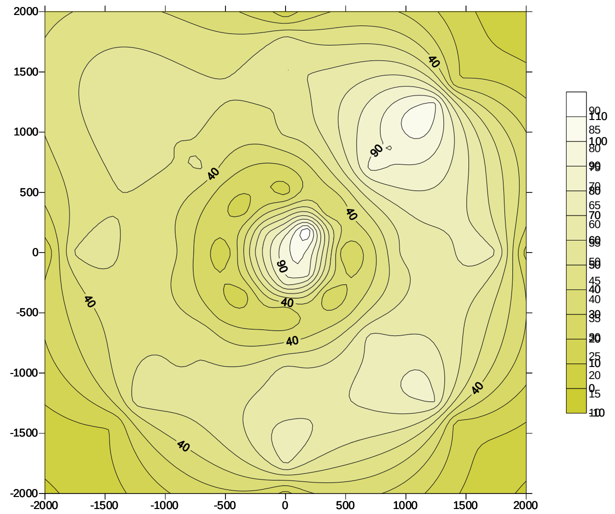

Figure 7 The prediction of SO_2 dispersion

Result of the dispersion model was contour map of concentration distribution of all pollutants released from the point source called isopleths, as shown in Figure 5 to Figure 9. The concentration of pollutant was diminishing as it travels along the terrain. The concentration map was circulating the point source wherein the highest and the lowest concentration are at the centre and the outskirts of the map.

Human Health Risk Assessment

For this study, 72 cases and 62 controls were interviewed. Table 6 shows descriptive characteristics of the cases and controls. From that table, it confirmed that the cases and the controls were similar in terms of social-economic level. Once unpleasent odor appeared, 100% of exposed population were suffering eye irritation, 29% were suffering breathing annoyance, 4% were suffering skin itchiness, 8% were suffering cough. In contrast, 100% unexposed population were not suffering any symptoms except cough for almost 26% of population.

Case-control studies cannot calculate incidences or prevalences. They can however calculate relative risk as OR. Table 7 shows the results of OR, estimated indirectly by comparing disease frequency for the exposed population and unexposed population.

The odds ratio for eye irritation; cough; breathing annoyance; and skin itchiness sequentially were 17712; 3.14; 173.65; and 128.35. The OR interpretation for all symptoms as follows :

1. Eye irritation was 17712 times as frequent in exposed group (KSW) in the source population.
2. Cough was 3.14 times as frequent in exposed group (KSW) in the source population.
3. Breathing annoyance 173.65 times as frequent in exposed group (KSW) in the source population.
4. Skin itchiness 128.35 times as frequent in exposed group (KSW) in the source population.

Table 6. Descriptive analysis of characteristics of controls and cases based on quisionaire and interview

Variables	Cases (total = 72)	Control (total = 62)
Reside time periods :		
0 – 5 year	9	10
6 – 10 year	5	7
11 – 15 year	7	8
>15 year	51	37
Occupation :		
Farmer	26	17
Laborer	22	24
Goverment Officer	5	6
Private Officer	5	4
Trader	4	5
Unoccupied	3	2
Solid waste incineration :		
Yes	22	30
No	50	32
Source of water :		
Groundwater	72	4
Springwater	0	58
Sanitation facilities:		
Yes	48	20
No	24	42
Air comfortness :		
Yes	4	62
No	68	0
Time of unpleasent odor :		
morning	12	0
day time	64	0
afternoon	25	0
night	12	0
Health complaints :		
Eye irritation	72	0
Breathing distubance	21	0
Skin itchiness	3	0
Cough	6	16

Predicted concentration data may provide some insight into the potential health burden associated with air exposure. However, this study was conducted after the symptoms receded. The people at the time of study were healthy and no longer suffer any symptom. But the leaves of coconut trees within the KSW were brown as illustrated in Figure 10. It showed a typical sulfur dioxide poisoning. SO_2 predicted concentration was below ambient standard, meanwhile, PM predicted concentration (356,26 μg/Nm^3 in KSW and 331,99 μg/Nm^3 KC) exceeded the standard (230 μg/Nm^3). There was likely that the health effect suffered by the inhibitants were caused by SO_2 which absorbed in PM.

Table 7. Summary of health risk estimation

Variables	Cases	Controls	OR
Eye irritation :			
Yes	72	0.5	17712
No	0.5	61.5	
Cough :			
Yes	6	16	3.14
No	66	46	
Breathing annoyance :			
Yes	21	0.5	173.65
No	51	61.5	
Skin itchiness :			
Yes	3	0.5	128.35
No	69	61.5	

Figure 8. Coconut trees condition in KSW

Based on windrose, the wind blew to North East only twice in 6 month. So, KSW inhibitants might be exposed in that time and suffered indirect effect as a consequence of pollutants accumulation for certain periods.

CONCLUSIONS

In conclusion, the study confirmed that there was relationship of the health effects with air pollutants exposure from the industrial sources.The KSW inhabitants who were exposed to ambient air pollutants more likely suffered eye irritation; cough; breathing annoyance; and skin itchiness : 17712 times; 3.14 times; 173.65 times; 128.35 times as compared to KC inhibitants who were not exposed.

It was recommended that the factories on one hand, should improve their emissions, and on the other hand, a continuous air pollution monitoring device should be installed to be able to evaluate better the pollutants existing at the time of epidemic. In addition, it was clear that there is need to use more powerful study designs, such as prospective cohort studies, designed specifically for areas with lack of sufficient data.

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DETERMINE NITROGEN DIOXIDE IN JOGJAKARTA USING FREE HANGING FILTERS AS PASSIVE SAMPLERS

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ABSTRACT

This paper describes a new method for the determination of NO_2 applied in large parts of the city of Jogjakarta, Indonesia. The sampler consists of a Free Hanging Filter with a diameter of 2.5 cm, impregnated with triethanolamine, with which NO_2 can be bound. With standard colorimetrical analysis, the amount of NO_2 on the filter is determined. Fritted bubblers filled with Saltzman reagent are used to determine the ambient NO_2 concentration. With a special procedure the absorption efficiencies of the fritted bubblers are determined using ambient air, without the use of standard gases and electronic analytical instruments. The ratio of the amount of NO_2 on the filter and the ambient concentration, the Sampling Volume (SV) is 0.0166 m^3. SV depends on the amount of triethanolamine on the filter, the surface of the filter and the time. The Sampling Rate of the filter (SR) is 4.6 cm^3/s. Hourly averaged measurements are performed for 3 days, 15 hours per day in four busy streets. The measured amounts of NO_2 on the filters varied between 0.57 and 2.02 µg NO_2, at ambient air concentrations of 32 to 141 µg/m^3 NO_2. The wind velocity between 0.2 and 2.0 m/s has no influence on the uptake of NO_2. Neither the humidity between 24 and 83 % nor the temperature between 22^0 and 38^0 C have any influence on the uptake. The method is inexpensive and very well suited for use in low-budget situations and in large areas. Using the free hanging filter method, other compounds such as O_3, NH_3 and SO_2 can be measured as well.

Keywords*: standard colorimetrical analysis, standard gases and electronic analytical instruments*

INTRODUCTION

In a number of publications passive sampling techniques have been described. In this type of samplers the transport of the pollutant takes place in a steady state, where the amount of pollutant taken up by an absorbent is determined by diffusion according to Fick's First Law (Hofschreuder et al., 1999).

Since Palmes c.s. have constructed their well known tube (Palmes et al., 1976), other apparatus constructions were developed such as badge type samplers (Lewis et al., 1985) with draught shields (Orr et al., 1987; Willems and Hofschreuder) and protective shelters (Plaisance et al., 2002) to reduce the influence of wind and atmospheric turbulence (Orr et al., 1987; Willems and Hofschreuder, 1987). However, even with the use of protecting shelters, the influence of meteorological parameters causes uncertainties up to 30%. Necessary calibrations of passive samplers are performed under laboratory conditions with gas standards (Krochmal and Kalina, 1997). New constructions of passive samplers, with sampling rates of about 1 cm^3/s are reported (Piechocki-Minguy et al., 2003) as well. A typical problem is the influence of the wind velocity on the sampling rate of the described passive samplers (Hofschreuder et al., 1999; Piechocki-Minguy et al., 2003; Yanagisawa et al., 1986; Ballesta et al., 1993). However, due to its relatively simple operation, the passive sampling technique, is well suited for the large scale determination of a number of compounds in the ambient atmosphere as NH_3 (Hargreaves and Atkins, 1987), SO_2 (Plaisance et al., 2002; Krochmal and Kalina, 1997), O_3, NO_2 (Palmes et al., 1976) and NO_x (Singer et al., 2004).

In this paper, we present a very simple method to determine the atmospheric NO_2 concentrations, which has pronounced advantages above the existing passive samplers. The technique employs free hanging filters without the use of protective devices over the impregnated filter with a tube or box, like the Palmes-tube or the Willems-badge, (Palmes et al., 1976; Willems and Hofschreuder, 1987).

For this reason the free hanging filters are not based on diffusion. Free filters are easier to operate and cheaper to use. Therefore the free hanging filters are exceedingly suitable in large scale area and in low budget countries. In the following sections we will present a detailed description of the employment of the free hanging filters in the city of Jogjakarta, Indonesia. Furthermore, a novel calibration method is described that avoids the expensive use of calibration standard gases.

PRINCIPLE OF THE FREE HANGING FILTER

The principle of the Free Hanging Filter is based on the direct reaction of the pollutant with an absorbent impregnated on the filter. Whatman GF-A glass fiber filters have proven to be very suitable for this purpose. To measure NO_2, the filter is treated with triethanolamine. NO_2 forms a complex compound with triethanolamine on the filter in a heterogeneous reaction. Due to the direct exposure of the filter to outside air, diffusion plays no role in the uptake process of NO_2.

The amount of NO_2 bound by triethanolamine is therefore directly proportional to the concentration of NO_2 in the ambient air, the amount of triethanolamine in the filter, and the exposure time. The repeatability of the method is dependent on the accuracy of the impregnation.

The sampling volume SV of the filter is defined by m/C. Knowing the SV of the filter unknown ambient concentrations can be calculated based on m, the amount of NO_2 is found on the filter.

DETERMINATION OF THE ABSORPTION EFFICIENCY OF THE FRITTED BUBBLERS

The fritted bubblers, as used in this study, are described in the ISO 6768 (1998). The bubbler of the type C is used. However, the calibration procedure described in ISO 6768 has not been followed. A simpler method is followed instead and has the important advantages that (i) no complicated preparation of standard gas mixtures is required, (ii) no expensive electronic measuring instruments are necessary.

If the absorption efficiency of the fritted bubblers is known, fritted bubblers are well suited to determine ambient air concentrations and thus to calibrate free hanging filters by performing simultaneous measurements with free hanging filters and fritted bubblers.

In these calibration experiments, polluted outside air was led through two fritted bubblers, placed in series. In a second experiment, the order of the bubblers was reversed (See Figures 1 and 2).

In the first experiment, the bubblers are connected in series, as given in Figure 1.

C_1 = concentration of NO_2 in the atmosphere ($\mu g/m^3$)

C_2 = concentration of NO_2 in the outlet of bubbler 1, being the inlet of bubbler 2 ($\mu g/m^3$)

v = velocity of the air intake, volume rate (m^3/s)

t = sampling time (s)

f_1 = absorption efficiency of bubbler 1 (-)

f_2 = absorption efficiency of bubbler 2 (-)

m_1 = absorbed NO_2 in bubbler 1 (μg)

m_2 = absorbed NO_2 in bubbler 2 (μg)

In the second experiment the bubblers are placed in a reversed order as illustrated in Figure 2. The meaning of the symbols in the reversed order is:

C_x = concentration of NO_2 in the atmosphere during the second experiment ($\mu g/m^3$)

C_y = concentration of NO_2 in the outlet of bubbler 2, being the inlet of bubbler 1 ($\mu g/m^3$)

m_x = absorbed NO_2 in bubbler 2 (μg)

m_y = absorbed NO_2 in bubbler 1 (μg)

Figure 1

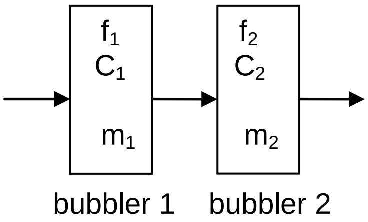
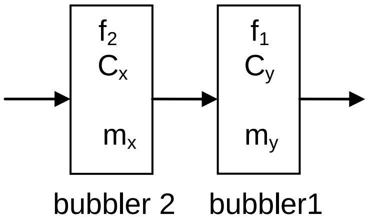


Figure 2



The calculations of the absorption efficiencies (f_1 and f_2) are as follows:
For the first situation, as given in Figure 1, we may write:

$C_1 \times v \times t \times f_1 = m_1$ or $C_1 f_1 = m_1/vt$ (1)
and
$C_2 \times v \times t \times f_2 = m_2$ or $C_2\, f_2 = m_2/vt$ (2)

From $C_2 = C_1\,(1 - f_1)$ and (2) follows:
$C_1\,(1 - f_1)\, f_2 = m_2/vt$ (3)

Combination of (1) and (3) results in:

$f_2 = (m_2/m_1)\,(f_1/(1 - f_1))$ (4)

For the second situation, as given in Figure 2, with the absorption bottles in the reversed order, with respect to Figure 1, a similar formula can be obtained in the same way:
$f_1 = (m_y/m_x)\,(f_2/(1 - f_2))$ (5)

From (4) and (5) the absorption efficiency (f_1) of bubbler 1 can be expressed in the values of absorbed NO_2 found in the bubblers for the two situations:
$f_1 = (m_1/m_2 - m_y/m_x)\, m_2/(m_1 + m_2)$ (6)

Knowing f_1, the value of f_2 can be calculated with (4). Note that this method does not require that the inlet concentrations C_1 and C_x are equal.
The absorption efficiencies of 4 bubblers have been determined in this way. The results are summarized in Table 1.

Table 1. Absorption Efficiencies of fritted bubblers for measuring NO_2 ambient concentration, with Saltzman reagent. Sampling time: 1 hour, intake velocity : 0.6 l/min

	Bubbler 1	Bubbler 2	Bubbler 3	Bubbler 4
	0.83	0.88	0.83	0.87
	0.82	0.84	0.80	0.86
	0.83	0.88	0.83	0.82
	0.82	0.84	0.79	0.81
	0.82	0.82	0.82	0.87
	0.82	0.82	0.81	0.82
Avg.	0.83	0.85	0.81	0.84
Stnd ev	0.005	0.028	0.015	0.026

The variations in the absorption efficiency of the bubblers listed in Table 1 is 3 % or less. The respective values show good similarity.. It should be noted, that the absorption efficiencies of the fritted bubblers depend strongly on the reactivity between NO_2 and the Saltzman reagent in the bubbler. Care should therefore be taken to apply this reagent always in the same concentration.

USE OF FREE HANGING FILTERS AS A PASSIVE METHOD FOR THE DETERMINATION OF NO_2 CONCENTRATIONS IN THE AMBIENT AIR

The extended test of this filter has been performed in four busy streets in Jogjakarta, Indonesia. For this purpose Whatman GF-A filters (glass fiber) were used with a diameter of 2.5 cm. The filters had been impregnated with triethanolamine

The amount of NO_2, expressed in micrograms, found on each filter, was determined by the Balai Laboratorium Kesehatan (BLK), Jogjakarta.

The uptake of NO_2 by the filter can be treated as a heterochemical reaction represented by:

$NO_2 + F \rightarrow$ Adduct (7)

F is the reactive part in the filter consisting of the triethanolamine molecules that are able to form an adduct with NO_2. For practical reasons F is expressed in g NO_2 . The rate of formation of the adduct on the filter is then expressed as:

$dm/dt = A \times F_t \times k \times C$ (8)

where:

m: amount of adduct found in the filter, in μg NO_2.

A: surface impregnated filter on both sides: 9.8×10^{-4} m^2.

F_t: number of available active places per m^2 at time t, expressed as μg NO_2

k: rate constant of the adduct formation, expressed as $m^3/(s.\mu g\ NO_2)$

C: concentration NO_2 in the atmosphere, in μg/m^3

As $dm/dt = - A\ dF/dt$ (9)

Equation (8) may be written as

$dF/dt = - k.C.\ F_t$ (10)

or:

$dF/F_t = - k.C.dt$ (11)

After integration, Equation (11) will be transformed into:

$F_t = F_o\ e^{-k.C.t}$ (12)

where F_o is the number of available active places on the filter after impregnation with triethanolamine at time zero, expressed as μg NO_2 per m^2. Since the amount of NO_2 bound on the filter $m = (F_o - F_t) \times A$, equation (12) may be written as:

$m = A.F_o\ (1 - e^{-k.C.t})$ (13)

However, if $F_o >> m$, F_t may be considered constant and roughly equal to F_o. Under these conditions Equation (8) may be written:

$dm = A.F_o.k.C.dt$

or:

$m = A.F_o.k.C..t$ (14)

With this simplification, a reasonable approximation for the uptake rate constant, k, can be obtained.

RESULTS AND DISCUSSION

The Free Hanging Filters have been tested for three days from 06.00 – 21.00 LT, in four streets in Jogjakarta. Six filters, three on each side of the street, were exposed for one hour. For one day on one side of the street the NO_2 concentrations were also measured with fritted bubblers. The results of the latter measurements are given in Table 2, together with some meteorological variables. From this table it can be seen that the measured amounts of NO_2 on the filter (m) range between 0.57 and 2.02 μg NO_2. The atmospheric NO_2 concentrations (C) range between 32 and 141 μg/m3 NO_2. The relation between m and C is depicted in Figure 4. Table 3 summarizes the obtained sampling volume (SV) of the Free Hanging Filter (SV) defined as $m/C = A.F_o.k.t$ (m^3) (Eq. 14)

The average values from Table 3 are obtained from 15 measurements in each street. In general, the best estimate of the uncertainty in the averages is given by $2.s/\sqrt{n}$, with s the standard deviation, and n the number of experiments. As the overall standard deviation of SV is ± 0.0022 (Table 2), the uncertainty in the overall average of SV becomes ± 0.0006 (with *n* =58, within a confidence interval of 95%). The observed average values of *SV* of the 4 streets are all within the confidence limits for the estimate of *SV* of 0.0166 ±0.0006. Hence it can be concluded that no systematic differences of the value of *SV* between streets exists due e.g. to different geometry of streets and environmental conditions.

Table 3. Sampling volume *SV (m/C, m^3)* of free hanging filters, average of 15 triplicates measured at 30° C in each of the four streets, Jogjakarta, Indonesia, June 2008

Sampling Locations	Avg. Sampling Volume SV (m^3)	Avg. [NO_2] in ambient atm. (μg/m^3)	Avg. amount NO_2 on the filter,m, (μg)
Mataram Street	0.0164	68	1.10
Magelang Street	0.0172	49	0.84
Terban Street	0.0167	59	0.97
Godean Street	0.0163	77	1.23
Average	0.0166		

Figure 4 depicts the relation between m and C. Using linear regression and allowing (0,0) as part of the relation, SV = 0.0160 m^3, with R^2 = 0.76. From Table 2 overall value of SV amounts to 0.0166 with an uncertainty of 0.0006 (3.6 %, 95 % confidence interval). Hence, the value of 0.0160 is not excluded. However, Figure 4 displays two outlying values (88, 2.02) and (141, 1.71). Excluding these two values the SV will be 0.0161, with R^2 = 0.83, within the confidence limits of 0.0006.

From all the 1080 observations (360 triplicates) 10 triplicates were excluded from further calculations because their in between differences were more than 10%. From the remaining 1050 observations (350 triplicates) 96 filter results were also marked as outlier when one value of a triplicate deviated more than 10% of the remaining two. These results of 254 triplicates and 96 duplicates were used for further calculations.

The spreading in the amount of NO_2 in the triplicates is less than 10% for 94 % of the filters. The spreading in the duplicates is less than 10% for 96% of the filters (Figure 3).

The amount of triethanolamine used for the impregnation of each filter is 0.1134 mmole. This amount is equivalent to 5214 μg NO_2, and determines the maximum capacity of one filter with a diameter of 2.5 cm. From this the capacity per m^2 Free Hanging Filter F_o is calculated:

$F_o = 5.31 \times 10^6$ μg NO_2 .m^{-2}.

With this value of F_o , and with Equation (13) the average value of the rate constant, k, of the reaction between NO_2 and the Free Hanging Filter is calculated:

k = 8.9×10^{-10} m^3/(s. μg NO_2)

The standard deviation of k: is s = 1.21 m^3/(s. μg NO_2); the relative standard deviation is 13.6 %, (n= 58). The estimate of the uncertainty in k is 2s/√n yielding 3.6% within a confidence interval of 95%.

With Equation (14) the same value of the rate constant is obtained, because of the condition F >> m has been fulfilled. From the sampling volume, SV, the sampling rate (SR) of the filter can be derived: SV/t = SR = k.F_o.A (m^3/s). For t = 3600 s, the mean value of SR is 4.6 cm^3/s. This value of SR is high compared with reference (Piechocki-Minguy et al., 2003), where a SR of 1 cm^3/s was reported as a high value.

THE BOUNDARY LAYER THICKNESS OF THE FREE HANGING FILTER

According to Ballesta (1993) the boundary layer thickness, d, depends on the size of the flat surface and is a function of the wind velocity according to: d = f ($u^{-0.2}$). Applied to the Free Hanging Filter this should mean a higher uptake of NO_2 by the filter at higher wind velocity. However, according to our observations with the Free Hanging Filters, there is no influence of the wind velocity between 0.2 and 2.0 m/s (Figure 5). If a boundary layer would exist over the filters, a higher uptake should be expected at higher wind velocities. Apparently the reaction rate between NO_2 and triethanolamine on the filter, k, was not influenced by the variations in the meteorological conditions as they were encountered in the Jogjakarta streets. It may be even expected that at higher wind velocities than 2.0 m/s the uptake of NO_2 remains unchanged.

As for the wind speed, no influence of the relative humidity between 24 and 83 % and of the temperature between 22° and 38° is observed on the uptake of NO_2 (Figures 6 and 7). No significant correlation is observed between these variables and the observed uptake of NO_2 by the filter.

CONCLUSIONS

Free Hanging Filters, made from Whatman GF-A filter with a diameter of 2.5 cm, impregnated with triethanolamine, are exceedingly suitable as passive sampler for the determination of nitrogen dioxide in the ambient atmosphere. These filters can be calibrated with ambient air using fritted bubblers, without the use of expensive techniques such as standard gases and electronic analytical instruments. Free Hanging Filters are inexpensive and very well suited for use in low-budget countries and can be applied in large areas.

The amount of nitrogen dioxide collected on the Free Hanging Filters varies linearly with the concentration NO_2 in the ambient air, the amount of triethanolamine on the filter and the exposure time. An analysis of a large amount of samples in four busy streets in Jogjakarta revealed that the spreading within the triplicates and the duplicates is in 95 % of the samples less than 10 %. A low-cost measurement technique as outlined in this paper could help local governments to monitor air quality over long time periods and over large areas.

EXPERIMENTAL

Preparation of the Free Hanging Filters

Whatman GF-A filters (glass fiber) with a diameter of 2.5 cm are used as Free Hanging Filters. These filters are impregnated with a solution of 5 ml (= 5.63 g) triethanolamine (M = 149) in 100 ml acetone. To each filter 0.15 ml of the absorption solution is added in small aliquots equally distributed on the filter surface. After 3 minutes the filter is dry. Then the other side of the filter will be treated with again 0.15 ml in the same way. The total amount of triethanolamine on the filter is 0.1134 mmole, equivalent with 5214 µg NO_2. Equal amounts of triethanolamine have to be applied to each filter in well known quantities. These must be equally distributed on both sides over the filter.

The accuracy of the impregnations determines the repeatability of the filter results. As the measured amount of NO_2 on the filter is also dependent on the amount of triethanolamine on the filter, it would be wise to impregnate the filters always with the same amount triethanolamine. Impregnated filters are stored in closed containers, protected against light and pollution.

Exposure of Free Hanging Filters to The Ambient Air

At the measuring site the filters have to be hanged at about 6 cm under a roof of 12 x 20 cm^2 to protect the filters from rain and sunshine. With a mini pincher the filters are attached to a short line, connected to the roof. Filters are able to move freely in the ambient air without touching each other. After exposure the filters must be disconnected from the pinchers and stored in small plastic containers.

Analysis of the Free Hanging Filters

The exposed filters are treated with 2 ml Saltzman reagent (ISO, 1998) in their containers, if the exposure time is one hour. The containers are closed and kept in the dark for at least 30 min. They are stirred periodically to allow proper dissolution of the NO_2 -complex in the reagent.

Then 1.6 ml, or as much as possible, is dispensed from the container into a centrifuge tube, and centrifuged at about 8000 rpm for 15 min. to remove glass fibers. Next step is to measure the absorbance at 540 nm in a micro optical cell of 1 cm path length (0.8 ml), with demineralised water as reference. The average blank readings are subtracted from the readings of the samples.

Calibration of the Free Hanging Filters with Fritted Bubblers

Atmospheric concentrations of NO_2 are determined with fritted bubblers of type C. These bubblers have to be filled with 10 ml Saltzman reagent. The procedure is performed according to ISO 6768 (1998). The filters are analyzed as described above. The results of the free filters are compared with the results of the bubblers. This delivers the value of the sampling volume (SV) of the Free Hanging Filters (Table 3).

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INTEGRATION METHOD OF DISASTER RISK REDUCTION INTO SPATIAL PLAN: CASE STUDY JOGJAKARTA SPECIAL PROVINCE AND BANTUL REGENCY, INDONESIA

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ABSTRACT

Indonesian government is recently striving to integrate disaster risk reduction into the development plan, including spatial plan.This article is to elaborate the disaster risk reduction integration into spatial plan in Indonesia. Pioneering formulation of risk based spatial plan was Jogjakarta Special Province and Bantul Regency in 2007-2008. Critically, revised regional spatial plan and revised detail spatial plan for 20 years period is not yet fully implemented in the disaster risk reduction element. In the context of disaster risk reduction, spatial plan is an essential mitigation tool to put built environment into safer area. Risk based spatial plan is aimed to the direction of spatial pattern and spatial structure to be in effective, efficient and sustainable manner, in order to reduce potential of being hit by disaster. Prior to that, there is a need to integrate spatial plan with HRV (Hazard, Risk and Vulnerability) model. The research applies inductive logic.Research observed whether latest spatial plan in prone earthquake hazard area such as Bantul, Jogjakarta had integrated disaster risk reduction or not. Afterward, research seeks opportunity of possible integration method to attach HRV Method into spatial plan. Since the distribution of hazard occurrence is unevenly distributed, thus spatial-temporal approach is applied. The exquisite geographic information system (GIS) supports the analysis. The research reveals that HRV Model has been attached in the spatial pattern for regional basis, whilst, in local basis the integration is limited to list of hazard occurrence. It is also found that integration method is not simple; it involves strategic dimension, technical dimension, substantial dimension and procedural dimension. The experience revealed that the integration method in the technical level is quite difficult compare to the strategic integration. While the integration on the substance is prerequisite, afterward, planner may focus on the integration of the procedure dimension.

Keywords: *spatial plan, integration, hazard, vulnerability, risk, disaster, Jogjakarta, Bantul, Indonesia.*

INTRODUCTION

Spatial plan is one of the essential mitigation tools to reduce further disaster impact (Mileti and Galius, 2005). Steven et al. (2009) explain that wise planning avoided people and property from hazard prone area, and at the same time it maintains the natural environment. Pearce (2003) notes that the spatial plan is an inseparable method attached to proactive approach on disaster risk reduction frameworks. Proactive approach aimed at introduction of hazard, vulnerability and risk information to the community at very early stage; therefore, they prepare more knowledge to mitigate disaster events (Pearce, 2003).

Spatial plan is not merely a tool to prevent peoples from worsened situation; it also functioned as a tool to prepare for better situation (Ramroth, Jr., 2009). Moreover, Ramroth, Jr. (2009) argues that planners should consider induction, deduction and abduction logic. The first two logics are quite common in scientific realm, while abduction logic refers to educated guessing based on the past experiences. It means that in concluding the risk based spatial plan, planner should consider *spatio-temporal approach*. As the nature of disaster event is unpredictable, it is assumed that we should learn from the trend of the occurrence. Therefore, the indication of future event is depicted from accumulation of past events. In conclusion, spatial plan requires abundance analytical method, more variables and indicators.

Spatial plan has significant role in disaster mitigation by influencing urban structure and urban pattern which at the end induce urban resilience (Fleischhauer, 2008). Furthermore Fleischhauer (2008) noted that mechanism of the spatial plan is limited, it calls for integrated approach which deals with hazard or disaster analysis. Risk based land use plan will not be effective tool, unless most of the stakeholder actively involved in the implementation, monitoring and evaluation phases (Steven et al., 2009). Active participation may be endorsed by the authority (government in every level) and it involves the community from various level and social groups.

INTEGRATION METHOD OF DISASTER RISK REDUCTION INTO SPATIAL PLAN

Integration of disaster risk reduction into spatial plan was emerging in Indonesia. Integration refers to association or linkage of all aspects or dimension into the destined framework (Wardani and Kodoatie, 2008). The integration is an incessant or progressive process, which should be sustained. Emerging research question is "*how to integrate the disaster risk reduction into spatial plan?*". Preliminary hypothesis conclude that the entry point to integrate disaster risk reduction into development agenda is prominently taking into account on the political system and the decision making process. Spatial plan is an authoritative and legally binding, therefore political system and decision making process is essential in the integration process. This hypothesis was derived from the elaboration of Neo-Marxist tradition, which explained by Hewitt (1983) in Pelling (2003). Hewitt (1983) noted that Neo-Marxist tradition believed that social structure formed the very root cause of disaster, and at the same time allowed public regulation to rule the preparedness and the resource distribution. Moreover, Pelling (2003) in his book explained that there were hidden attribute that might cause vulnerable groups became more vulnerable and hazardous area became more hazardous. The hidden attribute were addresed to the political system. Other similar ideas revealed that succesfull hazard mitigation planning cannot be done solely by particular level of authority, which means it addressed the communicative planning and multi stakeholder involvement (Lorch, 2005 in Stevens et al., 2009). Mileti and Galius (2005) added that mitigation tools did not relied on technical or structural solution, on the other hand, it should embedded within social value to be successfully implemented. These arguments highlighted importance of socio-economic, politic and cultural dimension in seeing disaster. As the spatial planning is non value free document, thus the integration of disaster risk reduction should also attentively attached to socio-economic, political system and decision making process.

As indicated above, each of the integration is initiated by political intervention. The following figure expressed intervention of political system into natural, built in and social environment. The intervention is reflected in dotted line break, since it has no exact shape, it is attached in environment and reflected in every sector of environment. The intervention of political system clearly expressed top down system. Prior to the integration method, political system set up strategic integration to influence fundamental thinking in every layer of environment. Other possible integration set up by political intervention is technical integration (T). Technical integration explained possible method to realize conceptual ideas expressed in strategic integration. Integration of disaster risk reduction into spatial plan impacts so many consequences. An example is delineation of hazard prone area. Government should bear responsibility if there is potential hazard in an area, community had full right to have secure livelihood. Therefore, any information related to hazard, will assure full commitment. It refers to, technic to delineate hazard should be legalized and fully supported by all means. In accordance to that, government, academics, practitioners and community should have similar understanding towards substantial matter to be integrated. Substantial integration (Sb) delineate concept into smaller and rigid concept to be implemented. So that lower layer of environment able to translate concept and ideas. At some point, all of the method of integration will not working without any procedural integration. Procedural integration (P) is formulation of mechanism, technic and operational guidance to make integration feasible. As noted earlier, spatial plan comprises direction of safer environment subjected to development activities. At the same time, spatial plan should provide safer environment from any possible destruction. Analysis to come up with such dualism requires myriad scientific logic, such as induction, deduction and abduction logic. These logics approach spatial plan from past, present and future condition. It means, spatial plan should have not comprise of merely projection about future condition from recent condition, it should also provide consideration of future trend from past and present condition.

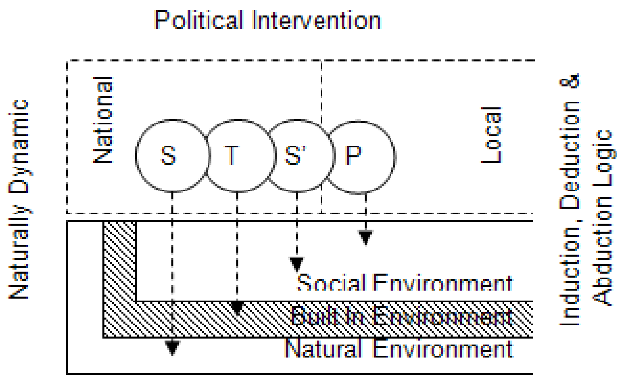

Figure 1. Intervention of political system into dy namic natural, built-in and social environ- ment

As noted above, there are several integration method. Each integration method had different details such as level of authority, aspect to be integrated and product/document. The following table explores details of each integration metho in Indonesia which is simplified into fourfolds. Strategic integration aimed at integrating the vision, mission and other substantial matter into the bigger scope of authoritative document. By confirming the national commitment, this will assure the local level to immediately take actions despite the variety of resources obstacles. Technical guidance is prominent integration issues. Since each area promotes dinamic social, cultural, economic and ecological condition, thus, it has varied method to deal with it. Substantial integration deals with delineation of scope of study. As noted earlier, disaster risk reduction comprises various elements, and it cannot be done by simply added all elements into spatial plan. Spatial plan had its own substance which need to be improved. Therefore, there is a need to delineate scope of disaster risk reduction which is suitable to spatial plan substance. This surely requires schoolars and practitioners to conclude the discussion. Finding of substantial integration will not posited as end result, it will be evolving trhough time. Substantial integration requires many involvement, since delineation towards scope of study need commitment and input from various point of views. Last but not least is operational integration conducted by community level in the form of projects which apply the suggestion from the authoritative technical guidelines document.

Table 1. Type of disaster risk reduction integration into the development plan

Type of Integration	Level of authority	Aspects to be integrated	Document	Example in Indonesia
Strategic	National /Regional Level	Vision; Mission; Goal; Objective Concept	Acts; National Law	Law Nr. 24 Year 2007 Law Nr. 26 Year 2007
Technical	Regional/ Local Level	Methods; Time Table;	Guidelines; Programs	Revised Spatial Plan in Yogyakarta Province;
Substantial	All Level	Scope of studies	Guidelines Programs; Planning document	National Action Plan or Regional Action Plan encana Aksi Nasional/Pr ovinsi)
Operational	Communi ty Level	Aplication	Projects	Community Action Plan in Bantul Area

Source: Desk study, 2009

Strategic Integration

Strategic integration in Indonesia is initiated by publication of Law Nr. 24/2007 on Disaster Management and Law Nr. 26/2006 on Spatial Plan. Law Nr. 24/2007 mandated to all level of government to mainstream disaster risk reduction into development agenda (Article 32a; 35; 42). Specifically, Law Nr. 26/2007 noted that spatial plan formulated for longer term of 20 years period, in between it should be revised once every 5 years, and for particular case such as hazardous area, revision should be carried out annually (Article 23(5)).

Government Regulation Nr. 21/2008 distin-guished activity to tackle disaster in two time-span, such as emergency event (crisis event/per disaster) and non emergency (non crisis event/pre-post disaster). Spatial plan is an integral part of disaster management during non-emergency event. Furthermore, national government stated that disaster management implementation in non-crisis (pre disaster) should covers activity from disaster manage-ment plan; disaster risk reduction; prepared-ness; integration of disaster management into development plan; requirement set up for dis-aster risk analysis; implementation and en-forcement of spatial plan; education and train-ings; and technical standard to cope disaster management (Article 5 (1)). It was clarified in the next article that disaster management plan should cover these following analyses: introduction towards hazard, vulnerability, impact, mitigation strategy, preparedness and awareness, and roles/responsibility towards resources allocation (Article 5 (3)).

Government Regulation Nr. 22/2008 adopted similar time-span scenario for financial management of disaster. Financial management is divided into two categories, first, financial support during non emergency event and second, financial support during emergency event. During non emergency event, funding for disaster management is allocated for facilitation of development plan agenda; disaster risk reduction program; disaster management program; integration of development plan and disaster management plan; disaster risk analysis formulation and facilitation of implementation and enforcement of spatial plan.

As an integral part of Law Nr. 26/2007, national government published Government Regulation Nr. 26/2008 on National Spatial Plan. In Article 7 (section 3g) noted that spatial plan should able to empower risk area to adopt any productive activity that able to increase their mitigation strategy. It means that shall there any risk area, spatial plan allows any management of potential resources in certain level to cope with any possible threats. This argument leads to hypothesis that HVR Method should consider Capacity Analysis.

The following table expressed national strategic plan to mainstream disaster management within development agenda.

Table 2. Strategic plan of disaster risk reduction in Indonesia

Law (Undang-Undang)	Government Regulation (Peraturan Pemerintah)	Focus Attention to Spatial Plan
Law Nr. 24/2007 on Disaster Management	Government Regulation Nr. 21/2008 on Disaster Management Implementation	Article 5 (1) Article 5 (3)
	Government Regulation Nr. 22/2008 on Disaster Management Funding	Article 13
	Government Regulation Nr. 23/2008 on International Agencies Involvement During Disaster Management	-
Law Nr. 26/2007 on Spatial Plan	Government Regulation Nr. 26/2008 on National Spatial Plan	Article 7 (3g)

Source: (Badan Nasional Penanggulangan Bencana (BNPB), 2007; Pusat Pengolahan Data (PUSDATA) Kementrian Pekerjaan Umum Repubilk Indonesia, 2009)

Technical Integration

In technical integration, implementation of HVR Method in Spatial Plan had been argued among several issues. First issue is controversy among aim and objective of spatial plan either “protection or development”. Some questioned, “why integrating these (risk) information, if it only cause more spatial problem and lowering spatial prosperity?“ This argument is logical, since spatial plan is not yet effective tool to direct sustainable development, why would people bother to add more consideration and complexion into it. In opposite some would addressed question of “how spatial plan effective and efficient for future sake without any hazard, vulnerability and risk analysis integration?”. Within this group, the argument noted that each people had right to find safe place to live. Therefore, spatial plan is apparently available to direct people to select safer area. Whilst, moderately some scholar added some question “how spatial plan able to justify which information that benefit to both interest, protection and development?”. These remaining questions had more challenges since spatial plan had not yet been formulated.

Second issue is question on setting of integration. At some point, function of spatial plan is equal to function of HVR Method, both are essential to promote mitigation strategies. Mitigation strategy is designed action for elimination or reduction of hazard probability, analyzed potential loses (vulnerability) and prediction of risk index (Quarantelli, 1986 in Pearce, 2005). Mitigation strategy is not limited to actions at the aftermath of disaster, it should also covered all activities before the event (pre-disaster) or preventive action (Pearce, 2005). Reflected back to initial function of spatial plan which attached not only in disaster occurrence, but at the same time should promote more spatial prosperity. If spatial plan is scrutinized as an effective tool to mitigation strategy, where should HVR Method attached? Whether in spatial structure or spatial pattern or else, it should be separate scenario on spatial structure and spatial pattern.

Third issue is subjective justification on aplication of GIS techniques. Argumentatively, schoolar noted that disaster occurrence is geographically dependant, therefore information system should integrate geo-information system to capture the dynamic image (Xu and Zlatanova, 2007). Although adoption of GIS technique for planning is doubted in mid 1990s, the system kept evolving, provide more tools to analyze the large object into simplified dynamic model (Pettit and Pullar, 2009). During pre-disaster phase, GIS technique provide predictions, while during emergency phase, GIS technique allows planner to conduct rapid assessment, therefore this technique is reliable to assist decision maker to produce decision input. Some would argue that GIS technique had some limitation. Dynamic nature of disaster differentiate characteristics among regions. Whilst, dynamic characteristics requires up date information to tackle precision of occurrence prediction. In addition to that, GIS Technique cannot scrutinize relevant variables and indicators to define dynamic characteristics of hazard, vulnerabilty and risk. As argued, disaster phenomenon is naturally and socially constructed (Blaikie et al., 2005). This expands scope of discussion subject and leaves another task for planner to define variables and indicators of hazard, vulnerability and risk analysis. The argument was emphasized by Clark et al. (1998), who noted that impact of disaster are distributed unevenly throughout nations, regions, communities and individual groups depend on various indicators. Each project applies HVR Method conceives different variables and indicators (Dwyer et al., 2004). Other remaining task for planner is to justify what and how to select variables and indicators to be quantify in spatial manner. In return, HVR Method cannot solely solve problem, it also requires subjective justification to scrutinize unfavorable condition.

Fourth issue is concern on over generalized result due to distinct data input. Spatial approach easily defines unsafe environment via map. Map is collective graphic representation of natural environment, social-economic activities and man-made environment (Pine, 2009). As argued by Pine (2009) that displaying information concern with unfavorable natural condition may provoke social riots, thus it needs excellent means to inform the "*bad news*" into "*positive news*". In order to predict precise projection, planners require abundance of data input. Scholar highlighted that hazard; vulnerability and risk are naturally dynamic process which relied on the update information, and large scale of data (Gobel et al., 2005). Research delineate hazard by natural boundary. In the mean time, supporting social impact originated from secondary data which generally expressed by administrative boundary. Therefore, overlay information generalized or homogenize characteristics between natural and administrative boundary. Over generalization or over homogeneity cause improper prediction which leads to mismatch research result.

HVR Method produce hazard map, vulnerability map and risk map. Generally, in risk based spatial map, planners attached final assessment of risk analysis. The following table revealed distinguished information displayed in each maps (see the following table).

Substantial Integration

According to the Law Nr. 24/1992, substance of spatial plan in Indonesia is twofold. First substance is spatial pattern and the second substance is spatial structure. Spatial pattern divides areas into threefold, namely protected area, productive area and strategic area. Spatial structure focuses on settlement system development plan and infrastructure system development plan. The following figure shows substance of spatial plan in Indonesia according to Law 24/2007 and Law 26/2007. Substantially, risk area is classified as protected area in spatial pattern unit.

As argued, spatial plan is essential to mitigate disaster event by influencing the spatial structure (Fleischhauer, 2008). Fleischhauer (2008) argued that the spatial (urban) structure is understood as threefold:

1. Physical environment of the (urban) environment such as settlement structure, communication network, network of green spaces and other infrastructure system.
2. Socioeconomic structure such as distribution of social groups, distribution of income and degree of economic and social coherence
3. Institutional structure such as hierarchy of institutions, legitimating decision, public trust to the institution, quantity and quality of institution's personnel, degree of responsibility, and degree of cooperation or coordination among institutions.

Apparently, risk analysis is not yet reflected in spatial structure, it is justified in spatial pattern as expressed in figure above.

Critically, there are connecting variables express vulnerability level and spatial structure. Vulnerability analysis applied indicators such as demographic condition, property and built in condition which at the same time indicates spatial structure. From the argument, it is clear that vulnerability analysis is prior substance to be integrated in spatial structure analysis.

Table 3. Identification of map in HRV model

Types of maps	Function	Element	Product
Hazard map	Display the probability of an event causing injury to life or damage to the property and the environment.	Hazard type; Physical characteristic; Magnitude; Frequency;	Delineation of area threaten by particular hazard
Vulnerability map	Display the potential losses in the area threaten by particular hazard.	Vulnerable group; Properties at risk; Infrastructure at risk; Environment at risk;	Delineation of potential losses in particular threatened area
Risk map	Display the probability of the consequence that might occurred due to the potential hazard and potential loses	The likelihood of the occurrence; The severity of the impact to the people, property, infrastructure and environment	Delineation of the hazard likelihood and severity of impact.

Source: (Pine, 2009, pp. 10 - 12)

Procedural Integration

Integration of HVR Method into Spatial Plan requires legalized procedures. The procedure assist stakeholder involved to distinguished their roles, responsibility and contribution. Unclear procedure leads to chaos, conflict and illegitimate decision making process. An example: to produce hazard map, planners need input data. Research argue, which institutional government had legal authority to publish distribution intensity of particular threat? As scholar argued, each hazard comprise different approach, therefore, institution in charge should have authorization to publish related data. If planners took other source of data, then, who would bear the responsibility over it? There are abundance academic overviews on particular hazard. Unfortunately it cannot compensate something when prediction turns to reality. Therefore, it is essential to carefully select source of data to produce hazard map, vulnerability map and risk map. Standard operation procedure is needed to guide planners and decision maker to conduct integration of disaster risk reduction into spatial plan.

Table 4. Variable of vulnerability and spatial structure

Variable of Vulnerability Analysis	Variable of Spatial Structure	Indicator
Demographic condition	Socioeconomic structure	population density, age, family structure, disability, income, occupation, race/ethnicity and lifelines, distribution of social groups, distribution of income and degree of economic and social coherence
Property/Assets Built in condition	Physical environment	Settlement structure, communication network, network of green spaces, infrastructure system, productive land, productive industry, cattle etc.
	Institutional structure	Hierarchy of institutions, legitimating decision, public trust to the institution, quantity and quality of institution's personnel, degree of responsibility, and degree of cooperation or coordination among institutions.

Source: Desk Study, 2010

REFLECTION OF HVR METHOD IMPLEMENTATION IN JOGJAKARTA SPECIAL PROVINCE AND BANTUL REGENCY

Jogjakarta Special Province had carried out implementation of HVR Method into spatial plan, while Bantul Regency not yet formulated it. HVR Method attached in spatial pattern, had less integration with spatial structure. The following sub chapter addresses implementation of HVR Method in both case studies, subjected to earthquake hazard.

Disaster occurrence had spatial pattern. Jogjakarta Special Province consist of four regencies (Bantul, Sleman, Kulonprogo and Gunung Kidul), and one municipality (Jogjakarta). In the case of Jogjakarta Special Province, earthquake pattern is likely threatening Bantul area (see following figure). It is indicated that Bantul Regency suffered utmost from the earthquake threat. Therefore, Bantul Government had been fully supported by various national and international institutions to formulate risk based spatial plan (Bapeda Propinsi Daerah Istimewa Jogjakarta, 2008).

Figure 3 below indicated that distribution of risk is distinguished into three categories, such as high risk (tinggi), medium risk (sedang) and low risk (rendah). High risk area is located nearby fault and riverbanks, such as *kecamatan* Piyungan, Prambanan, Pleret, Jetis, Bambanglipuro and Pundong. Administratively, these *kecamatan* is located in Bantul Regency. Unfortunately, HVR Methods had not yet been implemented in detail scale of spatial plan.

As discussed earlier, HVR Method is concerned with different range of variables and indicators. Research revealed that Jogjakarta Special Province conducted very simple hazard analysis. Following table indicates indicator selected to define earthquake hazard. Planners buffer area alongside fracture/fault which consider as earthquake epicentrum. At the same time, planners buffer area along riverside. At the aftermath of disaster event, government classified area based on its impact of destruction. This added consideration of severity level. Each buffer zone and destruction classification is scored accordingly, the least the score, the higher potential of being threatened by earthquake (see Figure 4).

After delineating hazard area, planner had task to analyze vulnerability level. Vulnerability analysis is a process to identify the potential losses in prone area of hazard. Potential losses can be identified in two categories: material losses, and immaterial losses. Material losses comprises from any asset or community possession either individual or public-owned property. Material losses is easily identified and quantified. Immaterial losses comprises from non material losses, such as trauma, injuries, death or severe illness. Immaterial losses are difficult to be quantified. In vulnerability analysis, there should be identification towards (Clark et al., 1998):

1. Demographic condition (population density, age, family structure, disability, income, occupation, race/ethnicity and lifelines) → addressed as social-economic vulnerability
2. Property (private assets, communal assets such as land use etc) → addressed as economic vulnerability or natural vulnerability for land use losses (Szlafsztein & Sterr, 2007)
3. Built in condition (infrastructure, housing, public service) → addressed as economic vulnerability.

In the case of Jogjakarta Special Province, analysis of vulnerability was using these following criteria (see Table 4). The provincial government tried to identify the demographic and economic condition in the hazard prone area using questionnaire and collective secondary data. While the capacity indicator was collected using ground check and questionnaire.

The vulnerability and capacity analysis in Jogjakarta Special Province was very simple, and hardly explained real vulnerability condition in the hazard prone area. Indicator distribution applied in Jogjakarta Special Province did not explain the potential losses. Only vulnerable groups were identified. People posses properties, privately or communally, and these indicator were not identified clearly. Indicator selection was not adequate to explain the social economic and natural losses. Therefore, vulnerability and capacity analysis for Jogjakarta Special Province should be revised.

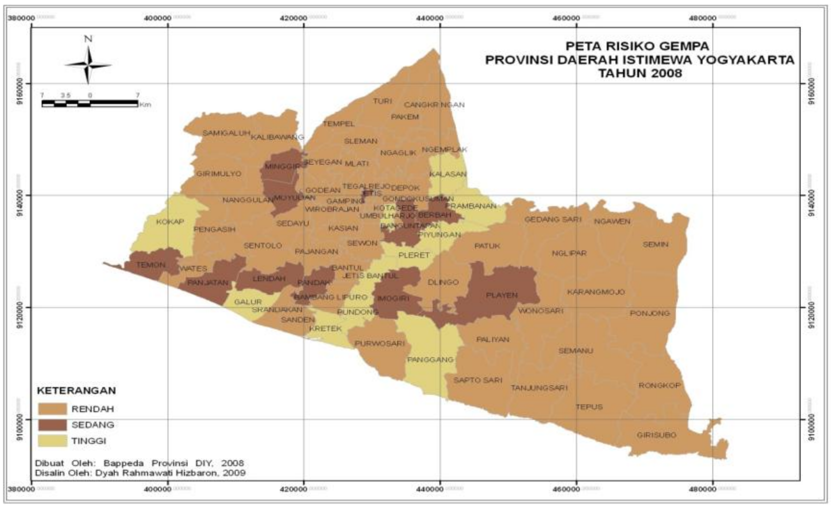

Figure 2 Earthquake hazard map of Jogjakarta Special Province
Source: (Bapeda Propinsi Daerah Istimewa Jogjakarta, 2008)

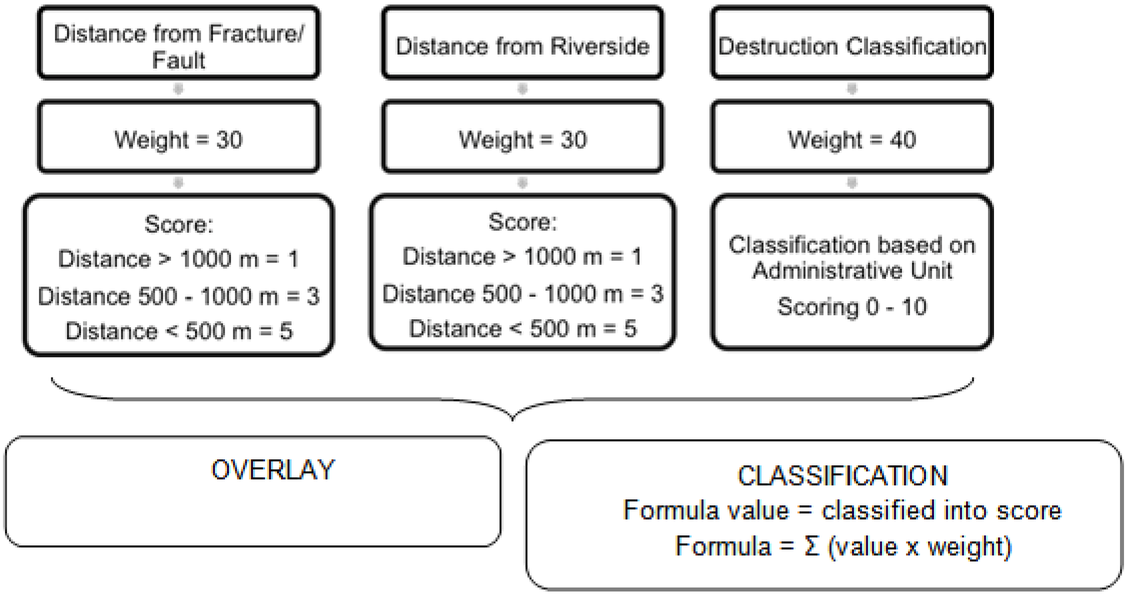

Figure 3. Method of earthquake hazard assessment for Jogjakarta Special Province
Source: (Bapeda Propinsi Daerah Istimewa Jogjakarta, 2008)

Each of the indicators was weighted and scored. Score is unevenly distributed. The formula is as follow:

Weight indicator =
Value of indicator x weight indicator
Total vulnerability value =
Weight A + weight B + ...

Source: (Bapeda Propinsi Daerah Istimewa Jogjakarta, 2008)

Risk analysis in Jogjakarta Special Province was resulted from the following equation.

Vulnerability

The equation is derivate from vulnerability and hazard analysis. Since the vulnerability and capacity analysis was not yet adequate, the result of risk analysis was questioned. At provincial level HRV Map is displayed using scale 1: 100.000, while at local level is 1 : 50.000 (regency) or 1 : 10.000 (municipal level). Different scale distinguished information displayed in each level of government. The bigger the scale, the more detail information shown on the map. Since Jogjakarta Special Province had provide us with small scale information at provincial level, thus, it is a challenge to figure out thorough information at detail level, which should have been presented in revised spatial plan in Bantul Jogjakarta.

Table 5. Vulnerability variable and indicator in Jogjakarta Special Province, 2007

Vulnerability Variable	Vulnerability Indicator	Unit of analysis
Demographic Condition	demographic condition household poor household agriculture household	Kecamatan (Administrative Unit)
Economic Condition	Number of industry Per capita income Household assets (catte, productive agriculture land)	Kecamatan (Administrative Unit)
Capacity Variable	Capacity Indicator	Unit of analysis
Physical	Early warning system Evacuation line Health centre Medicine Telecommunication and information Infrastructure road/airport.port	Kecamatan (Administrative Unit)
Social	Training on disaster Disaster organization	Kecamatan (Administrative Unit)

Source: (Bapeda Propinsi Daerah Istimewa Jogjakarta, 2008)

SUMMARY AND CONCLUSION

This article aimed at analyzing possible integration method of disaster risk reduction to spatial plan. In Indonesia, disaster risk reduction has been integrated in spatial plan from strategic plan. Integration on substance, technical and procedure is not yet fully implemented.

Essential factor to initiate integration is political commitment and strong involvement from various stakeholders. Article revealed that Indonesia will not immediately taken disaster risk reduction into account, without any national mandates to the local level. Jogjakarta Special Province learned that there was no shortcut to integrate disaster risk reduction into spatial plan. Provincial government successfully provided overview information about prone hazard area, by getting full support from various stakeholders in the national and international level. Despite enormous critics, pioneering work in Provincial level had endorsed simplification of complicated concept into technical guidance. The local levels were advised to make detail explanation about the information.

Substantially, integration of disaster risk reduction into spatial should refer on the level of analysis. From Jogjakarta experience, we learned that the entry point of the integration subjected to spatial pattern. In spatial plan document, planners set up spatial pattern in different manner. Example: after delineating risk area for earthquake, which coincidently overlapping with area for productive agriculture sector, decision makers argue "*how to protect the area from further losses*?". Risk zonation is still in debate, it should have more explanation on correlation with other sectors or other spatial pattern which coincidently overlapping. This is political question, at one side, government should deliver information about risk area, but at the same time the government will not agree if productive area is banned from any mutual activities. The regional level is encouraged to find earnest solution to accommodate problem in the local level.

Technically, shortage of knowledge cannot be judged as fundamental reason of simplification of disaster risk reduction integration into spatial plan. Integration method is incessant process, which should be improved at any level. Therefore, this research highlighted that among shortage of knowledge, experience in Jogjakarta and Bantul had shown remarkable social capital in a form of shared knowledge which can result simplification method of disaster risk reduction element.

Simplified quantification of disaster risk reduction is not get along with integration method. This article has shown that the integration of disaster risk reduction into spatial plan is not simple. It should involve strategic dimension, technical dimension, substantial dimension and procedural dimension. All level of government should work together to produce risk based spatial plan. Different level of government came up with different risk based spatial plan. Depth of analysis, scope of analysis and unit of analysis in each level of government were different. Therefore, the integration of disaster risk reduction into spatial plan requires improvement of knowledge and support on the data and information. We can conclude that to produce risk based spatial plan, there is no way to work it out solely, it calls for multi-institutional cooperation and coordination, and at the same time involve merits of expertise. The multi-dimensional approach will be a benefit to communicate the result of the risk based spatial plan.

There are abundant work remains to be solved. First, is question on integration of HRV Method into spatial structure? Second is task to conduct analysis of hazard, vulnerability and risk for Bantul Regency. Third is argumentation on how to connect result of HRV Method into local spatial structure?. This would be an advantage for local and provincial government to pursue mitigation strategy from spatial plan.

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BUILDING BACK BETTER
EXPLORING DISASTER RECOVERY THROUGH A VULNERABILITY AND SUSTAINABLE LIVELIHOODS (VSL) FRAMEWORK

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ABSTRACT

In the context of recovery from disaster events, a newly popularized approach to rehabilitation arose from the astounding international response to the 2004 Indian Ocean tsunami event. This approach, termed 'build back better', builds on vulnerability research and the theory that the post-disaster context offers a window of opportunity for disaster risk reduction and improved re-development. In this sense, the recovery period is seen as a tool for implementing policies and programs designed to remedy the weaknesses in developmental policies, infrastructure and institutional arrangements. Although many governmental and aid organizations have adopted the term 'building back better' to define their reconstruction and recovery activities, defining what building back better encompasses has been difficult and poorly researched. A variety of factors play a role in the perceptions that community members, government agencies and aid organizations have of 'better' and trade-off's exist between the many potential forms of betterment.

This presentation will explore and critique the concept of 'building back better' through an analysis of the difficulties in interpreting the meaning of 'better'. While the recovery efforts in some sectors have focused on building back 'faster', other organizations and stakeholders have argued for an approach that focuses on improving safety, improving the social and economic conditions of the community and increasing resilience to future hazardous events. From this review of various understandings and perceptions of 'better', a framework for exploring and evaluating disaster recovery efforts is presented through the Dimensions of Better model. This model builds on the hazards vulnerability and resilience literature to provide a framework for exploring various components of better and focuses on the long-term security and sustainability of recovery efforts.

Keywords: *recovery, vulnerability, resilience, building back better*

INTRODUCTION

Although natural and human-induced hazards have been a risk for human communities for centuries, the number of disaster events and their associated impacts has been increasing (Abramovitz, 2001; UNDP, 2004). During the ten-year period from 1992 – 2001, the losses associated with natural disasters averaged US$65 billion per year, which represents a seven-fold increase since the 1960's (Freeman, Keen, & Mani, 2003). Munich RE estimates that by the year 2050, the costs associated with disaster events could exceed US$300 billion per year (UNISDR, 2002). Within the context of climate change and increased pressure on, and conflict over, natural resources, the number of hazards is expected to continue to increase (Abramowitz, 2001; Bogardi et al., 2005).

In many countries, particularly less developed ones, governance capacity and hazard prevention measures are either not in place, or are unable to handle the hazard that occurs. In these instances, when a disaster event does occur, relief and recovery operations begin, often with the stated intention of returning the community to pre-disaster norms.

Yet many have acknowledged that returning communities and households to pre-disaster norms leaves them in a position of vulnerability to future hazards (Mileti, 1999; McEntire, 1999; McEntire et al., 2002; Wisner et al., 2004; Birkmann & Fernando, 2008). Recently, researchers, humanitarian and government agencies have recognized the importance of reducing vulnerability to future disaster events as well as incorporating preparedness and mitigation initiatives as part of the post-disaster recovery process.

The following paper outlines the recovery strategy of building back better, followed by an overview of three concepts that could be integrated to provide a conceptual framework for understanding 'better', namely vulnerability, resilience and sustainable livelihoods. The ulnerability and sustainable livelihoods framework is presented, followed by an overview of various dimensions of 'better'.

Building Back Better

The 2004 Indian Ocean tsunami devastated many communities in South East Asia, particularly those in coastal Indonesia, India, Sri Lanka and Thailand. The overwhelming international response to this event led to increased interest in disaster recovery operations, resulting in a newly popularized approach to recovery termed 'build back better' (Lloyd-Jones, 2007; Kennedy et al., 2008). This approach builds on vulnerability research and the theory that a 'window of opportunity' for disaster risk reduction and improved re-development is created during the post-disaster recovery period. During this period, local citizens may have increased awareness of disaster risks and place pressure on government and organizations to use reconstruction funds to remedy the weaknesses in developmental policies, infrastructure and institutional arrangements (Christopolos, 2006; Clinton, 2006; UNISDR, 2005).

Although many government institutions and aid organizations have adopted the term 'building back better' to define their reconstruction and recovery activities, defining what building back better encompasses has been difficult. Alexander (2006) argues the concept must be operationalized under a holistic framework that offers a comprehensive vision of the future. While this comprehensive framework is lacking, there has been a limited attempt to explore different understandings of 'better', particularly through Clinton's (2006) 10 key propositions for building back better, including:

Proposition 1: Governments, donors, and aid agencies must recognize that families and communities drive their own recovery.

Proposition 2: Recovery must promote fairness and equity.

Proposition 3: Governments must enhance preparedness for future disasters.

Proposition 4: Local governments must be empowered to manage recovery efforts, and donors must devote greater resources to strengthening government recovery institutions, especially at the local level.

Proposition 5: Good recovery planning and effective coordination depend on good information.

Proposition 6: The UN, World Bank, and other multilateral agencies must clarify their roles and relationships, especially in addressing the early stage of a recovery process.

Proposition 7: The expanding role of NGOs and the Red Cross/Red Crescent Movement carries greater responsibilities for quality in recovery efforts.

Proposition 8: From the start of recovery operations, governments and aid agencies must create the conditions for entrepreneurs to flourish.

Proposition 9: Beneficiaries deserve the kind of agency partnerships that move beyond rivalry and unhealthy competition.

Proposition 10: Good recovery must leave communities safer by reducing risks and building resilience (Clinton, 2006: 3).

These propositions focus on the role of governments and aid organizations as well as offering strategic approaches to recovery that should help to achieve the goal of 'better'. These propositions also incorporate many of the ideas from the vulnerability and post-disaster recovery literature, including addressing some of the underlying vulnerabilities and inequalities as well as linking recovery efforts to longer-term development initiatives. On the other hand, propositions may create controversy through differing ideologies on development and the strategies used to achieve these goals. For example, proposition 8 focuses on promoting entrepreneurship through a variety of means, including tourism, which may be in conflict with local desires.

In terms of measuring and analyzing the concept of 'build back better', Kennedy et al. (2008) explore the difficulties in interpreting the meaning of 'better'. A variety of factors play a role in the perceptions community members and aid organizations have of 'better' and trade-off's exist between the many potential forms of betterment (Labadie, 2008). During the 2004 Indian Ocean tsunami recovery effort, the practical constraints of funding mandates, timelines and organizational focus on the product as opposed to the process, led to diminished opportunities to 'build back better'. In trying to balance the variety of perceptions, needs and risks in the community, the interpretation in some sectors was to 'build back faster' as opposed to 'build back better' (Kennedy et al., 2008: 28). This led Kennedy et al. (2008) to explore the concept of 'better' as 'safer'. This understanding of 'better' explores how safety to future hazards should comprise the main component of recovery efforts. Unfortunately, this analysis has a tendency to focus on building reconstruction with limited emphasis on providing a holistic and comprehensive understanding of what effective disaster recovery entails for different stakeholders.

More recent approaches explore the role of vulnerability, particularly Birkmann & Fernando (2008) who argue that disaster recovery and reconstruction should incorporate development strategies that are mid-to-long term in nature and "promote disaster-resilient societies by reducing vulnerability" (82). In this conception of 'building back better', the "identification and assessment of 'most vulnerable' areas, groups and infrastructures are essential, particularly after a disaster, to ensure that sustainable recovery takes place, rather than just the rebuilding of structures that proved highly vulnerable" (Birkmann & Fernando, 2008:83; Kennedy et al., 2008).

Reducing Vulnerability

As many scholars have acknowledged the role of vulnerability in creating disaster events, the following section outlines the importance of incorporating a vulnerability approach during the post-disaster recovery period.

Historical approaches to hazards research often viewed vulnerability as synonymous with exposure. In this understanding of vulnerability, the responsibility of society in creating vulnerable populations that have a lowered ability to cope and respond to hazardous events is limited. Cannon (2000) argues that this approach has a tendency towards 'hard science' strategies for mitigating disaster events where there is "an inherent danger that people are perceived as victims rather than being part of socio-economic systems that allocate risk differently to various types of people" (p. 3).

More recent approaches to disaster management and mitigation focus on the social, political and economic processes that create differential levels of vulnerability and capacity. This impacts the ability of individuals, groups and communities to resist, respond and recover from disaster events (Blaikie et al., 1994; Cutter, 1996; Hewitt, 1997; Anderson & Woodrow, 1998; Cannon, 2000).

Although there are different understandings and approaches to conceptualizing vulnerability (see Villagrán, 2006; Birkmann, 2006), more recent approaches in the hazards literature view vulnerability as a pre-existing condition (Cannon, Rowell & Twigg, 2003; Hewitt, 1997). From this perspective, vulnerability can be defined as "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al., 2004:11). This definition provides an understanding of vulnerability that exists before, during and after a disaster event and sees coping capacity and resilience as an inherent part of overall vulnerability. From this perspective, some of the main factors that influence levels of vulnerability include access to various forms of tangible and intangible assets (such as social and material goods), access to knowledge and information, and access to power (Chambers, 1989; Blaikie et al., 1994; Alexander, 2000; Hewitt, 1997).

Anderson & Woodrow (1998) argue that through an exploration of the vulnerability of households and communities, an understanding of why the disaster occurred, the level of impact, as well as why particular groups of people were more or less severely impacted can be reached. Through this approach "it is especially important to recognize this *social* vulnerability as much more than the likelihood of a building to collapse or infrastructure to be damaged. It is crucially about the characteristics of *people*, and the differential impacts on people of damage to physical structures" (Cannon, Twigg, & Rowell, 2003, p. 5). Through this focus on the socially constructed nature of vulnerability, the larger-scale processes that are a reflection of the power relations in a given society are emphasized (Cannon, Twigg, & Rowell, 2003, Hewitt, 1997; Blaikie et al., 1994).

Reducing vulnerability during the post-disaster reconstruction and recovery period has been identified as a key strategy to reduce the likelihood of future disaster events. Evidence has indicated that in some cases, the post-disaster relief and reconstruction activites perpetuated systems of marginalization and vulnerability (see Wisner & Luce, 1993; Mustafa, 2003; Wisner et al., 2004). This indicates the need for an explicit focus on vulnerability reduction during the recovery period to attend to issues of marginalization, lack of social protections and engage in actions to prevent further harm from hazards.

Increasing Resilience

While the previous section focused on how concepts of building back better should reduce vulnerability, the following section explores how recovery efforts can increase resilience to future hazardous events.

Similar to vulnerability, there are somewhat varied definitions for resilience. Resiliency can be defined as the activities and capacities which allow communities and societies to withstand, rebound and bounce back after disaster events (Paton, 2006; Ronan and Johnston, 2005; Foster, 1995). Buckle, Mars & Smale (2000) similarly define resiliency although they argue that these definitions appear somewhat static and fail to "identify that individuals, groups and communities may each possess degrees of resilience which will vary over time and within each of these categories".

While many definitions focus on the ability to quickly return to normal operations, others argue that communities will never return to the pre-disaster state, as a disaster will result in changes to the physical, social and psychological reality of societal life (Paton, 2006; Alesch, 2004). Paton (2006) defines resilience as "a measure of how well people and societies can adapt to a changed reality and capitalize on the new possibilities offered" (Paton, 2006). In this sense, resilience is a measure of the adaptive capacity of individuals, groups and communities.

From these various understandings, Maguire and Hagan (2007) conceptualize resilience along three different dimensions: resistance, recovery and creativity (see also Adger, 2000). *Resistance* relates to the ability to withstand or absorb an external pressure or disturbance before long-term impacts are experienced. The amount of time it takes the community to 'bounce back' to previous levels of functioning is the *recovery* approach to resiliency. While these conceptualizations of resilience are common in the hazards literature, McGuire and Cartwright (2008) argue that the resistance and recovery approaches are deterministic and fail to incorporate the dynamic nature of people and communities. The *creativity* approach to resilience, on the other hand, is related to the idea of increasing the functionality and resiliency of the community after a disaster event. In this sense, creativity is the process of mitigating and "adapting to new circumstances and learning from the disaster experience" to create communities that have achieved greater resiliency and functionality through the recovery process (Maguire & Hagan, 2007:17; Adger, 2000).

The notion of creative resilience leads into the growing body of literature that focuses not only on returning the community to its previous level of functionality, but also as a tool for promoting positive growth (Ronan & Johnston, 2005; Kumpfer, 1999; Paton, 2006; Kulig, 2000). Folke (2006) focuses on the positive aspects of disaster events, viewing them as having the "potential to create opportunity for doing new things, for innovation and for development" (253). Through this approach, a hazardous event can be viewed as a catalyst for transformation and growth in the community (Kumpfer, 1999). This view of resilience "accepts that change is inevitable, rather than seeing change as a 'stressor' from which a community needs to recover its original state" (McGuire and Cartwright, 2008). This conceptualization of resilience effectively links to 'build back better' strategies of recovery whereby communities use disaster events to initiate a move towards more effective mitigation and preparedness programs, as well as increased emphasis on reducing vulnerabilities and building capacities.

To this point, vulnerability and resilience have been discussed separately, although an emerging literature recognizes the complexity and similarities that exists between these two concepts (Adger, 2006). Smit & Wandel (2006) suggest that the concept of vulnerability explicitly incorporates, or is reflective of, the resilience of that system. In this sense, vulnerability is not viewed as separate from resilience, but an inherent part of it. Incorporating resilience into vulnerability concepts is important for several reasons: "it helps assess hazards holistically in coupled human-environment systems; it stresses the ability of a system to deal with a hazard, absorbing the disturbance or adapting to it; and it helps explore policy options for dealing with uncertainty and future change" (Haque and Etkins, 2007; Berkes, 2007).

While researchers have identified that some relationship exists between vulnerability and resilience, there is some discrepancy in defining the nature of this relationship. Some argue that vulnerability and resilience are the positive and negative aspects of a singular concept that can be represented along a continuum (see Berkes, 2007), while others argue that the nature of the relationship is more complex (Doberstein, 2009; McGuire and Cartwright, 2008). As Mayunga

(2007) and Klein et al. (2003) note, defining resilience as the opposite of vulnerability results in circular reasoning and provides limited new knowledge.

This paper presents an understanding of the relationship between resilience and vulnerability along two separate continuums, thereby creating a set of quadrants in which communities experience differential levels of resilience and vulnerability over time (see Figure 1).

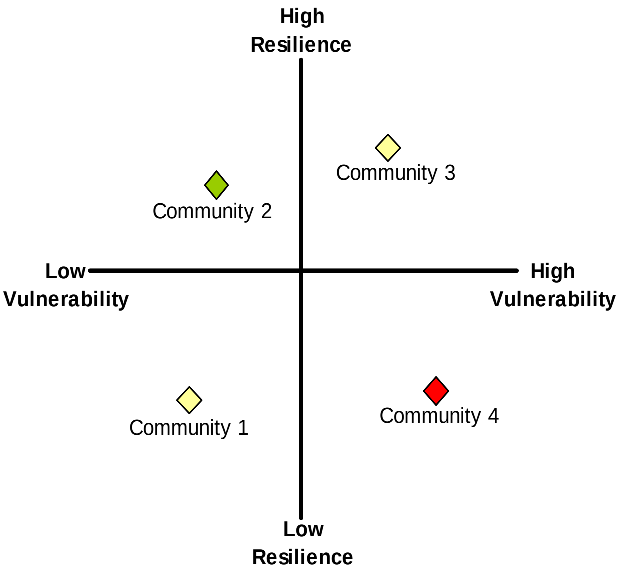

Figure 1. Relationship between vulnerability and resilience

In this model, if all four communities experienced similar exposure to a hazard, community 4 would experience the highest level of impacts and the most difficulty during the recovery period due to high vulnerability and low levels of resilience. On the other hand, community 3, although experiencing high levels of vulnerability, may have less difficulty during the recovery period due to the ability to cope and adapt during the post-disaster period. This indicates the need to incorporate both concepts (vulnerability and resilience) in understandings of building back better in order to provide a full overview of the strengths and weaknesses of individual, group and community capacity to mitigate, prepare, respond, and recover from hazardous events.

Sustainable Livelihoods

Increasingly, concepts of sustainable livelihoods have been acknowledged as an important component of post-disaster recovery operations. The following section outlines the contributions of a sustainable livelihoods approach for effective disaster recovery.

Sustainable livelihoods (SL) is an approach to development that places people, particularly the poor, at the centre of development (Ashley & Carney, 1999). While traditional measures focused on increasing levels of consumption, the SL approach measures development and increases in standards of living as “the ability to save and accumulate, to adapt to changes, to meet contingencies, and to enhance long-term productivity” (Chambers, 1987, p. 15).

Chambers and Conway (1992) provided a definition of sustainable livelihoods that has been widely used and adapted by researchers, government institutions and aid organizations to this day:

> A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

As livelihood activities have an impact on the level of exposure to hazardous events through the location of work and home activities (i.e. fishermen who live by the coast are at a higher risk of being vulnerable to storm surge and tsunami hazards), they should be explored in any analysis of hazard risk and vulnerability. Livelihood activities can also have an impact on the environment leading to increased risk and severity of hazarouds events (i.e. development on hill slopes can increase the risk of landslide events, as well as longer-term processes such as soil erosion; agriculturalists who do not leave appropriate fallow periods between crop seasons can increase the impacts of soil degradation and drought events) (Abramowitz, 2001). These examples provide an indication of the linkages and feedbacks between human interactions with the environment and the environmental impacts on human activities.

Livelihood strategies and activities also impact the level of income and access to resources and assets that individuals and households can utilize in their response to hazardous events. Thus, particular livelihood strategies, and the associated assets they provide will influence the ability to cope and recover from disasters. As many of the key models of vulnerability (see the Pressure and Release and Access models below) see access to and use of resources and assets as a key component of vulnerability, the relationship between vulnerability and livelihoods is important.

By linking vulnerability and sustainable livelihoods, this provides a connection between disaster recovery and preparedness efforts and longer-term development programs (Arnold, 2006; DFID, 1999). In order for development to be sustainable, there is a need to continually address hazards and vulnerability issues. This implies that disaster preparation, mitigation and capacity increasing activities and development programs should be viewed as a similar process (Cannon, 2000; Cannon, Twigg and Rowell, 2003; Arnold, 2006). Through the incorporation of a sustainable livelihoods approach into disaster recovery initiatives, the linkages between these processes are explicitly acknowledged and recognized.

Although SL approaches have been increasingly incorporated into disaster recovery programs, reconstruction and rehabilitation of business and economic activities has been ad hoc in nature and there is a lack of theories and conceptual models guiding reconstruction efforts in this sector (Régnier et al., 2008). Régnier et al. (2008) note that experience in livelihood recovery projects has been somewhat limited and successful efforts are highly localized in nature. In the context of "build back better", this lack of conceptual and theoretical guidance in planning reconstruction activities, particularly in relation to livelihood strategies, presents a challenge. Incorporating an SL framework with vulnerability and resilience concepts provides an opportunity to build conceptual and theoretical guidance for livelihood reconstruction initiatives.

Vulnerability and Sustainable Livelihoods Framework for Recovery Evaluation

Despite the fact that large amounts of money have been spent to rebuild after disaster events, "there is rarely any systematic consideration of whether such lengthy projects actually achieve the goals for which they were implemented" (Labadie, 2008). Researchers and aid organizations alike have increasingly identified the need for a systematic, independent and replicable framework and approach for monitoring, evaluating and measuring the longer-term relief and recovery operations of major disaster events (Brown et al., 2008). By using a framework that incorporates many of the key issues addressed in the vulnerability, resilience and sustainable livelihoods literature, a disaster reconstruction and recovery evaluation process could holistically examine whether aid organizations have effectively "built back better", increased capacity to cope with future events and addressed some of the underlying root causes of vulnerability and marginalization.

For this purpose, vulnerability should be examined within the context of its underlying causes and origins, specifically through the Pressure-and-Release (PAR) model developed by Blaikie et al. (1994) and Wisner et al. (2004). The PAR presents a schematic expression of the complex interactions between the macro-level social processes that create vulnerability and the hazard itself (Blaikie et al., 1994). The model is built on the juxtaposition between these two opposing forces. In this model, 'pressure' builds through increased vulnerability and exposure to hazards, while the 'release' conceptualizes the mitigation activities taken to reduce the impact of the disaster – the reduction of vulnerability (Blaikie et al., 1994). The PAR explicitly focuses on the underlying causes of vulnerability, examining the progression from root causes, through dynamic pressures to their visible manifestation as unsafe conditions.

The PAR model effectively links to the 'Access' model, which focuses on the role of livelihoods and how livelihoods are influenced by both structure and agency. In this model, specific hazards exist within time and space characteristics which may result in a trigger event for a disaster. Concurrently, during normal times, households are subject to both unsafe conditions and political economy structures (social relations and structures of domination) that impact livelihood strategies and the various decisions made over time regarding livelihood opportunities (Wisner et al., 2004). During a disaster, the trigger event breaks through social protections, while the subsequent coping, reconstruction and recovery strategies may or may not attend to issues of vulnerability, lack of social protections and engage in actions to prevent further harm from hazards (Wisner et al., 2004). Together, the PAR and Access models provide a comprehensive analytical link between political and socio-economic models.

Using the PAR and Access models as a framework for exploring disaster recovery efforts provides a conceptual link between vulnerability and sustainable livelihoods (VSL) theories and models. While early work on sustainable livelihoods acknowledged the importance of security in the face of shocks and stresses, more recent work has recognized the value of explicitly linking vulnerability and sustainable livelihoods concepts (see the work of Cannon, Twigg and Rowell, 2003; Lautze and Raven-Roberts, 2006; Pomeroy et al., 2006;

Birkmann and Fernando, 2008; Regnier et al., 2008).

While these two models provide an important connection between vulnerability and SL, further work is required in order to incorporate concepts of resilience. Although some conceptualizations see resilience as an inherent part of vulnerability (see Birkmann & Fernando, 2008; Wisner et al., 2004), the relationship between these concepts needs to be explicitly incorporated into a model in order to effectively conceptualize an understanding of ‘building back better’.

Dimensions of Better

While the above sections have outlined the origins of ‘building back better’ as a disaster recovery framework as well as three conceptual tools for guiding recovery strategies, the following section explores the meaning of ‘better’.

The term ‘better’ implies a condition that is improved, more advantageous, and/or more favourable than a previous state (Merriam-Webster’s, 2009). In the context of disaster recovery in both developing and developed countries, there are many ways in which individuals, groups, communities and stakeholders perceive and define ‘better’. While research focused on ‘building back better’ is limited and further research is required to determine how these various groups conceptualize ‘better’, the concepts discussed above provide guidance in proposing various dimensions of ‘better’ (Régnier et al., 2008).

Table 1 outlines various proposed dimensions of ‘better’ and demonstrates how these concepts are linked to the various literatures discussed throughout this paper. In this table, two distinct approaches for defining dimensions of ‘better’ are identified: a sectoral approach and an ideological approach. Sectoral approaches focus on both the individual level and community (and larger) scales and examine various concrete areas in which improvements could be achieved during the recovery process.

On the other hand, ideological aspects of ‘better’ focus on world views that define and direct the actions and goals of initiatives and interventions in the recovery process. This dual approach provides a method for exploring both the direct programs and initiatives that have taken place during the recovery process, as well as the underlying philosophy’s that are guiding these programs and initiatives.

Table 1. Sectoral and Ideological Dimensions of Better

Dimension		Description
	Access to services	Individual and community access to various services, including health, education and social services
	Infrastructure	A measure of the amount, type, complexity and safety of infrastructure in the community with a focus on equitable access
	Livelihoods	Individual and community sustainability and diversity of economic activities
	Social connections	Individual and community horizontal and vertical networks in both formal and informal settings
	Psychological	Focuses on feelings of belonging, sense of place and empowerment at individual and community scales
	Political capacity	Individual and community capacity to influence decision-making, overall functioning of political entities
	Institutional capacity	Considers the role and strength of local and national institutions, particularly in regards to vulnerability, resilience and disaster management
	Environmental quality	Individual and community access to natural resources, sustainable use of resources and overall human-environment interactions
Ideological	Modernization	Emphasis on traditional development processes whereby 'better' is viewed as increased modernity (i.e. urbanization, industrialization)
	Safety	Focuses on policies and implementation of building codes and safety standards
	Neoliberalism	Better’ is understood as economic growth, obtained through structural reform, deregulation, liberalization, and privatization. The ‘how-to’ of development and recovery processes are shifted from the government and NGOs to market forces
	Human/social development	Focuses on social and community development where 'better' is seen as a multi-dimensional, bottom-up process that relates to economics and broader social, cultural, political and environmental factors
	Vulnerability and sustainable livelihoods	Emphasis on building capacities and reducing vulnerability to future hazards and improving the sustainability of livelihood strategies

In this sense, the sectoral and ideological aspects present two different approaches for exploring concepts of 'better'. While the former focuses on tangible outcomes of 'better', the latter approach examines various perceptions of what 'better' might look like for various stakeholders.

From this framework, at the individual level, the focus is on access to various forms of assets, relating to the conceptualizations of vulnerability proposed by Chambers (1989), Watts & Bohle (1993); Blaikie et al. (1994) and Wisner et al. (2004). At the community and larger scales, the focus is on both the implementation of services (i.e. infrastructure, health, education, disaster preparedness), as well as larger scale processes that impact levels of vulnerability and resilience (i.e. political power, economic processes such as globalization, and social/cultural trends).

From the ideological standpoint, it is clear that there are various perceptions of 'better' and conflicts can arise in the post-disaster context regarding how the recovery effort should proceed (see Geipel, 1982; Barton, 1969; Mileti, 1999). Further research is required in order to identify the various perceptions of 'better' held by different stakeholders as well as how these conflicts are resolved during the recovery process.

CONCLUSIONS

This paper has outlined the three main concepts that should be incorporated into an understanding of what it means to 'build back better'. Although a specific approach has been put forth to provide an understanding of the meaning of 'better' through a vulnerability and sustainable livelihoods framework, it is acknowledged that other understandings of 'better' exist for the various stakeholders involved in the disaster recovery process. For these reasons, further research is required in order to identify the various conceptualizations of 'better' held by the variety of actors in the post-disaster context in order to provide an understanding of how conflicts over these different perceptions are acted out during the recovery period. As well, further research is required in order to adjust the PAR and Access models to explicitly incorporate concepts of resilience.

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REUSE OF DOMESTIC WASTEWATER FOR IRRIGATION
(Special Reference to Jogjakarta Area)

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ABSTRACT

Water crisis is a global problem which has been occurred in some countries and will be followed by others in the coming years. A better management of water use is urgently required to challenge this phenomenon. The use of minor water resources such as rainwater or even dew has been practiced in many areas in the world facing water problem. Included in these efforts is domestic wastewater/sewage reuse to replace water consumption for a particular need, in this case is for agriculture. Agriculture is the biggest water consumer sector in most countries. Hence, the use of wastewater to replace water needs will give significant impact to reduce water consumption. On the other hand, wastewater plays as a substitute of organic manure in agriculture. Although has been recognized for over a century, however, some potential problems were identified hindering its extensive application especially in Indonesia. This paper will explore the potency of the application of domestic wastewater reuse for irrigation in Jogjakarta area. Secondary data were analyzed as a preliminary study for a further and advance exploration of this topic.

Keywords: *sewage farning, Jogjakarta, sewage characteristic*, *ipal sewon*

INTRODUCTION

Natural phenomenon and mismanagement of water resources were the main causes of water crisis occurred in some areas in Indonesia. Water crisis can be measured by water consumption index (WCI). According to this index, the higher the value, the more critical water availability condition in one area. The value between 0,75 – 1 means water crisis. In 2000, water availability in Java, Madura and Bali Islands were categorized to be in very critical condition for their WCI values were above 1 (Sutawan, 2001).

Located in Java Island, Jogjakarta Province is facing the same problem. According to the data issued by Public Works Department in 1991, Jogjakarta is the second lowest after Jakarta in index of water availability percapita. This province have only 2,8 m^3/cap./day or ± 1.022 m^3/cap./year. Pereira (2002) concluded that water crisis occurred when water availability is less than 1.000 m^3/cap./year (Juliani, 2009). Considering the increasing population in this province within the last 20 years which means the increasing water need, it can be assumed that at present Jogjakarta is facing water crisis.

The solution to water problem can be achieved through a better water management by any practices within supply side and demand side measures. At the demand side, water consumption is reduced by avoiding wastage, using a more water efficient processes, etc. While, at supply side measures, the quantity of available water is increased by making best used of all sources of water. Some practical examples are showed in figure 1.

As shown in figure 1. one example of practices to solve water problem is the use of treated wastewater. Raw or treated wastewater can be used to replace water for irrigation. Utilization of wastewater for irrigation could give significant contribution to the reduction of water consumption since agriculture is the biggest water consumer in most countries including Indonesia. According to data from Aquastat, in 1990, from the total of 74,34 km^3 water withdrawal, 69,24 km^3 were used for agriculture. It means that almost 93 % of water consumption was aimed for agriculture sector. The development programmes within the last 20 years leads to the rapid increase of water nees. It is assumed that between 1990 and 2020, the demand will increase about 220 percent. Meanwhile, more than 50 percent of all irrigation water is consumed in Java (Aquastat, 1999).

The use of wastewater for agriculture has been recognized for over a century. Certain countries have applied this practice extensively. In Israel 67% of total wastewater effluent are used for irrigation, while it is 25 % in India and 24 % in South Africa (Blumenthal, et al, 2000). United States, Germany and England have also applied and developed this practice until today.

The addition of wastewater into the soil for agriculture has been proved to increase soil fertility through its high organic manure content. However application of this practice should consider also the possible health risk arise of sewage exposure to the environment. Standards have been formulated to minimize these possible risks. Somehow, due to differences both in characteristic of wastewater, agricultural practices, soil condition, etc, application of this practice should be initiated with intensive investigation upon affecting factors.

This paper will provide a preliminary study based on secondary data available on how this practice can be applied in Indonesia especially in Jogjakarta area.

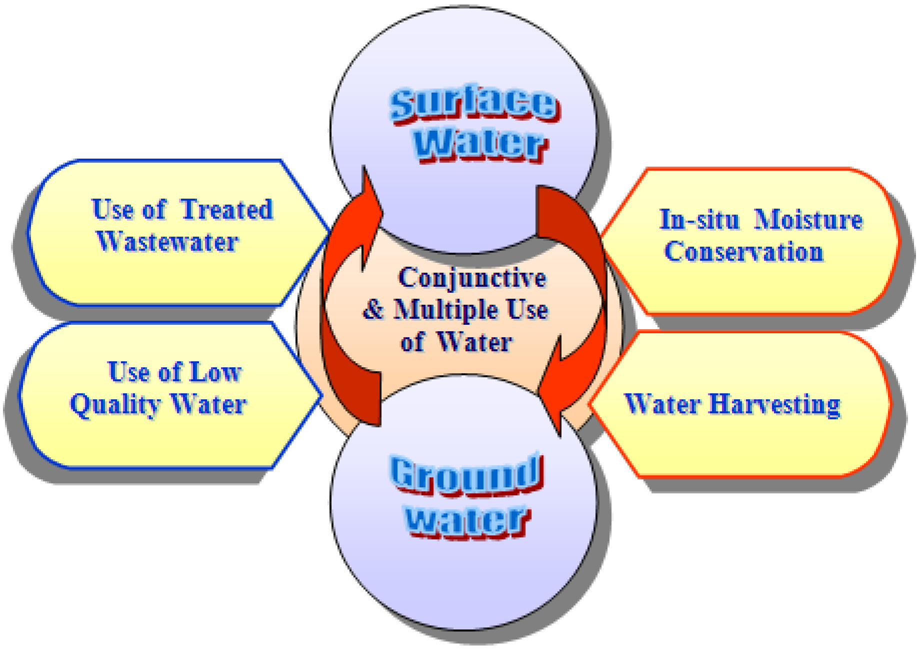

Figure 1 Conjunctive use of surface and groundwater (Prinz, 2005)

CHARACTERISTIC OF SEWAGE

Characteristic of sewage should be taken into consideration before its application fro sewage farming. It may be different from one area to another depends on many factors such as type of diet taken by the population, climate, condition of sewerage system etc. Characteristic of sewage is represented by some parameters such as follows (Weiner et al., 2003):

1. BOD (Biochemical Oxygen Demand) represents the rate of oxygen use. It is not a specific pollutant, but rather a measure of the amount of oxygen required by bacteria and other microorganisms engaged in stabilizing decomposable organic matter over a specified period of time. High BOD value indicates a high organic content easily degraded naturally.
2. COD (Chemical Oxygen Demand) also indicates organic content but of which oxidized chemically instead of biologically. Because nearly all organic compounds are oxidized in COD test, its value represents more than 90 % of organic content in the sample
3. Solids or Total Solids include any material left in a container after the water is removed by evaporation at 105 C. Total solids can be separated into Total Suspended Solids (solids that are retained on a 2 µm filter and Total Dissolved Solids (dissolved and colloidal matrial that passes through the filter.
4. Nitrogen occurs in five major forms: organic nitrogen, ammonia, nitrite, nitrate and dissolved nitrogen gas. While phosphorus oc-

curs almost entirely as organic phosphate and inorganic orthophosphate or polyphosphates.
5. Pathogens refers to a large number of infectious diseases may be transmitted by water. Due to a very large number of pathogenic organisms may be present, an indicatior is used. The most often is the present of *Eschericia coli.*

Heavy metals in significant amount can threathen human health. Some have chararacteristic of bioaccumalting in the food chain. This is why heavy metals concentration should be put into attention even if it is found in very small concentration.

SEWAGE FARMING

At the beginning, the addition of wastewater onto land or soil was the oldest practice used to manage wastewater and control environmental pollution. That is why it is also called land treatment or land application. By definition, land treatment is "the controlled application of partially treated wastewater onto land to achieve treatment and disposal goals in a cost-effective manner" (Crites et al, 2000 in Tzanakakis et al., 2006). It had been practiced by ancient civilizations and developed from time to time. After 1850, sewage farms were expanded in Europe and USA aimed to control pollution and protect public health (Tzanakakis et al., 2000). Due to the development of wastewater treatment technology in the beginning of 19th century, its application were declined but regain attention recently due to its low construction and maintenance costs. This makes it suitable to be applied for communities or decentralized system.

During the last decade, the purpose of land application practice was shifted to be one of efforts of answering the global water crisis problem. The increasing population growth and rapid development of human activities in industry and agriculture put pressure on the already limited water resources. This is worsened by pollution resulted in deterioration of water quality. Reusing wastewater for agriculture is one of main options to reduce the demand for freshwater which can be more allocated for domestic need.

The use of wastewater for irrigation was proved to be advantageous considering the following benefits (Brook, et al., 2001):
1. Higher crop yield (20-25 %) compared to borewell irrigation due to high nutrient load in sewage.
2. Lower fertilizer inputs needed.
3. Available during dry season.

However, the use of wastewater or sewage for irrigation can lead to health and environmental hazard. Some disadvantages were identified:
1. High nutrient load in sewage could also boost the growth of weeds and pests.
2. Increasing growth of weeds and pests means more pesticides application.
3. Soil and groundwater contamination.
4. Odour and mosquito infestations.
5. Source of sewage borne pathogens.
6. Sewage may contain heavy metal which can be the source of serious soil and groundwater contamination If exposed to the environment.
7. Pathogen may enter the food chain through the agriculture product.

Taking these disadvantageous into consideration, guidelines or standards required to remove health and pollution risk from the use of wastewater for irrigation.

AGRICULTURE IN JOGJAKARTA AREA

Based on the data in 2007, majority of population in Jogjakarta depend on agriculture sector to survive their living. It covers 32, 09 % of the total population. They work in agricultural area which covers 70, 43 % of the total Jogjakarta area or approximately 224.398 ha. From this number, 17, 97 % or around 40.324 ha are wetland paddy field. Mostly are irrigated (15, 05 %) and the rest are rainfed paddy field. Water management for these fields are mostly or around 86,1 % served by irrigation system belong to the public works. (BPS DIY, 2008).

The assumption of water consumption based on calculation by Notohadiprawiro (2006) for 1 ha of paddy field is 1,7 l/s. For an estimated planting period of 140 days, amount of water should be available for irrigation in Jogjakarta area per planting period is estimated around 83 million m^3. It means annually, for 2 times planting period, amount of water required is around 166 million m^3.

It is shown in previous simple calculation, how huge the amount of water required to support agricultural activity especially in Jogjakarta area. This huge amount will be a problem in the future since the available water resources are keep decreasing due to the increasing human population and water quality deterioration caused by pollution. The use of wastewater can reduce this amount so that the allocation can be shifted for domestic purposes. The potency is analyzed in the following section.

WASTEWATER FOR IRRIGATION IN JOGJAKARTA AREA

Based on the data in 2007, total population of Jogjakarta Province is 3.434.534 persons (BPS DIY, 2008). Using the assumption of water consumption percapita 120 l/day and wastewater generation is 80% of the average water consumption, domestic domestic wastewater generation in Yoygakarta area is estimated to be 329.715 m^3/day. Comparing this number to the total water required for wetland paddy fields per planting period as calculated in the previous section, wastewater generation is around 46 million m^3/planting period. It means wastewater can cover more than a half of the total water required for irrigation. This number is only an estimation that the generation can be different due to some factors such as season, variation in water consumption and possible losses due to many causes.

However this amount cannot be utilized directly. The use of raw wastewater may lead to environmental and public health hazard as written in the previous section about sewage farming. A study on the effect of untreated wastewater application for irrigation in Eritrea showed heavy contamination of vegetables with pathogenic bacteria and *Giardia lamblia.*

Table 1 Range of bacterial and parasites in wastewater and vegetables in Eritrea case study (Srikanth, et al., 2004)

Sources	Faecal coliform	*Giardia lamblia*
Sewage water used for irrigation	$4x10^4$–$13x10^9$ lt^{-1}	5–10 organisms/field
Vegetables	$2x10^3$–$4x10^6$ kg^{-1}	10–50 cyst/kg
WHO guidelines	1000 lt^{-1}	-

This study shows that 45,3 % farmers were found to be harbouring giardia cyst. The impact of contaminated vegetables also found considerable to the consumers. The complaints of diarrhea and fever is predominant among children and adults and it was much higher compared to other area which were free from the impact of sewage grown vegetables in their diet (Srikanth, et al., 2004).

The prior treatment would solve the problem of potential health and environmental hazard due to sewage application for irrigation. In developed countries, wastewater from households is well managed with a good access to centralized treatment plant through a good sewerage system. In Indonesia the treatment of wastewater is mostly done onsite which means a decentralized system. Sewerage system only covers urban area. Access to wastewater facilities in 2000 is presented in figure 2.

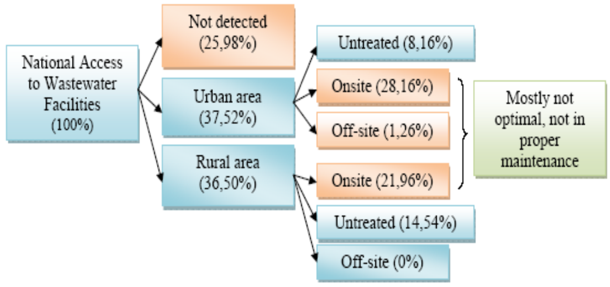

Figure 2 Access coverage of wastewater services in Indonesia in 2000 (Ministry of Public Work, 2005 in Roosmini, et al., 2007)

In Jogjakarta area, sewerage system covers only 6% of total population in 2010 or 96.910 persons and will be developed to be able to serve up to 273.000 persons in 2012 or 59 % of urban area in Jogjakarta. The system is connected to IPAL (wastewater treatment plant) Sewon which is located in Bantul Regency. The treatment capacity of this plant was designed to serve 18.400 persons, but at the moment, it runs only 40% of its capacity or only serves 7.700 persons. The capacity of the plant is 15.500 m^3/day or 179.4 lt/s (Kartamantul, 2006).

According to the data previously presented, if it was assumed that there was no losses during treatment so that the influent and effluent discharge of the treatment plant are the same, the potency of wastewater that can be utilized is 15.500 m^3/day. This amount can cover irrigation need for around 2,6 % of total paddy fields area in Jogjakarta.

To assess the possibility of treated wastewater for irrigation, the effluent quality of IPAL Sewon should be analyzed. Data on the characteristic of wastewater and effluent water of IPAL Sewon are represented in Table 2.

Table 2 Quality of effluent water from IPAL Sewon (Fatimah, et al., 2005)

Parameter	Unit	Analysis
pH		7
Fe	mg/l	0,25
Mn	mg/l	ND
Cu	mg/l	<0,0054
Zn	mg/l	0,0216
Cr^{+6}	mg/l	<0,005
Cd	mg/l	<0,0019
Hg	mg/l	0,0185
Pb	mg/l	<0,005
NH_3	mg/l	0,006
NO_3	mg/l	18,72
NO_2	mg/l	0,2
BOD	mg/l	16
COD	mg/l	40
Total Coliform	per 100 ml	2400
Faecal Coliform	per 100 ml	800

WHO has given a recommendation on wastewater quality for agricultural use. This guideline was aimed to protect the farmers who were directly and intensively in contact with wastewater, the consumers of the product and those living near the areas irrigated with wastewater and also the environment.

WHO only gives standard for faecal coliform (FC) and intestinal nematodes. No FC standard recommended for irrigation of ceral crops. So it is difficult to assess how the effluent quality of IPAL Sewon could be safe to be reused for irrigation. However, US-EPA (United States - Environmental Protection Agency) recommended that the acceptable guideline for irrigation be set at 1000 FC/100 ml (US-EPA, 1973 in Blumenthal, 2000). Using this standard, microbial quality standard of the effluent of IPAL Sewon should be sufficient for irrigation purposes.

Furthermore, USEPA had developed a guideline for agricultural reuse of wastewater which is presented in Table 4. In addition to FC content, other parameter should be considered are BOD and Cl_2 residual. BOD as already explained previously indicates the organic content of wastewater, while Cl_2 residual is related to disinfection process to reduce microbial content especially bacteria.

Table 3 WHO recommendation on microbiological quality for wastewater use in agriculture (WHO, 1989 in Blumenthal, 2001)

Category	Reuse condition	Exposed group	Intestinal nematodes (eggs/litre)	Faecal coliform/ 100 ml	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sport fields, public parks	workers, consumers, public	$\leq$ 1	$\leq$ 1000	a series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees	workers	$\leq$ 1	no standard recommended	retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	none	not applicable	not applicable	pretreatment as required by the irrigation technology, but not less than primary sedimentation

Table 4 US-EPA Guidelines for agricultural reuse of wastewater (US-EPA, 1992 in Blumenthal, 2000)

Types of Reuse	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring
Agricultural Reuse – *Food Crops Not Commercially Processed* Surface or spray irrigation of any food crop, including crops eaten raw	• Secondary[2] • Filtration • Disinfection	• = 10 mg/l BOD • No detectable fecal coli/100ml[3] • 1 mg/l Cl_2 residual (min.)	• BOD - weekly • Coliform - daily • Cl_2 residual - continuous
Agricultural Reuse – *Food Crops Not Commercially Processed* Surface irrigation of Orchards and Vineyards	• Secondary[2] • Disinfection	• = 30 mg/l BOD • = 30 mg/l SS • = 200 fecal coli/100ml[4,5] • 1 mg/l Cl_2 residual (min.)	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous
Agricultural Reuse – *Non Food Crops* Pasture for milking animals; fodder, fiber and seed crops	• Secondary[2] • Disinfection	• = 30 mg/l BOD[7] • = 30 mg/l SS • = 200 fecal coli/100ml[4,5] • 1 mg/l Cl_2 residual (min.)	• BOD - weekly • SS - daily • Coliform - daily • Cl_2 residual - continuous
Urban Reuse All types of landscape irrigation (e.g. golf courses, parks, cemeteries).	• Secondary[2] • Filtration • Disinfection	• =10 mg/l BOD • No detectable fecal coli/100ml[3] • 1 mg/l Cl_2 residual (min.)	• BOD - weekly • Coliform – daily • Cl_2 residual - continuous

Comparing the effluent data with USEPA standard above, using the first type, BOD of effluent of IPAL Sewon exceeds the value. Then following this guidelines, a further treatment process should be applied prior to land application.

Instead of microbial parameter represented by faecal coliform (FC) and BOD, heavy metal content should also be considered. As presented previously, one potential environmental hazard on reusing wastewater for irrigation is heavy metal content in wastewater which may contaminate the soil and groundwater. Indonesia has established regulation on water resources management Government Regulation No. 82/2001. There are 4 classes of water stated in this regulation indicating their quality for certain purposes. Stated here that water bodies categorized as Class II, III, and IV can be used for irrigation. Comparison of the quality of the effluent water of IPAL Sewon and this regulation is presented in Table 5.

Table 5 Quality of Effluent IPAL Sewon compared with Government Regulation No. 82/2001

Parameter	Unit	Analysis	Standard		
			Class II	Class III	Class IV
pH		7	6-9	6-9	5-9
Fe	mg/l	0,25	(-)	(-)	(-)
Mn	mg/l	ND	(-)	(-)	(-)
Cu	mg/l	<0,0054	0,02	0,02	0,2
Zn	mg/l	0,0216	0,05	0,05	2
Cr^{+6}	mg/l	<0,005	0,05	0,05	1
Cd	mg/l	<0,0019	0,01	0,01	0,01
Hg	mg/l	0,0185	0,002	0,002	0,005
Pb	mg/l	<0,005	0,03	0,03	1
NH_3	mg/l	0,006	(-)	(-)	(-)
NO_3	mg/l	18,72	10	20	20
NO_2	mg/l	0,2	0,06	0,06	(-)
BOD	mg/l	16	3	6	12
COD	mg/l	40	25	50	100
Total Coliform	per 100 ml	2400	5000	10000	10000
Faecal Coliform	per 100 ml	800	1000	2000	2000

Referring to this regulation, only NO_2 and BOD parameters exceed government standard. Nitrite is product of aerobic decomposition of organic nitrogen and ammonia. It is relatively unstable and changing easily to be nitrate (NO_3). Effluent showed high concentration of nitrite and nitrate due to oxidation process in the treatment plant.

From the analysis above, a further treatment to reduce organic content (BOD) and nitrite is necessary to meet either government regulation or WHO and US EPA recommendation guidelines. Furthermore, a national guideline specificly regulating the standard for reusing wastewater for irrigation is required considering its great advantages to solve water problem. Studies related to this topic can be used to establish this guideline so that local condition can also be considered and more compatible to Indonesian condition.

Several other parameters should also be taken into consideration to assess the possibility of treated wastewater to be used for irrigation.

- Nematode

A study in Mexico showed a significant occurence of *Ascaris* infection in farm workers and their children in contact with raw wastewater. Partial treatment of wastewater before use has reduced this occurrence to be found only in children. A further treatment to diminish nematode eggs resulted in a very little occurrence of Ascaris infection in any age group. The wastewater was treated by using reservoir performed as retention basin. The quality of the effluent could be improved by adding another reservoir put in series (Blumenthal, et al., 2000).

Another study in UK showed that spray irrigation of lettuce with wastewater contain 50 nematode eggs/l resulted in contamination of around 2,2 eggs/plant at harvest. Improving the quality of wastewater into 10 eggs/l resulted in maximum 1,5 eggs/plant (Blumenthal, et al., 2000).

Some other studies showed that following WHO guideline on nematode content to be maximum 1 egg/l resulted in no or very slight contamination of nematode eggs found in vegetable product during harvest.

- Standard for irrigation

Suggesting wastewater reuse for irrigation should not only taking environmental and public health concern into consideration. Reused wastewater should also be able to support maximum crop production. FAO has given a guideline for required water quality for irrigation and presented in Table 6. However it is only a guidelines and have to be adjusted to condition that prevail in the field. The climatic condition, physical and chemical properties of the soil, the salt tolerance of the crop grown and the management practices should be considered to establish local guidelines.

Table 6 Guidelines for water quality for irrigation (FAO, 1992)

Potential irrigation problem	Units	Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity				
EC_w[1]	dS/m	< 0.7	0.7 - 3.0	> 3.0
or				
TDS	mg/l	< 450	450 - 2000	> 2000
Infiltration				
SAR[2] = 0 - 3 and EC_w		> 0.7	0.7 - 0.2	< 0.2
3-6		> 1.2	1.2 - 0.3	< 0.3
6-12		> 1.9	1.9 - 0.5	< 0.5
12-20		> 2.9	2.9 - 1.3	< 1.3
20-40		> 5.0	5.0 - 2.9	< 2.9
Specific ion toxicity				
Sodium (Na)				
Surface irrigation	SAR	< 3	3 - 9	> 9
Sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl)				
Surface irrigation	me/l	< 4	4 - 10	> 10
Sprinkler irrigation	m^4/l	< 3	> 3	
Boron (B)	mg/l	< 0.7	0.7 - 3.0	> 3.0
Trace Elements (see Table 10)				
Miscellaneous effects				
Nitrogen (NO_3-N)[3]	mg/l	< 5	5 - 30	> 30
Bicarbonate (HCO_3)	me/l	< 1.5	1.5 - 8.5	> 8.5
pH	Normal range 6.5-8			

[1] EC_w means electrical conductivity in deciSiemens per metre at 25°C
[2] SAR means sodium adsorption ratio
[3] NO_3-N means nitrate nitrogen reported in terms of elemental nitrogen

CONCLUSIONS

Some conclusion remarks from the discussion in the previous section are:

1. Domestic wastewater is a potential source to reduce water need for irrigation in Jogjakarta area
2. The effluent of wastewater treatment plant Sewon can be developed to initiate this idea that its quality may not harm the environment and public health.

3. The analysis of the effluent quality showed that BOD still exceeds the available standard and guidelines, so a further organic treatment is necessary.
4. A national guidelines on wastewater quality for irrigation is required to accomodate local condition
5. Some parameters should also considered and regulate in the standard are nematode content in the wastewater and also quality requirement for irrigation water to support maximum crop production.

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STRUVITE SCALE FORMATION AND CONTROL:
A Review

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ABSTRACT

Scale formation is one of the pertinent problems in wastewater treatment and related industries. One of the main components of the scale is frequently struvite or crystals of magnesium ammonium phosphate hexahydrate ($MgNH_4PO_4.6H_2O$). Struvite crystallises along supernatant recirculation piping especially at the elbows and the suction side of pumps. It also occurs in the sludge derived from anaerobic processing of animal and agricultural wastes. Struvite crystallisation and its subsequent deposition on equipment surfaces and piping systems increase the energy required for pumping as well as the cost associated with maintenance and replacement of parts. Thus, the operational and technical problems eventually translate into substantial economic penalties. At the same time, struvite is a sparingly soluble mineral and considered potential as an alternative slow-release fertilizer. Hence, struvite crystallisation has been an extensive area of research. Struvite precipitates as stable white orthorhombic crystals according to the following reaction:
$Mg^{2+} + NH^{+} + H_nPO_4^{n-3} + 6\ H_2O \rightarrow MgNH_4PO_4.6H_2O + nH^{+}$. *Depending on the pH, n may equal 0, 1 or 2. Industrially, scale formation occurs in an environment which is very rarely free from the presence of admixtures. The effects of admixtures on crystallisation kinetics and crystal morphology, hence on scale formation, can be very significant even if the admixtures are present in trace amounts. While research on the effects of admixtures on struvite precipitation has been extensive, the effects are mostly specific that there is no unified theory that applies to all and every situation. This paper presents a comprehensive review on struvite precipitation kinetics focusing on the effects of admixtures on struvite scale formation and control. Results of laboratory work on induction time of struvite crystallisation is also presented and scrutinized.*

Keywords*: crystallisation, phosphorus recovery, struvite, wastewater treatment.*

INTRODUCTION

Scale formation is one of the pertinent problems in wastewater treatment and related industries. It is also prevalent in municipal water applications, treatment facilities of agricultural as well as animal wastes [Mohajit *et al* 1989, Yoshino *et a*l 2003, de-Bashan and Bashan, 2004]. In such facilities the water is usually polluted by phosphates and hence, it prones to phosphates-induced scale formation. One of the main components of the scale is frequently struvite or magnesium ammonium phosphate hexahydrate ($MgNH_4PO_4.6H_2O$) crystals. As a solid layer, the scale may become increasingly thicker during the process and the resulting deposit reduces the capacity of the treatment facilities through restriction of materials flow, corrosion and wearing out of construction materials. Struvite crystallisation and its subsequent deposition on equipment surfaces and piping systems increase the energy required for pumping as well as the cost associated with maintenance and replacement of parts. Thus, operational and technical problems eventually translate into substantial economic penalties.

Research aimed at preventing or controlling struvite scale formation has been extensive and significant advances have been made [de-Bashan and Bashan 2004, Anon. 2004]. However, currently available data have not yet been able to produce a general theory to elucidate all aspects of struvite scaling phenomenon. This paper presents a review on struvite precipitation kinetics focusing on the effects of admixtures on struvite scale formation and control.

The term scale formation or *scaling* is often used interchangeably with fouling (Krause,

1993) although the two terms are not necessarily the same and hence, a clearer definition can be made about them. Scaling is the process of scale deposition on a surface such as the wall of a pipe or other equipment surface (Epstein, 1983). The term "scale" it self means a solid layer and in most cases it consists of crystalline materials (Hasson, 1981, Nulty *et al,* 1991, Forster and Bohnet, 2000). Fouling, on the other hand, refers to any alteration on a surface of equipment due to accumulation of dirt, scale, corrosion products and other substances (Perry and Green, 1997). Fouling is an unwanted phenomenon because it reduces the rate of heat transfer and/or the rate of flow, which ultimately translates into loss of production. Although a variety of measures have been taken to prevent its occurrence, it is still one of the serious problems encountered in industrial operations, particularly those involving process equipment and piping systems.

CLASSIFICATION OF SCALING

Scaling is one of six major categories of fouling (Epstein, 1983, Perry and Green 1997, Bott, 1988). These categories are:

1.Particulate fouling: due to the accumulation

of suspended fine particles (in either a liquid or gaseous stream) onto a surface (Epstein, 1983, Bossan *et al,* 1995, Chamra and Webb, 1994, Grandgeorge *et al,* 1998, Gudmundsson, 1981, Karabelas *et al,* 1997, Masri and Cliffe, 1996).

2. Chemical reaction fouling: fouling due to

the deposition of materials onto a surface caused by chemical reactions, such as auto-oxidation, polymerisation and thermal decomposition (Crittenden, 1998, Watkinson and Wilson, 1997).

3. Corrosion fouling: the deposition of corrosion

products on surfaces of equipment especially heat transfer units (Crittenden, 1998).

4. Biological or bio fouling: fouling of the

surface due to growth and proliferation of micro- or macro-organisms, which are present in the fluid (Huttinger, 1988, Sheikholeslami, 1999, Sheikholeslami, 2000).

5. Crystallisation fouling: due to the

deposition of crystals, which crystallise out of supersaturated solutions, onto equipment surface (Bott, 1988a, Epstein, 1988, Helalizadeh *et al,* 2000).

6. Freezing fouling: fouling due to the

freezing of process fluid, which then coats the heat transfer surface (Perry and Green, 1997).

Briefly, scaling is one major category of fouling. Hasson (1981) refers to scaling as precipitation fouling due to the fact that the scale deposited consists of hard crystalline layers formed through a crystallisation or precipitation process.

MECHANISM OF SCALING

A review on precipitation fouling or scaling given by Hasson (1981) is probably one of the most comprehensive. The review describes the general mechanism of scaling once the supersaturated condition is established. The mechanism proceeds through five steps as explained below.

1. *Nucleation*: the formation of nuclei or active

centres or crystal embryos, which subsequently grow to become crystals.

2. *Diffusion*: the transport of the scale-forming

components such as ionic species, solvated ions, molecules, particulate solids etc. to the solid surface.

3. *Deposition*: due to adsorption or

attachment of the transported materials onto either the crystal surface or the solid surface.

4. *Removal*: detachment or removal of the

deposit layer due to shear stress exerted by the flowing fluid.

5. *Ageing*: changes to the scale

characteristics, caused by recrystallisation, phase transformation, Ostwald ripening, etc., which may either strengthen or weaken the scale deposit.

The five steps of scaling mechanism described above may occur concurrently or consecutively. In addition any two mechanisms may produce a synergistic effect [Hasson *et al,* 1996].

CRYSTALLIZATION OF STRUVITE

Under favorable conditions spontaneous formation of struvite may occur. Several factors are known to affect these conditions, such as level of concentrations of soluble magnesium (Mg^{2+}), ammonium (NH_4^+), and orthophosphate (PO_4^{3-}), level of pH, temperature, and intensity of mixing. The struvite crystallization reaction is as follows (Bouropoulos and Koutsoukos, 2000, Le Corre *et al,* 2005, Rahaman *et al,* 2006, Bhuiyan *et al,* 2008):

$$Mg^{2+} + NH^{+} + H_nPO_4^{n-3} + 6\ H_2O \rightarrow MgNH_4PO_4.6H_2O + nH^{+} \quad (1)$$

Depending on the pH level, ***n*** may equal 0, 1 or 2. Once the concentrations of Mg^{2+}, NH_4^+ and phosphate ions (PO_4^{3-}) exceed the solubility product (Ksp) for struvite the crystallization process of struvite begins. The Ksp is given by the following expression:

$$Ksp = [Mg^{\ 2+}]\ [NH^{4+}]\ [PO_4^{3-}] \quad (2)$$

Since the true value of Ksp is affected by many factors such ionic strength, and thereby difficult to determine, the conditional solubility is generally used [Britton et al, 2005], where the bracket in Eq.2 indicates concentration in moles L^{-1}. The variability of the Ksp for struvite is obviously caused by the presence of known and unknown compounds in the real wastewater, which can be different from place to place. In other words, the Ksp values can be system-specific.

A crystallization process proceeds through two stages: nucleation, followed by crystal growth. These two stages are affected by many factors, and in the case of struvite, molar ratios among the three components: Mg^{2+}, NH_4^+, and PO_4^{3-}, and pH level are the dominant ones. Once the crystals start growing, the scaling mechanism as discussed previously follows.

Struvite crystallization is getting more attention as a promising method to alleviate the unwanted deposits in wastewater treatment plants and related establishments. It is particularly attractive since the struvite crystals produced are a potential alternative of fertilizer [de-Bashan and Bashan, 2004, Wang *et al,* 2005, Anon., 2001a] and thus helps reduce the exploitation of natural phosphates reserves [de-Bashan and Bashan, 2004]. Since struvite contains nitrogen, struvite crystallisation from wastewater can also be applied for nitrogen removal.

Effect of pH

As can be seen from Eq. 1, struvite precipitation depends heavily on pH changes. [Anon., 2001]. However, pH adjustment using chemicals is costly. In general, the values of pH used in the crystallization of struvite are between 8.1 and 9.0 [Anon., 2001]. Other researchers [Wang *et al,* 2005] have reported the use of a wider range of pH from 7.0 to 11. It has been reported that the effect of pH on struvite crystallization was very substantial, that an increase of pH level from 7.0 to 9.0 had caused an increase in the amount of PO_4^{-3} by 250 folds Thus, its effect on the yield of struvite is substantial [Stumm and Morgan, 1970, Perera *et al,* 2007]. If pH was low and less than eight, struvite may crystallize very slowly, i.e. take several days [Battistoni *et al,* 1998]. As reported by Benisch and co-workers [2000] struvite crystallisation is also reversible with regard to pH. As pH decreases the struvite crystals become more soluble and vice versa.

One of the methods to increase these pH values is by degassing, thereby CO_2 dissolved in wastewater is stripped off resulting in the water becomes less acidic [Anon., 2001]. Investigation by Kalyuzhnyi and co-workers [2000] on phosphorus recovery utilizing liquid manure streams shows that phosphates removal is also realized by stripping CO_2 in the effluent streams

Another way of increasing the pH is by adding bases such as NaOH [Jaffer 1999] or $Mg(OH)_2$ [Salutsky *et al,* 1972, Munch and Barr, 2001]. Addition of $Mg(OH)_2$ serves two purposes: increasing the pH level of the crystallising solutions, and adding more Mg^{2+}, i.e. one of the struvite ion components, thus increasing the potential for struvite to crystallize. This method of adding $Mg(OH)_2$, however, is not always desirable since pH and concentration of magnesium ions in the solutions cannot be optimized and controlled independently.

A number of workers [Yamamoto *et al,* 1998, Sugimori *et al,* 1995] preferred using $MgCl_2$ instead of $Mg(OH)_2$ to enhance struvite crystallization since the former dissociates faster, hence the reaction time is shorter. These researchers also added NaOH to increase the pH level. From practical point of view shorter reaction times are more desirable since the size of equipment and its paraphernalia is smaller and can be more economical.

Effect of Temperature

The effect of temperature on crystallisation processes is generally shown in terms of the Arrhenius equation. The equation is written as

$$k = A\exp\left(\frac{-E_a}{RT}\right) \quad (3)$$

or in logaritmic form

$$\ln k = \ln A - \frac{E_a}{RT} \quad (4)$$

where,

k = reaction rate constant, dimensionless

A = Arrhenius parameter

= total number of effective collisions of molecules per unit time

E_a = activation energy, kJ mol^{-1}

R = universal gas constant, 8.31 kJ $mol^{-1}K^{-1}$

T = absolute temperature, K.

Using Arrhenius equation the reaction rate constant, hence the crystallisation rate can be determined. The value of activation energy, Ea, is used to indicate whether the crystallisation process is governed by diffusion or by surface integration. In the former case the Ea value is generally low, while for the later, the value is higher (Ea > 40 kj mol^{-1}) [Muryanto, 2002].

The temperature tested for struvite crystallisation usually ranges from room temperature to about 35^0C, (the range of temperature at which wastewater treatment systems are expected to operate) [Le Corre, 2006] In a crystallisation process, there is usually a lapse of time between the attainment of supersaturation and the detectable changes in the crystallising solution property, signalling the onset of crystal formation. This lapse of time is termed induction time, and is affected, among other parameters, by the temperature of the solution [Amjad, 1985]. As higher temperatures will cause molecules or crystal growth units to “move about” relatively quickly and more randomly, thus the probability of collision among the growth units is greater, it can be assumed that the higher the temperature the shorter the induction time. In the later part of this paper it is discussed that induction time is shorter if temperatures were raised.

Effect of Agitation

Agitation is a common way to enhance crystallisation process. It helps homogenize the crystallising solution which renders the mass transfer proceeds at a faster rate. Heat transfer is also promoted, but since energy requirement for crystallisation is generally minimal, effect of agitation on heat transfer is rarely calculated. A direct relationship exists between the intensity of mixing and the production rate of struvite crystallisation [Yoshino *et al,* 2003]. This is obvious since higher energy of mixing enhances nucleation in a similar manner as the effects of elevated temperatures discussed previously. In certain cases, it causes the emergence of spontaneous nucleation rendering the crystals obtained becoming fines [Bhuiyan *et al,* 2008].

Energy of mixing was also utilized although in an indirect manner. This was carried out by Liu and co-workers [2008] by providing a recirculation loop inside the reactor so that struvite seed crystals (0.12 to 1.2 g L^{-1}) promote secondary nucleation resulting in more struvite being crystallized.

Effect of Impurities

Effects of impurities are dramatic even if these subtances present in minute amounts [Hoang *et al,* 2009]. Common impurities found in struvite crystals are Fe, Al, K and Ca [Britton *et al,* 2005]. It is therefore common to utilize impurities as scale inhibitors. It is believed that the effects of foreign ions on struvite crystallization are not well documented [Le Corre, 2006].

Effect of Calcium Ions

Many researchers have worked on the efects of Ca ions on the crystallisation process of struvite [Le Corre, 2006, Yi *et al,* 2005, Le

Corre *et al,* 2007]. It was reported [Le Corre, 2006] that among the various ions which are found in wastewater sludge, are Ca^{2+} and Zn^{2+}. The presence of calcium ions in the solution, if the amount of these ions is significant, e.g. calcium ions concentrations range from 304 to 480 ppm, the phosphates may react with calcium instead of magnesium [Yi *et al,* 2005]. There can be a competition between Ca and Mg in the reactors. If Ca is eliminated, the struvite precipitation is favoured, and Ca phosphate precipitation is insignificant. In summary precipitation of struvite is interrupted if calcium ions are present, since these ions may precipitate as calcium phosphates [Golubev *et al,* 2001]. Le Corre and co-workers [2005] also reported that the morphology of struvite was also affected by calcium ions. In the presence of (substantial amount of) calcium ions, the struvite crystals obtained were not pure but consisted of another phosphates, i.e. calcium phosphates, morphologically different from that of struvite. As proposed by Wang and co-workers [2005] struvite purity will be highest if the molar ratio between Ca and P in the solution is less than 0.5 and the pH level can be maintained around 8.7.

Effect of Cu and Zn ions

Cu and Zn are usually included in the suplement food especially for pigs, hence these two ions can also be found in the effluent of biogas digester utilizing piggery wastes [Jaffer, 1999]. Among the various ions found in the effluent from dairy industries, Cu and Zn ions were also prevalent [Bragg, 2003]. Previous and current investigations on struvite crystallization with respect to scale formation and control have not adequately considered the influence of such cations.

Studies have shown that phosphorus pollutants originating from both industrial (i.e watercooling systems, oil production, textile processing) and household applications (i.e the use of detergents) such as mono- and polyphosphonates can be removed by several metallic cations: Cu, Zn, Ca and Fe functioning together [de-Bashan and Bashan, 2004]. It was postulated that these phosphonates formed complexes and adsorbed onto the surfaces of the oxides of the metals used [Nowack and Stone, 1999].

Effect of Fe ions

Addition of metallic ions to remove phosphorus from wastewater has been substantially studied. For iron, either $FeCl_2$, $FeCl_3$ [Prasad, 2009] or $FeSO_4$ [Frossard *et al,* 1997] has been used. $FeSO_4$ addition to anaerobic digested sludges resulted in the precipitation of $Fe_3(PO_4)_2 . 8H_2O$ – vivianite, a non-soluble ferrous phosphate.

The establised method for controlling filamentous algae by addition of $FeCl_2$ in ppm amounts, also has the additional benefit, i.e. removing the phosphates [de-Bashan and Bashan, 2004].

It should be stated that the investigation concerning the use of iron for phosphorus removal is not specifically targeted the influence of iron on struvite precipitation and struvite scale control. Instead the focus is on how effective the cations are for removing phosphorus. In almost all cases [Anon., 2001], the iron was used in its chloride salt form, i.e ferric chloride ($FeCl_3$) to act as coagulant for the wastewater sludges. The removal of phosphorus was realized as sludges containing phosphorus. Studies on the effects of Fe as cations interfering with either kinetics of struvite precipitation or struvite morphology is still lacking.

Studies by Britton and co-workers [2005] on struvite precipitation from anaerobic digester supernatant revealed that small quantities of Fe ions (together with Al, K, and Ca) were found in the struvite crystals obtained. It can be assumed that these metallic ions may interfere with struvite crystallisation, affecting nucleation, crystal growth as well as the morphology of struvite. The previous explanation about the effects of impurities indicates that the focus for crystallization of struvite was more on phosphorus recovery than on struvite scaling control. Had the focus been on struvite formation and control, as is evident from other scale components such as gypsum, barium sulphate, and calcium carbonate [Barbier *et al,* 2009, Jones *et al,* 2004, Isopescu *et al,* 2009], it should be possible to extract substantial information of the effect of admixtures on struvite crystallisation. On the positive sides, this condition may encourage more research into struvite scale formation and control with the emphasis on the effects of impurities.

EXPERIMENT ON INDUCTION TIME

An experiment was conducted using a one litre glass beaker agitated at 80 rpm with an impeller. The beaker was placed in a thermostated water bath for three different temperatures: 25, 30, and 35^{0}C. The struvite stock solutions were prepared by dissolving separately $MgCl_2$. $6H_2O$ and $NH_4H_2PO_4$ in double-distilled water. The distilled water was boiled to drive out CO_2 and was then kept in a closed plastic container. The stock solutions were filtered (Millipore™ filter paper) and diluted to a final concentration of 0.003 moles L^{-1} after mixing. Effect of admixtures on induction time was investigated by adding 5 and 10 ppm of Cu ions (diluted from $CuCl_2$ with distilled water) into the magnesium solution. The induction time was investigated by conductivity (Yokogawa SC82) and turbidity (HACH 2100A) measurements at different time intervals. A graph of time versus conductivity and turbidity readings was then plotted.

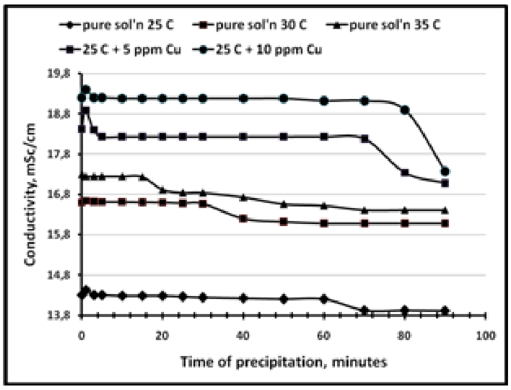

Figure 1 Conductivity vs. time

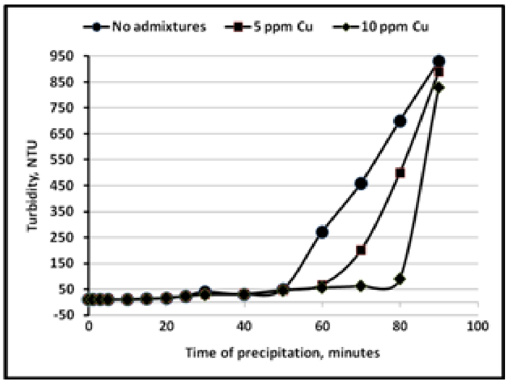

Figure 2 Turbidity vs. time

As can be seen in Fig. 1, the conductivity measurement shows that for pure struvite solution (without impurities) conductivity shortens as temperature increases. It reduces from 60 minutes at 25^{0}C, to about 30 and 15 minutes at 30^0 and 35^{0}C respectively. The sudden reduction in conductivity for the three solution temperatures at 60, 30, and 15 minutes indicates the end of the induction time. Thus, the nucleation, as the first stage of struvite crystallization process, starts in the solutions. Although conductivity is not considered as an accurate measure for determining induction time [Kabdasli *et al,* 2006], it should be sufficient to indicate the approximate time when nucleation is about to start. For struvite crystallization, pH change can be more suitable for the induction time measurement since the crystallization is heavily dependent on pH level.

Fig. 2 also reflects the conditions as shown previously for conductivity measurement. As can be seen, the addition of impurities prolongs the onset of turbidity, i.e. from around 50 minutes for pure solution to 80 minutes when 10 ppm of Cu ions were added. Turbidity of the solution indicates that crystals start forming.

Data as depicted in Figures 1 and 2 suggest that Cu ions in trace amounts could be capable of controlling struvite scale formation, by retarding the onset of nucleation and the subsequent growth of the struvite crystals.

CONCLUSIONS

Scale formation is a common and persistent problem in wastewater treatment facilities of industrial, agricultural as well as animal wastes. One of the main components of the scale is frequently struvite or ($MgNH_4PO_4.6H_2O$).

Prevention of struvite scale formation should take into account many factors, among which supersaturation, pH level, intensity of mixing, and impurities are the dominant ones. It has been shown that trace amounts of metallic ions are potential as the retarding agents for struvite crystallization.

An experiment was conducted to investigate the effect of temperatures and Cu ions on struvite induction time using conductivity and turbidity measurements. The results of the experiment suggest that induction time is significantly reduced at elevated temperatures. For solutions added with minute amounts of Cu ions, turbidity of the solutions, which indicates the start of struvite nucleation, starts longer than that without impurities.

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ANALYSIS OF COASTAL ABRASION AT SOFIFI COAST, NORTH MOLUCCAS PROVINCE

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ABSTRACT

At present almost all areas in Indonesia experience coastal abrasion. This is caused by rapid physical development leads to exploitation of coastal areas. The aim of study isto know coastal geomorphologic at Sofifi coastal area, the potential area with shoreline abrasion and alternative solution to anticipated abrasion. Data was collected through field studies and investigations. Data collected included characteristics of the substrate, dimensions of the beach, current conditions, wave and tidal and public perception. The result showed that several coastal areas have abrasion caused by human activity and natural processes.

Keywords: *coastal abrasion, Sofifi, North Moluccas*

BACKGROUND

The position of Sofifi city as the capital of North Maluku makes it very important and requires priority in policies of both urban structure and infrastructure development and strategies in an effort to fulfil public services. Development process deployed by the Regional Government of North Maluku utilizes coastal area to construct entire urban infrastructures.

Continuous management of coastal area which observes conservational and communal prosperity principles has not been effectively performed. Thus sectoral, exploitative and excessive utilizations have been common phenomenon in some parts of Sofifi coast. The impact starts to emerge, specifically in increasingly pace of environmental damages, including abrasion.

Abrasion potential is not only by infrastructural development, but also the habitude of people of Sofifi and companies which extract sand from the sea also contribute in increasing the abrasion potential in Sofifi coast.

Therefore, the study is intended to recognize the geomorphology formation of Sofifi coast, spotting areas potential of abrasion and to plan a handling system for the coast area that are potential to suffer abrasion

RESEARCH METHODOLOGY

Administrative approach was used un this study, in which the studied area were grouped into three parts; the north region, central region and the south.

Data collected are primary, while secondary ones are physical-chemical and biological environment components. The components will determine the direction of the planning and management of the study area associated with abrasion potential.

Coast's morphology analysis consists of geomorphology (landscape) of the coast and its material and or substrates characteristics and dimension. Hydrodynamic parameters discussed in this study comprise sea current pattern, sea waves, tidal wave, bathymetry and seabed sediments.

Mangrove sampling was performed by using "spot-check" method (English et al, 1994) and data analysis comprise density and frequency. Whereas seagrass sampling was performed by using transect line method by square sampling and analysed with domination index, species variety index.

Socioeconomic data collection is done by using the Rapid Rural Assessment (RRA) approach or the assessment of coastal villages' condition quickly by field observations method used to collect brief information brief village of conditions and social systems of society quickly.

RESULTS AND DISCUSSION

Overview of Study Area

Sofifi is administratively located in the region of Tidore. Tidore is a new autonomous region separated from Central Halmahera district according to the Law no. 1 of 2003. Geographically, the Tidore Islands is located at 0º - 20º North latitude and 127º - 127º 45' East Longitude. This region has an area of 9816.164 km ² of land and sea area of 4,403,956 km ². Thus the whole area is 14,220,020 km ².

Based on topographic data, Sofifi has (0-4%) of flat land, which is about 40% of the total area Sofifi. This allows Sofifi to be developed as the capital of North Maluku province. Sofifi city land usage is dominated by unused land or idle in the amount of 72.55% of the total land and 97.98% of them are still in the status of the right of use.

Climate Condition

The results of calculations for the wet and dry months, climate type in the studied location is averagely 9.18 for wet months and 1.91 for dry months with the index value Q by 20.81%. Thus be classified into climate type B or Wet climate type. Annual maximum air temperature of 31,º and minimum air temperature of 23.5º C with an annual average temperature of 26,6º C.

Sofifi Coastal Geomorphology

a. Coast Line Profile

Coastline measurements throughout the study sites had a 21.2 km of shoreline with inclination range of 4º to 10º and with the measured width for the beach at 7 to 15 m. The angle formed coastal ranges up to 0.2 o to 89.2 o of the shoreline with the sea. Angle shows that may not find the form of headland-resembling coast.

b. Coast-Composing Materials

Granulometric analysis results for 14 locations showed that most of the material characteristics are fine to medium sand. Sorting value of material is relatively high of in percentage of the grain size is relatively not normally distributed, especially in the surface layer. The consequence of such high sorting values is large enough to inform that the particles are unstable or likely separated from their group. Condition of instability of the material particles are more driven by the dynamics of aquatic systems in sorting fluctuant sizes within a relatively short time in a season.

Such short fluctuation causes the material particles tended to be separated from their group and carried by reflected wave towards the south. These conditions supported by the relatively straight angle formed a relatively straight beach in every region. The details for the physical characteristics of the material at the studied location are shown in table 1 below.

Table 1 Characteristics of coast-composing material at the studied coast

Location	Mean X (1 (mm)	Sorting (2 (mm)	Skewness (3 (mm)	Kurtosis (4 (mm)
Kusu	0.83	6.60	0.41	93.51
Northern Kusu	1.74	4.01	0.67	-
Oba	1.05	5.85	0.43	-0.47
Northern Oba	0.95	6.53	0.00	-0.93
South Oba	0.46	6.76	-0.06	-1.16
Estuary S.Oba	0.40	6.79	-0.19	-1.07
Sofifi	0.52	6.97	0.02	-1.16
Northern Sofifi	0.58	7.59	-0.22	-0.96
Southern Balbar	0.77	8.50	-0.03	-1.20
Northern Balbar	0.78	7.27	-0.05	-0.97
Southern Galala	0.47	5.90	-0.03	-1.02
Ferry Pier	0.46	6.35	-0.15	-1.08
Northern Galala	0.64	7.16	-0.18	-0.95
Southern Kayasa	0.67	7.03	-0.18	-0.96

c. Bathymetry Profile

Bathymetry sounding results in studied location was started from Kusu village waters to the waters around Kaiyasa village. The measurement took 11 lines. The bathymetry mapping resulted that the 80m depth contour of the waters found at two separate locations; in front of Sumahode village and the northwest of Oba village. Bathymetry profile of the studied location is showed in figure 1.

However, an 80m steep slope was found at the line III. After the depth the base profile was descending slightly with a relatively steep to the end of the line. In line V inclination of the base up to < 100 m formed a steeper slope compared to the next depth in the same line. The relatively flat inclination in line V found in > 900 m at 80 m depth.

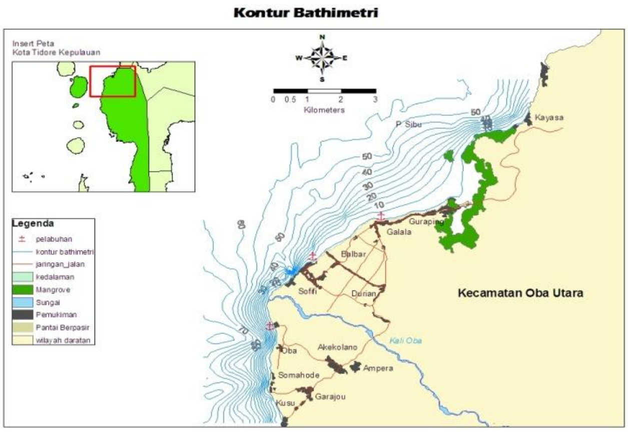

Figure 1 Bathymetry profile of Sofifi

d. Waves

Wave model at the planned or surveyed area quite vary. Such variety is caused by that the waves are generated by two sources. First, the deep water is much influenced by wind. Second, at the coastal area of the region is much influenced by tide. Wave height in the Eastern season is only about 0,7 m to 1,3 m.

In December to March, or the Western season, waves reach 2 meters in height with 1.8 m with 1.8 to 4 seconds of period. Due to seasonal wind changes in every 6 months, the new coast receives waves according to the direction of the wind. Wave direction in eastern season is generally come from the northwest while in western season comes from the west, of which much affected by the impulse of the Moluccan sea.

Calculation results of wind-generated waves in each group area are shown in Table 2 and Table 3. Generally, the two tables explain that in certain area of the west, south and north coast is likely to receive propagations, the amounts of such propagations depend on the developing season. Collectively, with average generating wind, the waves generated would reach the height range of 0.7 to 3.6 m. Such wave height is averagely broken on the depth of 1 to 3 meter. The breaking depth and location on which the waves broken depend on the bathymetry contour. Waves that break near the shoreline is highly potential toward abrasion.

Table 2 Wave characteristic projection in southern waters of the studied location and its surrounding

No	Angle	Fetch	Wave Parameter				
			H	T	C	E	Db
1	180	9	0.85	2.8	2.89	1.07	0.66
2	190	6.5	0.7	2.7	2.62	0.88	0.55
3	200	9	0.85	2.8	2.89	1.07	0.66
4	210	34	1.9	4.9	4.32	2.39	1.48
5	220	22.5	1.6	1.3	3.96	2.01	1.25
6	230	20.5	2.25	1.8	4.70	2.83	1.76
7	240	23	1.65	1.4	4.02	2.07	1.29
8	250	76	2.2	5.6	4.64	2.76	1.72
9	260	15.5	3.75	3.4	6.06	4.71	2.93
10	270	16	3.85	3.9	6.14	4.83	3.01
11	280	0	4.5	3.7	6.64	5.65	3.52
12	290	0	4.5	3.7	6.64	5.65	3.52
13	300	21	1.23	3.7	3.47	1.54	0.96
14	310	31.5	1.3	4.7	3.57	1.63	1.02
15	320	21	1.23	3.7	3.47	1.54	0.96
16	330	25	1.25	4.6	3.50	1.57	0.98

Inf. : Angle = angle of the winds coming; Fetch = Distance of open water that the wind has blown over (km); H = height of wave (m); T = period of wave (second); C = wave propagation (m/sec); E = wave energy (joule); Db = depth of wave breaking (m); * angle 0^o - 150^o blocked by Halmahera Island; dan ** = fetch more than 100 km

Tabel 3 Wave characteristic projection in northern waters of the studied location and its surrounding

No	Sudut	Fetch	Parameter Gelombang				
			H	T	C	E	Db
1	220*	32	1.31	4.7	3.58	1.64	1.02
2	230	40.5	1.73	5.3	4.12	2.17	1.35
3	240	37	1.27	4.2	3.53	1.59	0.99
4	250	67.5	2	5	4.43	2.51	1.56
5	260	37.5	1.47	4.2	3.80	1.85	1.15
6	270	39	1.53	5	3.87	1.92	1.20
7	280	33.5	1.27	4.2	3.53	1.59	0.99
8	290**	25	4.7	3.5	6.79	5.90	3.67
9	300	40.5	1.73	5.3	4.12	2.17	1.35
10	310	10	2.72	3	5.16	3.42	2.13
11	320	8	0.7	2.85	2.62	0.88	0.55
12	330	7	0.6	2.8	2.42	0.75	0.47

Inf. : Angle = angle of the winds coming; Fetch = Distance of open water that the wind has blown over (km); H = height of wave (m); T = period of wave (second); C = wave propagation (m/sec); E = wave energy (joule); Db = depth of wave breaking (m); * angle 0^o - 150^o blocked by Halmahera Island; dan ** = fetch more than 100 km

e. Stream

Stream condition in surrounding waters of studied location is much influenced by seabed topography and the neighbouring islands (a semi-closed area). According to the secondary data, trajectory and velocity of the stream around the Sofifi harbour showed that the current is a tidal current, which is a current generated by tidal activities occurred in the area on which waves break.

Average surface velocity on high tide is around 0,05 to 0,09 m/sec westward. While on low tide the current shows 0.03 to 0.12 m/sec north-westward. Maximum current velocity is shown at low tide in 0.12 m/sec.

f. Tides

Tidal movement on Sofifi waters, as most of Moluccan waters, is a propagation of the Pacific Ocean. As well as the influence of the topographic condition and resonance system of this waters which is a semi-closed shallow waters, have significant influence against its tidal pattern.

Value of high-watermark on spring tide, on the average highest at (MHHWS) 180,5 cm or 81 cm above MSL and average lowest on low tide at (MLLWS) 18,5 cm or –81 cm below MSL. While on neap tide, highest average on high tide (MHHWN) is 100,5 cm or 1 cm above MSL, while at low tide (MLLWN) is 98,5 cm or –1 cm below MSL. As for the highest tide (HAT) is 140 cm or 41 above MSL and the lowest tide (LAT) is -52,5 cm or -152 below MSL.

Therefore, tidal pattern developing in the waters of Tidore islands is generally mixed tide prevailing semidiurnal. This condition is shown on four locations in Table 4.10 with Fomrzhal value of (F) 0.26 to 1,50.

Bio-ecological Condition of the Coast

a. Mangrove Forest

Condition of the mangrove forest around Sofifi has grown to maximum in the coast, which is protected against strong waves and is having an estuary. Mangrove forest is only found at the northern of the studied location, the Kaiyasa and Guraping bay.

Calculation result of the density (Di), Frequency (Fi) and closure (Ci) is shown on Table 4. The table shows that Rhizophora apiculata is a species with the highest value where Di = 0.140, Fi = 2.80 and Ci = 4.038.

Table 4 Structure analysis of mangrove community

Type	Structural Variable of Mangrove Community						
	Di	RDi	Fi	RFi	Ci	RCi	NP
Bruguiera gymnorrhiza	*0.086*	22.39	2.40	24.00	3.02	21.06	67.45
Ceriops decandra	0.046	11.97	1.00	10.00	0.51	3.56	25.54
Rhizophora apiculata	0.140	36.45	2.80	28.00	4.03	28.09	92.55
Rhizophora mucronata	0.052	13.54	1.20	12.00	2.16	15.04	40.58
Sonneratia alba	0.008	2.08	0.40	4.00	3.20	22.30	28.38
Xylocarpus granatum	0.052	13.54	2.20	22.00	1.42	9.92	45.47
T o t a l	0.384	100.0	10.0	100.0	14.37	100.0	300.00

b. Coral Reef

Coral reef in Sofifi is a shore-type, and entirely in this study found 14 genera of reefs. Some of them are only found in certain locations such as Goniastrea, Millepora, and Pachyseris .

Highest coverage percentage of coral reef is found at the southern with 45.80%. Yap and Gomes (1984) categorized that reef which covers 0-24,9% means damaged, 25-49,9% is average, while 50-74,9% is good, and 75-100% is perfect. By observing the coverage percentage in both locations, the northern part (14%) is categorized as damaged. While average is categorized for its counterpart. Although the northern part categorized to be damaged, soft coral and algae coverage in the area is quite significant, 28.16% and 27.04%.

Potential Area for Abrasion

Results of the digital imaging analysis in 2006 found 16 areas at the studied location are potential and might have suffer abrasion, such locations are generally at the centre and northward, whereas area with accretion potential is at the southern part of the studied location (figure 2) which consists of 19 area. From the location, abrasion took 18.293 Ha while accretion adds 12.677 Ha (table 5). Upon such abrasion, there is averagely 4,57 Ha per year of abrasion and 3,17 Ha per year of accretion occurred annually.

Tabel 5 Abrasion at Sofifi

Point	Shoreline changes		Point	Shoreline changes	
	Abrasion (m^2)	Accretion (m2)		Abrasion (m2)	Accretion (m2)
1	12915.14	1603.29	11	3331.84	1970.89
2	3897.19	4262.70	12	2382.26	38134.55
3	31999.76	139.42	13	9148.34	2812.29
4	2837.95	288.00	14	29632.98	24367.94
5	22775.48	260.20	15	1948.82	40395.87
6	9745.09	450.50	16	2394.57	1842.03
7	4055.21	1381.79	17	182934.63	202.79
8	13312.94	0.24	18	45733.66	2163.26
9	11458.46	2573.61	**19**		2594.26
10	21098.60	1327.00	Total	411602.92	124176.37

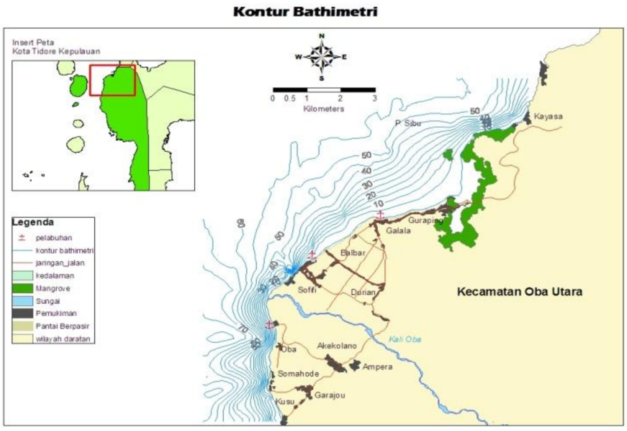

Figure 2 Shoreline changes at Sofifi

Analysis of shore materoal movement in the location showed that the amount of carried material in tide rise is lesser than that of carried in ebb. Averagely, material carried by the ebb is 63,2 gram/m2 while 40,6 gram/m2 on the flow. Such condition is caused by several factors:

1. The depth distribution of breaking waves are relatively far from the shore (50 to 150 m) which caused to drive relatively weak when they arrive at shore.
2. Wave propagation patterns with short periods causing ripples occur with high frequency when reaching the shore. This condition will select material that is more likely to be in the forefront of the beach.
3. Angle of the wave at > 45^0 triggers the formation of longshore current. Accumulatively, this condition causes a void when the water moving backwards, so that the wave velocity at ebb is higher than of the flow.
4. With the relatively high velocity of propagation and tidal fluctuations, the volume of the water will move with the waves forming a <45° angle to the southwest against coastline. This wave series will form a longshore current.
5. A < 45^o shore formation will trigger a faster wave movement against the shoreline before it breaks on its depth. Such condition in synergic will modify the shoreline and forms shore cliffs. Eroded material will spread and broaden the shoreline.
6. Pattern of wind propagation with maximum fetch will move synergistically with the wave propagation in the southern season, however the reflected wave movement will toward south (reciprocal wind and reflected wave directions). This condition causes a maximum energy to broaden the shore.

Securing Efforts and Abrasion Handling

1. Prevention

Prevention is an effort that every party have to perform to avoid further damage to the shore. The prevention may be done by the government through laws, supported by law enforcement. Prevention may by:

a. Socialization and knowledge improvement to the shore's community, management, and developers, in regard of shore damage which may happen due coastal activities such as building structures jutting into the sea, mangrove deforestation, and sand extraction.

b. Prohibition of extraction of sand, stones and gravels which suppose will cause damage to the shore. Locations of sand, stones and gravel extraction which supposedly will cause shore damage.

Rehabilitation

Rehabilitation is shore restoration to its initial condition before the damage. On the sandy beach which is damaged due parallel and perpendicular sand abrasion that exceeds its supply rehabilitation may be done by sand re-supply up to the initial shoreline, added with initial and periodic sand re-supply thus the expelled sand is equal to that of taken.

To reduce the amount of sand periodically supplied, perpendicular cribs or parallel cribs may be installed at the rehabilitated shore to reduce parallel sand carried.

In mangrove beach, rehabilitation may be done by mangrove reforestation. For the young mangroves to sustain waves, temporary structures may be deployed in front of the mangroves to break waves. Once the mangroves have grown and able to sustain waves, the breaker structure may not be functioning any longer. In coral shore, rehabilitation may be done by planting reefs; to stick corals to the existing roots. Special expertise is required for mangrove and coral shores; biology and environmental expertise.

CONCLUSION

Sofifi coastal city showed shoreline changes. There are two types of shoreline changes, abrasion and accretion. Abrasion usually occurs because of natural and anthropogenic factors. However the abrasion on the coast of the Sofifi city is more likely caused by coastal sand extraction by local residents. To stop this, the government shall ban sand extraction by the locals and build a shore wall and to rehab the remaining mangrove forests.

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PRELIMINARY STUDY: BLOOD LEAD LEVEL INFORMATION OF ELEMENTARY STUDENTS ASSOCIATED WITH AIR LEAD CONCENTRATION AND THE TRAFFIC DENSITY AT JOGJAKARTA

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ABSTRACT

The increasing numbersof vehicles causing air pollution. Lead (Pb) known as most dangerous pollutant emitted by vehicle emission. The increased level of lead in human's blood is toxic. It can decrease the intelligence and physical growth in children. This research was aimed to examine the relationship between lead air concentration with lead blood content in children ages 9-12 years, and to know how the blood lead concentration affecting in children intelligence. A cross sectional study was done to give initial information of blood lead level in students atage 9-12 years associated with air lead concentration a traffic density. The research was done in two elementary school located near high traffic density in Jogjakarta (SD Tukangan and SD Jetis). The level of lead in the air was measured with "Atomic Absorption Spectrophotometer"(AAS), using the samples of air collected by "High Air Volume Sampler" (HAVS). The blood was taken from peripheral venaThe level of lead in the blood was measured with "Atomic Absorption Spectrophotometer"(AAS). Whereas the traffic density measured was according to Indonesian highway manual capacity (MKJI, 1997). The result of study shows that the air leads concentration on two locations still under allowable limits. Most of blood lead level of students (70%) categorized as normal, one sample on Jetis have been indicate as dangerous level. Several research has been found that Lead causes neurological, physiological and behavioral problems in children, ranging from raised hearing threshold and decrease in intelligence quotient (IQ) at low blood lead concentrations to acute encephalopathy, memory loss and death at high blood lead concentrations. This study can give information about the initial condition of blood lead level in Jogjakarta.

Keywords:*blood lead level, air pollution, lead, traffic density*

INTRODUCTION

Urban air pollution from road transport is a growing concern in a large number of developing country cities. With rising income, the use of motorized transport is expected to continue to increase in the coming years, potentially worsening the air quality (Armolaitis, et al., 2002). As well as Jogjakarta city, also face though challenges in terms of air pollution caused by transportation. A large number of different motor vehicles, crossing the area to reach their destination, use either gasoline or diesel and emit gases full of different toxic substances, including SO_2, CO, Lead and particulates and etc, one of the most dangerous pollutant emitted by vehicle is Lead (Pb).

The use of lead additives in gasoline has been one of the main contributors to the exposure of urban populations to lead, world's bank technical report (Magda, 1998) show that vehicular traffic remains the single largest source of environmental Lead pollution in most urban areas in developing countries, typically accounting for over 90% of all Lead emissions into the atmosphere. Numerous studies indicate that blood Lead concentrations above 10µg per deciliter (0.483 µ mol per liter) are associated with adverse outcomes on measures of intellectual functioning and social– behavioral conduct.

Although Lead pollution related to the air pollution become a global problem, but the study about Lead exposure to child in Jogjakarta lagged far behind. The present study was designed to give preliminary information about the blood Lead level in students ages 9-12 in Jogjakarta associated with air Lead concentration and traffic density. It is hoped that the result of this study will provide base information for future study about effect of air pollution of Lead in Jogjakarta city.

METHODS

Sample Size

A cross sectional study was conducted, the research comprise of air quality sampling, transportation density measurement, blood sampling, and questionnaire on Lead exposure risk. Two elementary school located near to the road are being selected as research location. Sample population include 20 students (ages 9-12), sampling selection considering about the way students go to school (by walking or using vehicle).

Transportation Data

Vehicle volume sampling taken every 15 minutes, and divided into three section of time (07.00 am-08.00 am; 12.00 am-01.00 pm; 03.00 pm-05.00 pm), then measured by vehicle counter. The degree of saturation obtained to know the road capacity classification according to Indonesian highway manual capacity of road/MKJI 1997, the Traffic density itself measured by volume of vehicle/time.

Air Lead Concentration

A 12 hour Air quality sampling conducted on every location, sampling taken using high air volume sampler (HAVS). Air Lead concentration determined using atomic absorption spectrophotometer (AAS) refer to *SNI* 19-7119.4-2005. Meteorological data within 1 month collected from secondary data taken from Adisucipto airport meteorological station. Meteorological data like wind velocity, humidity, and temperature also collected on the spot while air quality sampling being taken. Air Lead concentration then compared with Indonesian national air quality standard.

Blood Lead Level

As much as 10 ml Vena blood was taken for Lead blood level refer to Indonesian ministry of health decree No 1406/Menkes/SK/XI/2002. Blood sample were collected using Lead free syringes then stored in the ice box before analyzed. Lead blood concentration determined using atomic absorption spectrophotometer (AAS) refer to APHA 3111 B, 2005 method. Collected blood Lead concentration data served compare with biological exposure index (BEI) of Lead, according to WHO 1977.

Data Analysis

To know the influence of transportation activity on air pollution in terms of Lead, both data (traffic density and air Lead concentration) are being compared. The air Lead concentration data also compared with Indonesian air quality standard. Then the blood Lead level also compared with some factor that may affect on Lead exposure risk from the questionnaire and study reports.

RESULTS

Transportation Data

Traffic density, which incorporates the number of vehicles passing a given section of roadway during a given time interval, seems to be more suitable to use instead of traffic volume. Density is an appropriate parameter to indicate the quantity of traffic operations Direktorat Jenderal Bina Marga, 1997). In this study, traffic density is used to correlate with air pollutant concentrations. Traffic density on two locatios showed in Figure. 1. The highest traffic density was 87 unit/minutes on Jetis at Morning. Overall data show that traffic density on Jetis was higher than Tukangan. The high traffic density on Jetis could be due to fact that Jetis is situated adjacent to the main road (Monjali-street) which has become a popular alternative route. In other hand, Tukangan location adjacent to the smaller street compared to the Jetis.

The volume of vehicle data then used to calculate the road's degree of saturation (D). The overall data of D can be shown on Figure.2.According to the Indonesian highway manual capacity of road/MKJI 1997 (D) classified into several groups that indicate the services level of the road, in this case both of (D) classified to B class (0.20-0.44) or stable flow zone. The driver has enough freedom to choose the speed. It means there was not too much traffic jams occurred on the two location. But in peak time (16.00-17.00), traffic jam often occurred on Jetis, it is because of the increasing of Motorcycle populations that used by people.

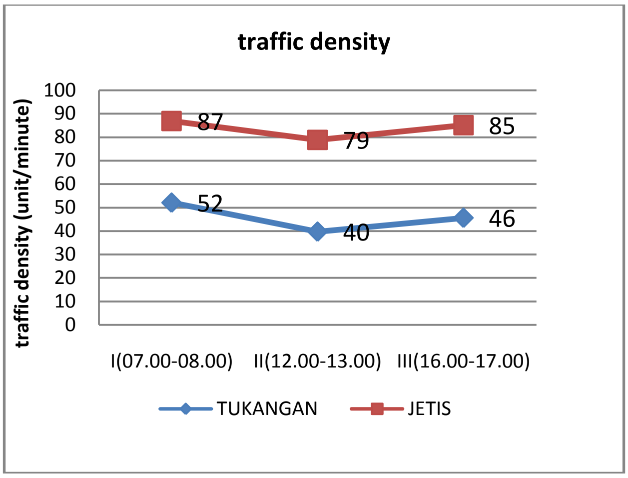


Figure 1 Traffic density each location
(primary data, 2008)

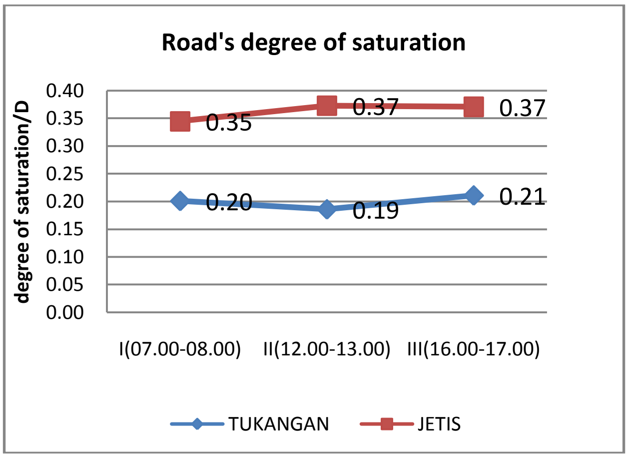


Figure 2 Road capacity on each location
(primary data, 2008)

Air Lead Concentration

The measurement results for air lead concentration levels at a distance of 0 meters from street highway can be seen in figure 3, The Overall mean air Lead concentration was 0.0122 µg /m^3 on Jetis while on Tukangan was 0.0098 µg /m^3 were still low and much below the allowable limit on Jogjakarta region (2 µg /m^3) (Lestari, 2006). However, elevated concentrations of Lead were often experienced from time to time at busy roads, especially during rush hours like in Jetis at sampling number III showed the highest Air Lead concentration (0.01423µg /m^3). While the lowest air Lead concentration was 0.00866µg /m^3 at afternoon on Tukangan.

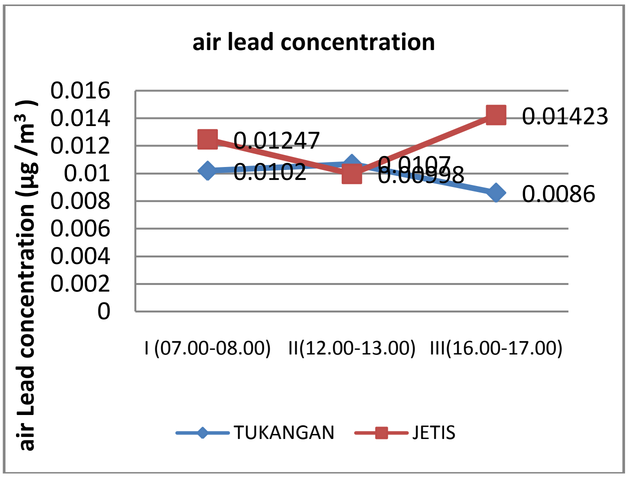


Figure 3 Air Lead (Pb) concentration
(primary data, 2008)

The highest traffic density resulted in high air Lead concentrations that indicate a positive relationship between traffic density and air Lead concentration**.** While the state of environmental meteorology during air sampling period Ambient is as follows: temperature Air 26-33 ° C, humidity 65 83% wind speed from 0.16 to 4.51 meters / second, wind direction and weather conditions was fluctuate. The occurrence of fluctuations in meteorological conditions variable can influence the occurrence rate of dispersion of substances pollutants in the atmosphere. Therefore, limitations this study is that factors weather can affect the level of accuracy measurement results, which means that the pollutant levels on the same locations, may be different if the weather conditions are different.

Blood Lead Level

The blood Lead level has been categorized to some groups (Centers for Disease Control and Prevention, 1991) as follows: Normal (<40µg/dL); Tolerance (40 µg/dL-80 µg/dL);and Danger (>120 µg/dL). According to those categories, we can infer that of student's blood lead level is normal. The highest blood Lead level found on Tukangan (128.5 µg/dL) whereas the lowest blood Lead level (7 µg/dL)found on both location with mean blood Lead level was about 22.81 µg/dL. The overall data of Blood Lead level students age 9-12 in every school showed in Figure. 4. Although overall bloods lead level was normal but some sample categorized into dangerous, it make sense to be an intensive care for lead treatment. The present study in Bandung-Indonesia (Lestari, 2006) showed that leaded petrol in Bandung is directly harming children's health. The result, blood tests on school children shows from every 20 children studied, five of whom had passed the quality standard of per deciliter of blood established by WHO. Which average blood lead concentration in children were 1.57 ug / dl.

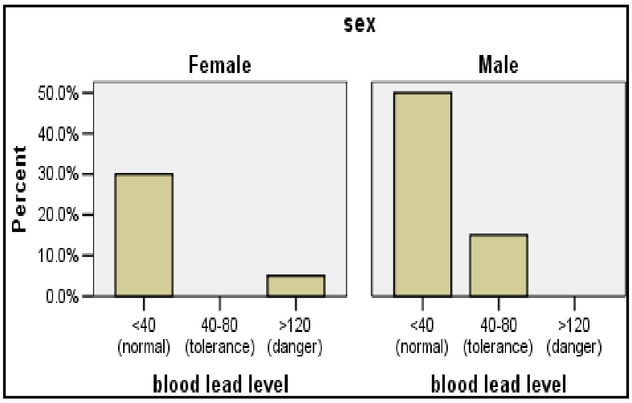


Figure 4 Blood Lead level on students (primary data, 2008)

Lead compounds may enter the human body by way of the respiratory tract, gastrointestinal tract of food or direct contact with skin. Respiratory tract becomesthe dominant ways entering human body, according to Mukono (2003) absorption rate was strongly influenced by particle size of lead compounds that exist and the volume of air that is able to breathe when breathing. The smaller the particle size of dust and the increased volume of air that is inhaled the greater the concentration of lead is absorbed by the body, Approximately 75% of lead particles produced by motor vehicles that are so small (<0.9 μ) it's make lead easy absorbed through the alveoli (George, et al., 1978).

DISCUSSION

Effect of Transportation Density on Air Lead Concentration

As it can be clearly seen from Figure 5 that the most dominant type of traffic was motor cycle, which represented the highest percentages (82%) of the total traffic volume. Light vehicle (car, passenger bus) represent the second largest group about 13%. The amounts of lead additives used in gasoline, and the volume and patterns of traffic, have a strong influence on airborne lead concentrations. The Lead from vehicle emissions is deposited in dust, soil and other ecosystems (Momeshora, 1981) and subsequently ingested by children (Gloag, 1981), fuel specifications currently circulating in Jogjakarta still contained lead used as an octane enhancer in fuel, data from LSAP report amount of lead up to 0,13 g / liter fuel (LSAP Kota Jogjakarta, 2006), all those reason clearly showed that vehicle emission in Jogjakarta contribute in air lead concentration.

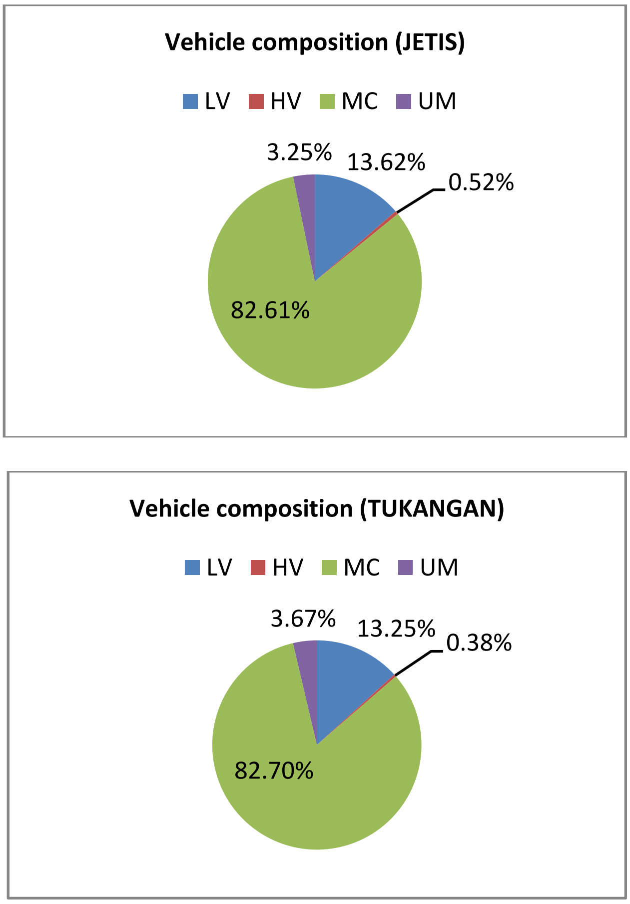


Figure 5 Vehicle composition on location (primary data, 2008)

As determined from the traffic survey data. It was revealed that during rush hours a comparably higher traffic volume occurred for all locations. During this time, traffic moved more slowly, resulting in high smoke and particulate containing Lead. Where traffic flows are slow, more pollutants will be emitted by vehicles, especially diesel engine buses, many of which are old and inefficient. We also revealed that air pollution from traffic emissions depends on the physical conditions in narrow streets enclosed by tall buildings which govern the ability of atmosphere to disperse the pollutants. Taller building adjacent to the Jetis location resulted in higher air lead concentration than Tukangan. In addition Jetis location is very close to the road (about 3 m) and there are no fences or trees as an barrier to air pollution exposure.

Gas emissions resulting from fuel combustion in the engine combustion chamber is influenced by fuel quality, vehicle technology, emission control technologies, and vehicle maintenance. The availability of unleaded gasoline (unleaded gasoline) and diesel oil with low sulfur content is a key factor in the reduction of vehicle emissions, because fuel types are a prerequisite for the use of advanced technology vehicles that are capable of significantly reducing vehicle emissions. It is possible to produce petrol of high and desirable octane number without the use of lead tetraethyl using appropriate technology e.g. cracking of higher molecular crude, use of methyl tetra-butyl ether (MBTE), and Fluid Catalytic Cracker(FCC).

Blood Lead Level Effect on Student

In this study, student's reports (point) were investigated, and then correlate with the blood lead level of every student. The result show that there was negative correlation between the blood lead level and student's reports (point), although there was unclear connection because data limitation, but a highly significant association was found between lead exposure and the IQ of school-age children by several studies (Bellinger, 1992; Needleman, 1979). According to a review of epidemiological studies (CDC, 1991), a 10 microgramper deciliter (µg/dl) increase in blood lead (the best indicator of current exposure) can be associated with a 2.5 point decrease in the IQ of exposed children.

The Centers for Disease Control & Prevention (CDC, 1991) identifies lead as the number one environmental health threat to young children. Lead toxicity can have an adverse affect on virtually every system in the body. The result of lead toxicity can be seen in the peripheral nervous, hematopoietic, renal, and gastrointestinal systems. It effects the regulation of vitamin D, and the growth, hearing, and cognitive development of a young child. Most importantly, it can cause irreversible damage to the central nervous system. At very high levels, lead exposure can cause seizures, coma, and death.

Further research (Bitto, et al., 1997) that specifically looked at a large number of children with BLLs known to be <10g/dL, deficits in cognition and academic abilities associated with lead exposure have been noted. Adjusting for factors known to have an impact on these outcomes, children with BLLs >3g/dL demonstrated impairment in cognitive, memory and visual-spatial skills. The adverse effects of lead on reading and other languages based abilities was significant, as these are potent predictors of academic achievement and anti-social behavior.

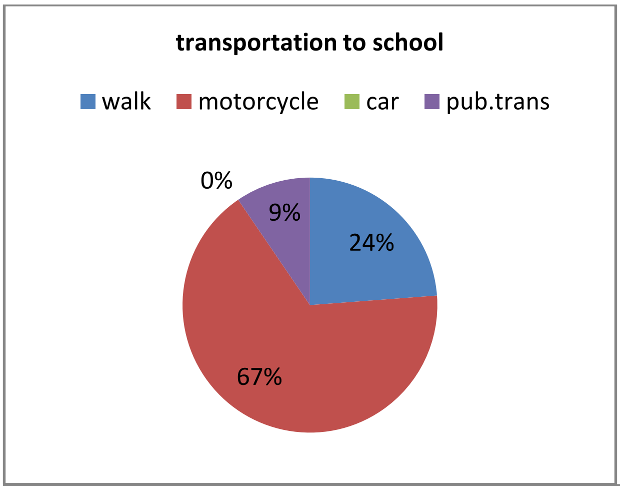
Factor Associated on Blood Lead Level

Level exposure to metallic lead (Pb) to humans is not only influenced by the amount of lead contained in the air. Environmental conditions surrounding the residence were also very influential on the risk of exposure to metallic lead in figure.6. Our findings show that children who school on Jetis with high levels of traffic congestion had higher blood lead concentrations than those who school in Tukangan. It is because students spent most of their time in school (about 6 hour) in risk potential lead exposure area. In 1990, a study in Hungary reported mean blood lead concentrations of 20 µg/dl in children who lived near traffic and main roads (Bitto, 1997). After lead was eliminated from petrol, a study in 1994 showed that the mean blood lead concentrations had fallen to 6.9 µg/dl. Similarly, the removal of lead from petrol in the United States resulted in a decrease of 37% in the mean blood lead concentrations between 1976 and 1980 (Annest, et al., 1983).

Metabolism of lead in the body as reported in study, about 10-20% of lead retained in the body is stored in soft tissues such as kidney, liver, bone marrow, and brain. It is in these sites where lead has the most toxic effects to children. The toxic effects vary inversely with the age of the poisoned child: the younger the child, the more vulnerable the sites are to lead exposure (Wasserman, 1998). The extent of damage to soft tissues is related directly to the amount and duration of exposure: the longer the exposure, the more severe the effects. In other words, the younger the child and the longer the exposure, the greater the severity of the effects is likely to be. In addition De Ross (1997) also found that Excretion of Pb in several ways, most important is through the kidneys and gastrointestinal tract, excretion through the urine of Pb 75-80%, through the fecal material and the other 15% through the bile, sweat Hair and nails.

CONCLUSIONS

Our finding show that general air quality on two location were under the allowable limits, but some of Blood lead level on students categorized in dangerous level. The study also found that Jogjakarta is highly risk of Lead exposure especially on children. Refer to adverse effect of lead, To protect the public from this pollution, preventive measures are necessary to reduce the air pollutant emission rate by improving traffic conditions. As data on atmospheric pollution and conditions in Jogjakarta are rather scarce, this study could serve as a good support to better understanding of the atmospheric environment in Jogjakarta.



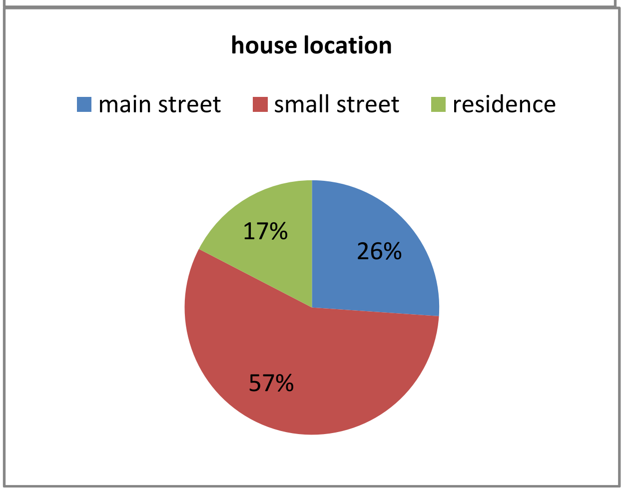


Figure 6 Observed Lead exposure risk (primary data, 2008)

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CONCENTRATION OF HEAVY METAL ON SNOW FALL IN SAPPORO CITY

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ABSTRACT

Sapporo is one of the few metropolises in the world with such heavy snow fall. The chemical study of snow cover can be a useful tool for determining deposition chemistry and chemical in atmosphere. In this study, snow samples were collected in the Sapporo city and determined eight elements (Mn, Al, Cd, Co, Mn, Cu, Ba, and Mg).Snow samples were taken by bottles sample and cylinders. The sampling sites were classified into three categories: Odori, Sapporo Station, and Susukino represented commercial areas; Inaho Factory, Oyachi Factory and Naebo Factory represented industrial areas; Maruyama and Teine Maeda represented residential areas. Beside these categories, the snow also collected in Hokkaido University. The measurement of heavy metal concentration in the snow was carried out by Inductively Coupled Plasma Mass Spectrometer (ICP-MS).The mean concentrations of the elements studied were in the order Mg > Zn > Al > Ba > Mn > Cu > Co > Cd. The highest concentrations of heavy metals were found in the old snow. Because it was collected from standing accumulations of various depths and it affected by many factors than in the fresh snow and falling snow. The heavy metal concentrations in the fresh snow and old snow were generally highest in commercial area. It was affected by urban pollution in the center of the city. However, heavy metal concentrations in the falling snow were relatively similar for each area. Compared with heavy metal concentration in unpolluted snow as a background levels, snow fell in Sapporo city was contaminated by heavy metal in low concentration.

Keywords: *snow, heavy metal*

INTRODUCTION

Japan has several densely populated areas that are subject to heavy snow. Example of such area is Sapporo city. Sapporo is situated near the west coast of the Hokkaido Island in Japan. The area of Sapporo City is 1.118 km^2, of which the urban area is 232 km^2. Sapporo had a population of 1.800.000 in 2005.

When snow is present it acts as both a filter and as a chemical reactor. In filter mode, snow is a collector of contaminants and chemical tracers from the atmosphere that are held by the snow. Snow can function as a significant source of water pollution since it accumulates a variety of contaminants from the atmosphere, motor vehicles, and roadways. These contaminants include salts and salt additives, asbestos, petroleum products such as oil and grease nutrients, bacteria, organic chemicals such as pesticides and PCBs, soil material, and heavy metals. Although snow melt water typically contains lower contaminant concentrations than rainfall runoff (Bennett, 1981), contaminant loads generated from urban roadways and carried in runoff and snow melt water is of the same magnitude as that of raw sewage (Novotny, 1981).

Snow also can contribute as an effective scavenger to the removal of pollutants from atmosphere. As a result the snowbound pollutants will be transferred to the adjacent environments (aquatic systems, soil, and vegetation) during melting. Therefore, the determination of pollutants in snow represents an interesting approach for the evaluation of the impact of anthropogenic pollution.

The chemical study of snow cover can be a useful tool for determining deposition chemistry and chemical in atmosphere. Chemical constituents are retained in the snow cover during the winter periods in Sapporo (Suzuki, 1982). It can be considered that the concentration of chemical constituents in the snow cover corresponds to the weight mean concentration of the chemical constituents in snowfalls in the winter season. In this study, snow samples were collected in the Sapporo city and determined eight elements (Mn, Al, Cd, Co, Mn, Cu, Ba, and Mg). The pollution characteristics of each source were distinguished by municipal, industrial, and residential area in the city of Sapporo.

MATERIAL AND METHODS

Sampling Sites

Snow sample were collected on February 16th 2010 and February 25th 2010. For the investigation several sampling points in Sapporo City were chosen. The sampling sites were classified into three categories: Odori, Sapporo Station, and Susukino represented commercial areas; Inaho Factory, Oyachi Factory and Naebo Factory represented industrial areas; Maruyama and Teine Maeda represented residential areas. Beside these categories, the snow also collected in Hokkaido University (Hokudai). The residential area was situated so that the sample was not directly polluted by traffic or human activities but affected by atmospheric pollutants due to deposition. The commercial area was situated directly at the road and therefore the snow samples were highly affected by traffic load. The industrial area was situated so that affected by industrial activities.

Sample Collection

In this study, snow samples were taken by bottles sample and cylinders. The bottles sample aimed to investigate the heavy metal concentration in old snow and fresh snow. Whereas the cylinders (13.2 cm diameter x 49 cm high) made of biphenyl materials aimed to investigate the heavy metal concentration in falling snow.

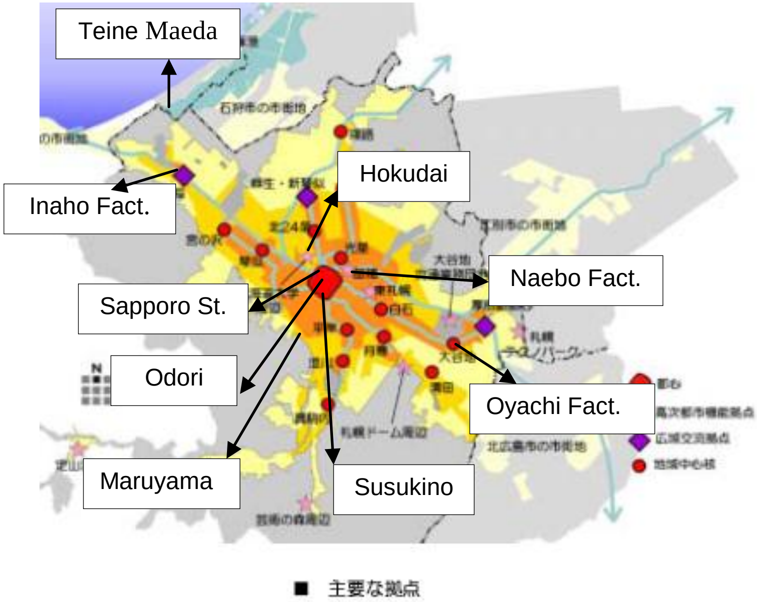

Figure 1 Sampling sites of bottle sampling

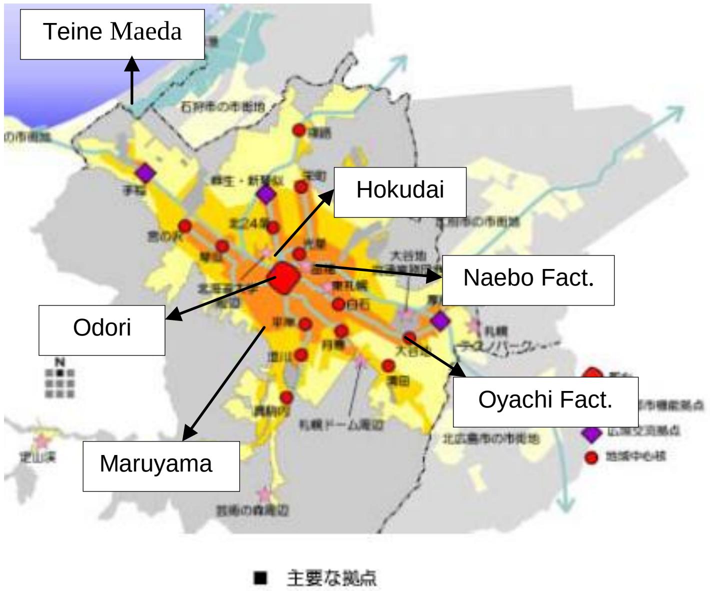

Figure 2 Sampling sites of cylinder sampling

Laboratory Analyses

The snow samples were melted at room temperature. Each sample divided in two bottle samples. The first one is for field measurement. Conductivity, pH, COD, NO_2, NO_3, and PO_4 were measured immediately after melting on an unfiltered sample. Conductivity and pH were measured by Eutech Instruments, Multi Parameter PCS Test 35 and COD, NO_2, NO_3, and PO_4 were measured by ion selective pack test. The second one is for heavy metal concentration measurement. The melt water filtered through 0.45 µm filters. To prevent chemical precipitation forming in the samples, the filtered water samples were acidified with 100 µl of concentrated HNO_3. The measurement of heavy metal concentration (Mn, Al, Cd, Co, Mn, Cu, Ba, and Mg) in the snow was carried out by Inductively Coupled Plasma Mass Spectrometer (ICP-MS). ICP-MS is a multi-element technique which can be used for the simultaneous determination of most elements, in sample volumes of only a few millilitres and with detection limits typically less than 1 µg/l. (Date and Gray, 1989).

RESULT AND DISCUSSION

Comparison of Heavy Metal Concentration in Fresh Snow and Old Snow

In this study, the snow sampling periods were taken three times. In the first sampling, two types of sample were taken. It aimed to distinguish the snow contamination of both snow types. The fresh snow collected either during or within a few hours or few days of snow fall and the old snow collected from standing accumulations of various depths more than one week in age. The surface of old snow developed a dirt grey appearance. It is due to an accumulation of black dust particles. Sampling sites were chosen owing to three categories area (Industrial area, commercial area, and residential area). Table 1 showed the heavy metal concentration in each sampling sites.

Based on the table 1, the composition of old snow contrasts sharply with the fresh snow. Generally the concentrations were higher in samples taken from commercial area than others area. It was probably due to differences in traffic load. Odori, Sapporo Station, and Susukino areas have a high traffic so that automobile emissions are still considered the primary source of contamination in snow. Moreover contamination of snow can be derived from road dust. Road dust contains metals, carcinogens such as benzopyrene, sulfates, nitrates, carbonaceous organics, ammonium, and lead, which are mostly attributed to traffic exhaust (Koziel, 1993; Miguel et al.,1999; GeoViro, 2001). Dust produced by studded tires "grinding" the asphalt and by the studded tires themselves contributes to the level of roadside particulate matter (Lindgren, 1996; Swedish VTI, 1995). Ground asphalt particles also act as carriers for traffic-generated pollutants from vehicles. It is important to note that studded tires and non-studded tires alike both contribute tire wear particles to the road. Overall, tire wear is the largest transportation-related contribution of zinc to the dust content (Lindgren, 1996). Other heavy metal elements in tire tread also pollute the environment. Fukuzaki et al. (1986) showed that tire tread contains heavy metals such as Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb, and tire dust pollution contributes to some of these elements in the form of airborne dust. Therefore, if these elements spread out into snow so that heavy metal concentrations in snow were obtained, especially for old snow.

Table 1 Comparison of heavy metal concentration in fresh snow and old snow

Sampling Date		Sampling Sites	Concentration of Heavy Metal (ppb)							
			Mn	Zn	Cu	Mg	Ba	Cd	Al	Co
Jan 17th, 10		Hokudai	2.79	14.89	5.174	132.15	1.7	0.3	60.69	0.034
Dec 25th, 09	Commercial Area	Odori (fresh)	7.77	45.42	13.12	968.44	10.28	0.643	186.74	0.903
Dec 25th, 09		Odori (old)	249.61	317.39	59.72	11800	143.09	1.01	4370	5.74
Jan 17th, 10		Sapporo St. (fresh)	5.07	63.15	7.27	250.81	4.54	0.01	119.7	-0.097
Dec 25th, 09		Sapporo St. (old)	374.49	732.45	217.08	11900	366.27	1.03	5780	8.35
Jan 14th, 10		Susukino (fresh)	3.18	141.67	-8.224	243.8	9.07	0.193	83.02	0.01
Jan 14th,10		Susukino (old)	150.48	1070	65.54	5260	221.46	0.96	2660	4.7
Jan 5th, 10	Resident Area	Maruyama (fresh)	8.76	25.88	9.09	1340	3.91	0.557	155.71	0.821
Jan 5th, 10		Teine Maeda (fresh)	3.02	18.6	5.21	483.72	3.97	0.514	64.77	0.598
Jan 5th, 10	Industrial Area	Inaho (fresh)	0.523	19.57	4.52	1560	1.42	0.561	28.32	0.58
Jan 5th, 10		Railway (fresh)	13.66	37.44	25.19	1850	12.3	0.639	41.12	0.676
Jan 14th, 10		Naebo (fresh)	32.55	141.73	36.47	-2610	19.11	0.12	551.47	1.01
Jan 14th, 10		Naebo (old)	501.04	801.44	152.19	12200	183.64	1.37	5380	11.73
Jan 14th,10		Oyachi (fresh)	20.81	72.13	11.7	-4345	18.79	0.229	415.78	0.818
Jan 14th, 10		Oyachi (old)	158.1	118.99	4.53	1850	32.73	0.794	768.92	2.16

Snow Sampling by Cylinder Set Up

1. Field Measurement

The second experiment was done by set up the cylinder in six sampling sites based on bottles sampling result. The cylinder sampling aimed to investigate the heavy metal concentration in falling snow without influence contamination from environment around snow falling. Oyachi and Naebo Factory were selected as industrial areas, Maruyama and Teine Maeda as residential areas, and Odori and Hokudai as commercial areas. The cylinders were set up in each sampling sites and snow samples were collected in a week for two times. The first sampling, the samples were collected from February 8 to February 16 and for the second sampling, snow samples were collected from February 18 to February 25. Table 2 and 3 showed the field measurement result for each sampling site.

Table 2 Field measurement of first sampling

No.	Sampling Site	Melted Snow (ml)	Falling Water Amount (ml/cm^2)	pH	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)	COD (ppm)	Conductivity (µS/cm)
1	Oyachi	280	0.512	6.38	0.02	<1	0.02	6	61.8
2	Naebo	262	0.479	6.60	0.02	<1	0.02	6	79.4
3	Maruyama	160	0.292	6.38	0.02	<1	0.02	7	85.55
4	Teine Maeda	114	0.208	6.48	0.02	<1	0.02	7	122.4
5	Odori	210	0.384	6.64	0.02	1	0.02	8	155.7
6	Hokudai	180	0.329	6.18	0.02	<1	0.02	8	63.8

Table 3 Field measurement of second sampling

No.	Sampling Site	Melted Snow (ml)	Falling Water Amount (ml/cm^2)	pH	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)	COD (ppm)	Conductivity (µS/cm)
1	Oyachi	226	0.413	6.27	0.05	1	0.02	7	57.8
2	Naebo	91	0.166	6.14	0.1	3	0.02	7	186.5
3	Maruyama	94	0.172	6.38	0.05	2	0.02	6	61.3
4	Teine Maeda	56	0.102	7.5			0.02	8	110
5	Odori	75	0.137	5.88	0.05	2	0.02	7	73.4
6	Hokudai	72	0.132	-	0.05	2	0.03	15	530

The pH of snow samples was relatively acid. As like natural rainwater, snow is slightly acidic because it interacts with carbon dioxide (CO_2) in the atmosphere, forming carbonic acid (H_2CO_3). Conductivity is the ability to conduct electricity. Water conducts electricity because it contains dissolved solids that carry electrical charges. For example nitrate carries negative charges. The significant changes in conductivity can be an indicator that a discharge or some other source of pollution has entered the water (snow). The second sampling at Hokudai had high conductivity. It might be caused by biological deposition to the cylinder by plants or animals. Concentration of NO_2, NO_3, PO_4, and COD tend to be low concentration.

2. Heavy Metal Concentration on Snow Samples

Heavy metal concentrations for each sampling site were showed in table 4 and 5. Generally, concentration of heavy metals were relatively similar for each area in the order Mg > Zn > Al > Ba > Mn > Cu > Co > Cd. The concentration of first sampling was lower than the concentration of second sampling. It might be caused by the small amount of falling water in the second sampling, while the pollution in the atmosphere almost similar for the both sampling. So that the accumulation of pollution in snow fell was higher for the second sampling.

For some elements such as Cu, Co, and Cd are high concentrations in Naebo Factory. It located close to JR Factory then It might be resulted by the accumulation mixing of the various pollutants from industrialization.

Then, compared with heavy metal concentrations for each type of snow, old snow was the higher concentration than fresh snow and falling snow as shown in figure 2.

Table 4 Heavy metal concentration of first sampling

No.	Sampling Site	Concentration of Heavy Metal (ppb)							
		Mn	Zn	Cu	Mg	Ba	Cd	Al	Co
1	Oyachi	5.58	20.05	4.66	536.01	6.98	0.628	18.61	1.49
2	Naebo	7.45	34.59	6.87	565.19	8.98	1.03	26.49	1.58
3	Maruyama	8.79	34.27	5.77	690.45	9.3	0.85	30.47	1.44
4	Teine Maeda	6.42	32.54	4.43	757.47	6.18	0.85	28.14	1.42
5	Odori	7.83	57.49	5.97	648.9	10.61	0.572	33.22	1.44
6	Hokudai	6.26	21.8	3.56	586.89	10.29	0.462	29.84	1.32

Table 5 Heavy metal concentration of second sampling

No.	Sampling Site	Concentration of Heavy Metal (ppb)							
		Mn	Zn	Cu	Mg	Ba	Cd	Al	Co
1	Oyachi	8.7	28.44	5.6	553.99	9.61	0.369	36.62	1.15
2	Naebo	11.43	94.06	7.96	615.8	10.87	0.536	14.82	1.32
3	Maruyama	8.02	55.59	6.21	369.17	8.44	0.813	18.61	1.06
4	Teine Maeda	12.29	52.52	4.6	691.93	9.83	1.03	16.08	1.25
5	Odori	9.89	70.39	6.9	515.29	12.28	0.739	25.83	1.03
6	Hokudai	12.11	41.36	10.46	807.54	9.93	0.739	40.16	1.08

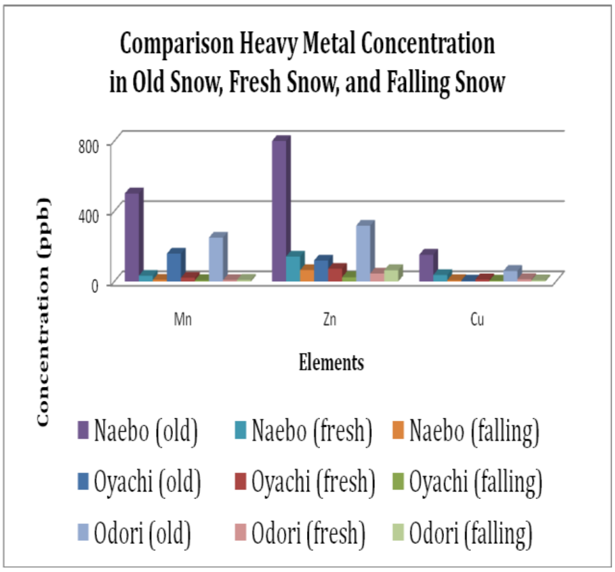

Figure 2 Comparison heavy metal concentrations in old snow, fresh snow, and falling snow

According to Elgmork *et al.* (1973), snow pollution depends upon both the thickness and duration of the snow cover. Therefore it was one of reason which influenced the concentration of heavy metal was higher in old snow > fresh snow > falling snow.

3. Comparing Heavy Metal Concentration in Snow in Sapporo City to Japan Regulation and Heavy Metal Concentration in Snow in Unpolluted Areas

Based on Japan Regulation of Water Purity Article Number 50 Year 2007, there are some exceeded values for standard regulation especially in old snow.

Table 6 Japan regulation of water purity article number 50 year 2007

Parameter	Unit (mg/l)
Mn	< 0.05
Zn	< 1.0
Cu	< 1.0
Mg	< 300
Ba	-
Cd	< 0.01
Al	< 0.2
Co	-

Table 7 Exceeded values of heavy metal concentrations in snow

Snow Type	Sampling Site	Mn (mg/l)
Old snow	Odori	0.249
	Sapporo St.	0.347
	Susukino	0.15
	Naebo	0.501
	Oyachi	0.158

Snow Type	Sampling Site	Al (mg/l)
Old snow	Sapporo St.	5.78
	Susukino	2.66
	Naebo	5.38
	Oyachi	0.768
Fresh snow	Naebo	0.551
	Oyachi	0.415

Thus, heavy metal concentration in snow in Sapporo City was compared to heavy metal concentrations in snow in unpolluted areas to obtain the background levels.

Table 8 Comparison of heavy metal concentrations in snow of unpolluted areas

Area	pH	Element (ppb)				References
		Mn	Zn	Cu	Cd	
Mt. Kita-nomine		2.1	1.5	ND	ND	Saito, 1981
Nebraska		4.0	12	4.0	0.63	Struempler, 1976
Houhei-kyou	4.8	2.5	3.4	0.6	0.05	Sakai, et al., 1988
Greenland (1807-1915)		0.10	0.38	0.15	0.034	Weiss et al., 1975
Greenland (1966-1971)		0.25	1.05	0.85	0.639	Weiss et al., 1975

Compared with the concentration in snow fell in Sapporo city is still higher than in unpolluted areas. Therefore it indicated that snow fell in Sapporo city was contained by heavy metal even in lower concentration.

CONCLUDING REMARKS

The aim of this study was defined of the characteristics heavy metal pollution in snow fell in Sapporo City. The mean concentrations of the elements studied were in the order Mg > Zn > Al > Ba > Mn > Cu > Co > Cd . The highest concentrations of heavy metals were found in the old snow. Because it was collected from standing accumulations of various depths and it affected by many factors than in the fresh snow and falling snow. The heavy metal concentrations in the fresh snow and old snow were generally highest in commercial area. It was affected by urban pollution in the center of the city. However, heavy metal concentrations in the falling snow were relatively similar for each area. Based on Japan regulation of water purity article, heavy metal concentration in snow in Sapporo city was below the standard value. However, there is some exceeded value for old snow. Compared with heavy metal contents in unpolluted snow as a background levels, snow fell in Sapporo city was contaminated by heavy metal in low concentration.

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TSUNAMI SIMULATION USING DIPERSIVE WAVE MODEL

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ABSTRACT

Tsunami is basically a long wave in which the wavelength is much longer compared to water depth. Hence, modeling of tsunami is usually conducted by using nonlinear shallow water equations which not include dispersion effect. Although propagated as a longwave, the dispersion plays a role when tsunami globally propagated through the world ocean, while the non-linear effects are important when tsunami propagated to the coastal area. The effects of dispersion for tsunami propagation are numerically investigated in this study. Weakly nonlinear dispersive wave model and nondispersive wave model i.e.: nonlinear shallow water equations are used here to simulate tsunami generation, propagation and runup. The model equations are finite differenced using predictor-corrector scheme. The numerical models are then applied to make simulation of the Indian Ocean Tsunami on 26 December 2004. Model simulation results are compared each other and against observations data. General features of tsunami wave patterns showed good agreement compared with observations data. Tsunami arrival time and maximum runup are also well predicted.

Keywords: *tsunami, Boussinesq equations, dispersion, runup*

INTRODUCTION

The Indian Ocean Tsunami (IOT) on 26 December 2004 is recorded as highest tsunami. Triggered by tectonic earthquake, the tsunami waves are generated by a complicated bottom uplift/downlift with multiple components of amplitude and frequency. The tsunami was globally propagated over the world ocean as trans-oceanic tsunami propagation. Very complicated structures of spatial and temporal waves are observed by many researchers. One of many lessons from the IOT event is the tsunami wave is remarkably dispersive. Kulikov 2005 reported the dispersion effect tsunami waves in the Indian Ocean from wavelet analysis based on satellite data record. It is indicated that for trans-oceanic tsunami propagation, dispersion effect could be significant factor for prediction of maximum amplitude. In the coastal area tsunami waves interact with very complicated bathymetry so the nonlinear combination will affect the profile of tsunami. Hence, model equations which include both dispersive and nonlinear terms are needed for better estimation.

Preliminary results of dispersive numerical model of IOT have been done by Watts et al. 2005 using Boussinesq-type model. Then more detail study of dispersion effect for IOT has been conducted using nonlinear shallow water, nonlinear Boussinesq and the full nonlinear Navier-Stokes models by Horillo et al. 2006. Grilli et al. 2007 also discussed the dispersion effect for IOT event. From the discussions, the dispersion effect is noticed at the south-west direction, while at the east part tsunami is essentially nondispersive.

The aim of this study is to reproduce simulation of IOT event using two different model equations i.e.: dispersive and nondispersive wave models as tools to study the dispersion effect of IOT at the initial stage (up to 3 hours tsunami propagation). The models results are compared each other and against observations data. Better understanding and prediction of tsunami propagation and runup are important for tsunami warning system and for evacuation of peoples when tsunami occurred.

MODEL EQUATIONS AND NUMERICAL SOLUTION

Model Equations

Two sets of model equations are used here i.e.: nonlinear shallow water (NLSW) equations and extended weakly nonlinear Boussinesq-type (WNB) equations of Nwogu (1993). Time-dependent of water depth (bottom) terms are included to the models based on derivation of Lynett and Liu, 2002. By including the time-dependent water depth, the models could be implemented to simulate tsunami generation by tectonic plate motions, earthquakes and underwater landslides. The sets of model equations contain equation for conservation of mass and momentum conservation. The model equations are taken in the following form

$$
\begin{aligned}
&\eta_t + \bar{h}_t + \nabla\cdot\left[\ h+\eta\ \ \tilde{\mathbf{u}}\right] \\
&\quad +\gamma_1\nabla\cdot\Big[\ \tfrac{1}{2}\tilde{z}^2-\tfrac{1}{6}h^2\ \ h\nabla\ \ \nabla\cdot\tilde{\mathbf{u}} \\
&\qquad\qquad +\ \ \tilde{z}+\tfrac{1}{2}h\ \ h\nabla\ \ \nabla\cdot(h\tilde{\mathbf{u}})+\bar{h}_t\ \ \Big]=0
\end{aligned}
\qquad (1)
$$

$$
\begin{aligned}
&\tilde{\mathbf{u}}_t + g\nabla\eta + (\tilde{\mathbf{u}}\cdot\nabla)\tilde{\mathbf{u}} \\
&\quad +\gamma_1\Big[\tfrac{1}{2}\tilde{z}^2\nabla\ \ \nabla\cdot\tilde{\mathbf{u}}\ \ +\tilde{z}\nabla\ \ \nabla\cdot(h\tilde{\mathbf{u}})+\bar{h}_t\ \ \Big]_t \\
&\quad +\mathbf{F}_b-\mathbf{F}_{br}=0
\end{aligned}
\qquad (2)
$$

where h is the still water depth, η is free surface elevation, g is the gravitational acceleration, while $\bar{h}$ is time dependent water depth. Subscript t denotes partial derivative with respect to time. Two-dimensional vector differential operator ∇ is defined by $\nabla = \ \frac{\partial}{\partial x}, \frac{\partial}{\partial y}\ $.

Equations (1) and (2) are full form of model equations used here. Setting variables $\gamma_1 = 1$ and horizontal velocity vector $\tilde{\mathbf{u}} = (\tilde{u}, \tilde{v})$ as velocity at an arbitrary level, $\tilde{z}$, reduces the model equations to WNB equations in which $\tilde{z}$ is recommended to be evaluated at $\tilde{z} = -0.531h$ (Nwogu, 1993). Then setting $\gamma_1 = 0$ and using depth averaged horizontal velocity vector $\tilde{\mathbf{u}} = (\bar{u}, \bar{v})$ i.e. by taking $\tilde{z} = 0$ reduces the model equations to NLSW equations.

The $\mathbf{F}_b$ and $\mathbf{F}_{br}$ terms in (2) are additional terms to accommodate bottom friction and energy dissipation caused by breaking waves, respectively. The bottom friction terms are given in quadratic formula. Although the friction coefficient should be a function of bottom roughness and velocity profile but a simple constant friction coefficient is used in this study. Eddy viscosity formula is used to model the turbulent mixing and energy dissipation caused by breaking waves. Treatment of wave breaking is similar to the eddy viscosity-type formula proposed by Kennedy et al., 2000 and Chen et al., 2000.

Numerical Solution

In order to eliminate the error terms to the same form of dispersive terms in the WNB model equations, fourth-order accuracy of numerical scheme for time stepping and first-order spatial derivatives are used (Wei and Kirby, 1995). High order predictor-corrector scheme is used for time stepping, employing third order time explicit Adam-Bashforth scheme as predictor and fourth order Adam-Moulton implicit scheme as corrector step. The corrector step must be iterated until a convergence criterion is satisfied. The system equations are written in a form that makes convenient for application high-order time stepping procedure. Hence, in Cartesian coordinate system, (1) and (2) are written in the following form

$$
\begin{aligned}
&\eta_t = E(\eta,u,v)+\left[E_1(\bar{h})\right]_t, \\
&U_t = F(\eta,u,v)+\ \ F_1(v)\ \ _t, \\
&V_t = G(\eta,u,v)+\ \ G_1(u)\ \ _t
\end{aligned}
\qquad (3)
$$

$$
\begin{aligned}
E(\eta,u,v) = &-\ \ Hu\ \ _x -\ \ Hv\ \ _y \\
&-\Big[a_1h^3(u_{xx}+v_{xy})+a_2h^2\ \ (hu)_{xx}+(hv)_{xy}\ \ \Big]_x \\
&-\Big[a_1h^3(u_{xy}+v_{yy})+a_2h^2\ \ (hu)_{xy}+(hv)_{yy}\ \ \Big]_y
\end{aligned}
\qquad (4)
$$

$$E_1(\bar{h}) = -\bar{h} -\ \ a_2h^2\bar{h}_x\ \ _x -\ \ a_2h^2\bar{h}_y\ \ _y \qquad (5)$$

$$F(\eta,u,v) = -g\eta_x - (u^2)_x - vu_y - F_b + F_{br} \qquad (6)$$

$$F_1(v) = h\left[b_1hv_{xy} + b_2(hv)_{xy} + b_2\bar{h}_x\right] \qquad (7)$$

$$G(\eta,u,v) = -g\eta_y - uv_x - (v^2)_y - G_b + G_{br} \qquad (8)$$

$$G_1(u) = h\left[b_1hu_{xy} + b_2(hu)_{xy} + b_2\bar{h}_y\right] \qquad (9)$$

$$U = u + b_1h^2u_{xx} + b_2h(hu)_{xx} \qquad (10)$$

$$V = v + b_1h^2v_{yy} + b_2h(hv)_{yy} \qquad (11)$$

where $H = h + \eta$ is total water depth. Subscript t denotes partial derivative with respect to time, while subscript x and y denote spatial derivatives in the x and y direction, respectively. Variables a_1, a_2, b_1, b_2 are defined as

$$a_1 = \tfrac{1}{2}\beta^2 - \tfrac{1}{6}, \quad a_2 = \beta + \tfrac{1}{2}, \quad b_1 = \tfrac{1}{2}\beta^2, \\ b_2 = \beta = \tilde{z}/h = -0.531 \tag{12}$$

for WNB model equations and $a_1 = a_2 = b_1 = b_2 = 0$ for NLSW model equations.

Following Wei and Kirby 1995, Adam-Bashforth scheme is used for predictor step and written as

$$\Omega_{i,j}^{n+1} = \Omega_{i,j}^{n+1} + \tfrac{\Delta t}{12}\ \ 23\Phi_{i,j}^{n} - 16\Phi_{i,j}^{n-1} + 5\Phi_{i,j}^{n-2} \\ + 2(\Phi_1)_{i,j}^{n} - 3(\Phi_1)_{i,j}^{n-1} + (\Phi_1)_{i,j}^{n-2} \tag{13}$$

Adam-Moulton scheme is used for corrector step and written as

$$\Omega_{i,j}^{n+1} = \Omega_{i,j}^{n+1} + \tfrac{\Delta t}{24}\ \ 9\Phi_{i,j}^{n+1} + 19\Phi_{i,j}^{n} - 5\Phi_{i,j}^{n-1} + \Phi_{i,j}^{n-2} \\ + (\Phi_1)_{i,j}^{n+1} - (\Phi_1)_{i,j}^{n} \tag{14}$$

where $\Omega = (\eta, U, V)$, $\Phi = (E, F, G)$ and $\Phi_1 = (E_1, F_1, G_1)$.
The values of u and v at time level (n+1) could be obtained by solving (10) and (11) using double sweep algorithm to solve tridiagonal matrix system.

A staggered grid system (C grid) in space is used to discretize spatial derivatives as shown in Figure 1. The horizontal velocity vectors (u, v) and sea level (η) are organized into triplets as visualized by triangle in Figure 1. The water depth is defined at the same point of sea level at the cell center, while vectors such as velocity components u and v are defined at the interfaces of the cell. At the cell interface, scalars are obtained by linear interpolation. For example, the total water depth at u point can be obtained by

$$\overline{h+\eta}_{\ i,j} = \tfrac{1}{2}\ \ h_{i,j} + \eta_{i,j}\ \ + \tfrac{1}{2}\ \ h_{i+1,j} + \eta_{i+1,j} \tag{15}$$

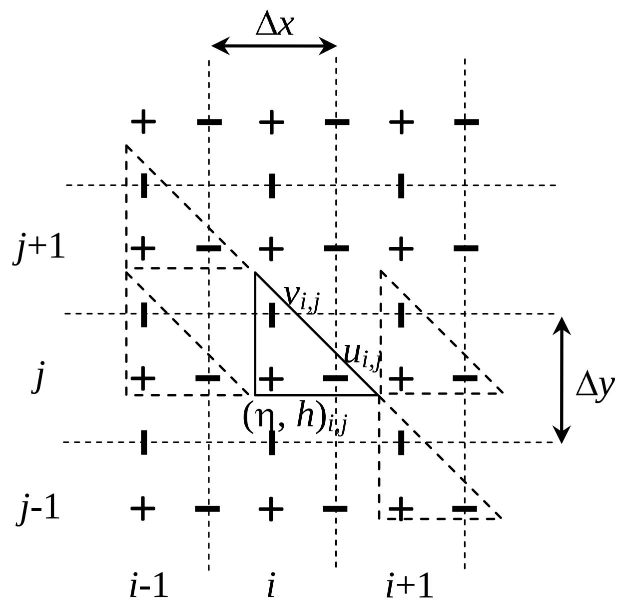

Figure 1 Staggered grid system for spatial discretization

Spatial discretizations are required for various orders of spatial derivatives on the right-hand side of (3) and (4) which include first-order, second-order and second-order cross derivatives. The first-order derivative of $f = \ \overline{h+\eta}\ \ u$ in the x direction is discretized by four-point finite difference method to eliminates fifth-order physical dispersion in the governing equations as follows

$$\left(\frac{\partial f}{\partial x}\right)_{i,j} = \frac{f_{i-2,j} - 27f_{i-1,j} + 27f_{i,j} - f_{i+1,j}}{24\Delta x} \tag{16}$$

The fourth-order accurate for first-order space derivative of η at u-point is

$$\left(\frac{\partial \eta}{\partial x}\right)_{i,j} = \frac{\eta_{i-1,j} - 27\eta_{i,j} + 27\eta_{i+1,j} - \eta_{i+2,j}}{24\Delta x} \tag{17}$$

First-order derivative of u^2 in the x direction is discretized by the following scheme

$$\left(\frac{\partial u^2}{\partial x}\right)_{i,j} = \frac{(u^2)_{i-2,j} - 8(u^2)_{i-1,j} + 8(u^2)_{i+1,j} - (u^2)_{i+2,j}}{12\Delta x} \tag{18}$$

Three-point central scheme is used for second order derivatives in the x direction as

$$\left(\frac{\partial^2 w}{\partial x^2}\right)_{i,j} = \frac{1}{\Delta x^2}\left[w_{i-1,j} - 2w_{i,j} + w_{i+1,j}\right] \tag{19}$$

where w = u or (hu). Similar expressions can be obtained in the y direction for both first-order and second-order derivatives. The cross-derivative terms in the x direction of u_{xy} and $(hu)_{xy}$ are approximated by the following finite difference scheme

$$\left(\frac{\partial^2 w}{\partial x \partial y}\right)_{i,j} = \frac{1}{\Delta x \Delta y}\left[w_{i-1,j} + w_{i,j+1} - w_{i-1,j+1} - w_{i,j}\right] \quad (8)$$

Again, $w = u$ or (hu) and similar expressions can be obtained in the y direction for v_{xy} and $(hv)_{xy}$.

MODEL SIMULATIONS AND DISCUSSIONS

Simulation Conditions

Simulations of The Indian Ocean Tsunami 26 December 2004 are conducted using the numerical models. In order to minimize the grid size and achieves resolution but accommodate gauges and satellite data, numerical domain is selected around Bay of Bengal from longitude 70^0E – 100^0E and latitude 7^0S – 23^0N. Bathymetry data is taken from ETOPO2 databank and refined into one minute resolution by linear interpolation resulting 1800 by 1800 of grid points with about 1.852 km x 1.852 km grid interval in the Cartesian coordinate. Compare to spherical coordinate, the Cartesian coordinate has embedded error of grid definition. The maximum error in the x direction is about 237,076 km (8.58 %) at the north part (23^O N) numerical domain and 44,052 km (1.49 %) at the south part (10^oS). While at the middle computation domain (8^oN) the error is about 27,661 km (0.93 %). It is decided to do not make correction to domain error because most part of research discussion is close to the equator line. The mean water level specified in the model simulation did not include the effects of tides. Coriolis effects also did not include in the models computation.

According to the grid resolution, time interval was chosen to be 2 seconds due to numerical stability of the model. Radiation boundaries are applied at the south, west and east part of numerical domain by adding sponge layers at the corresponding boundaries. Artificial slot technique for treatment 'wet-dry' condition for runup of Chen et al., 2000 and Kennedy et al., 2000 is used here. The continuity equation (1) must be modified to implement the artificial slot. Detail of implementation of artificial slot technique for runup treatment is referred to Kennedy et al. 2000 and Chen et al. 2000. Constant bottom friction coefficients of 0.001 and 0.0 are applied when the water depth less and greater than 1 km, respectively.

Figure 2 Locations of five rupture segment as tsunami source and final form of source elevation as combination of five Okada source determined by Grilli et al. 2007.

Table 1 Generating time and rising time for seafloor deformation to generate tsunami.

	Seg-ment 1	Seg-ment 2	Seg-ment 3	Seg-ment 4	Seg-ment 5
t_0 (s)	0	185	315	360	420
T_{rise} (s)	60	70	90	120	150

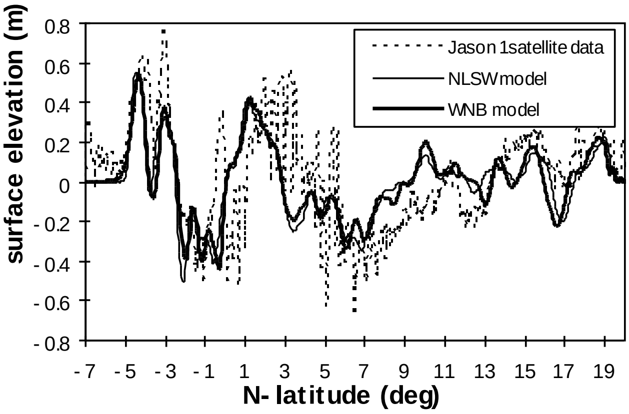

Figure 3 Comparison of surface elevation measured by Jason 1 satellite altimetry and results of model simulation using NLSW model and WNB model

Tsunami Generation

Grilli et. al. 2007 has studied source model of IOT event. The tsunami source is developed based on rupture (seafloor deformation) parameters which estimated by seismic inversion model and other seismological and geological data. According to rupture trench, Grilli et al. 2005 divided the rupture zone into five segments following the trench curvature. Parameter for each segment was characterized and defined by seismic inversion model. The geometry of rupture then estimated by using static dislocation formulae of Okada, 1985. The area of five segments rupture is presented in Figure 2 (left panel). Parameters to determine Okada's formulae for each rupture segment can be obtained in Grilli et al., 2007. The five segments of ruptures then used to find the best tsunami source after it is calibrated to the recorded data of Jason 1 satellite altimetry as published in Gower 2005 and Kulikov, 2005. The final form of seafloor deformation geometry is superposition of the five rupture segments and shown in Figure 2 (right panel).

To obtain a good agreement of sea surface along Jason 1's satellite transect, the five rupture segments are generated in different starting time (t_0) and rising time (T_{rise}) of vertical seafloor movement based on average shear wave speed about 0.8 km/s from the south to the north. Table 1 presents starting time and rising time of vertical seafloor movement of each rupture segment used in this simulations. Figure 3 shows comparison of free surface elevations between numerical results and Jason 1's satellite altimetry data. Model simulation using NLSW model and WNB model show a good agreement with measured data of Jason 1.

Dispersion Effect

To investigate the dispersion effect of tsunami propagation, numerical results of NLSW model and WNB model are compared. As the first check to visualize the dispersion effect, snapshot window of sea surface pattern at time 1 hour 40 minutes of tsunami propagation is depicted as shown in Figure 4. General features of wave evolution agreed very well by all models. However, some differences in reproducing dispersion effect become more noticeable as time advances and longer distance of propagation. The figure shows that the main of tsunami is propagated to the south-west direction, i.e. Maldives islands. Wave pattern at the west part simulated by WNB model is slightly different compare to the NLSW model result. The tsunami front face is shifted and split into more then one wave yielded a series of wave propagation in which the first one has higher amplitude and longer period than the last one.

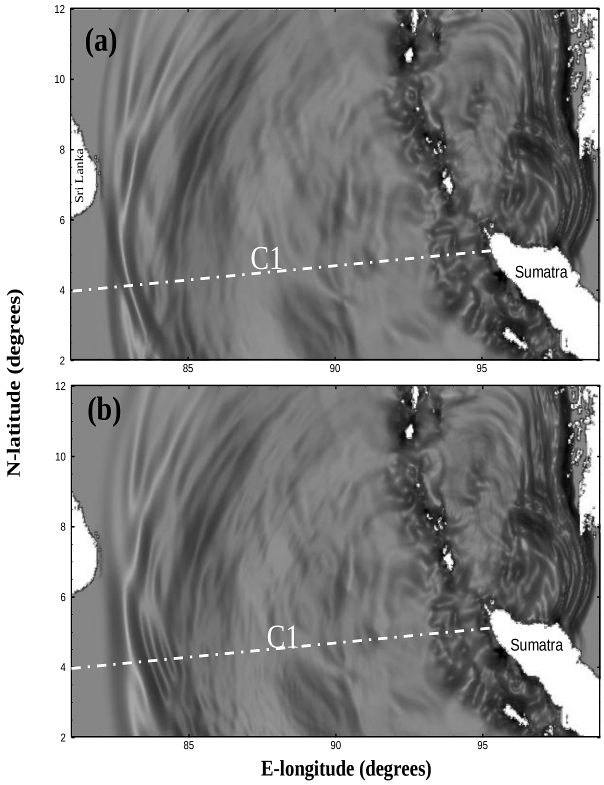

Figure 4 Snap shot window of surface elevation at time 1h 40min of tsunami propagation computed by: (a) NLSW model and (b) WNB model

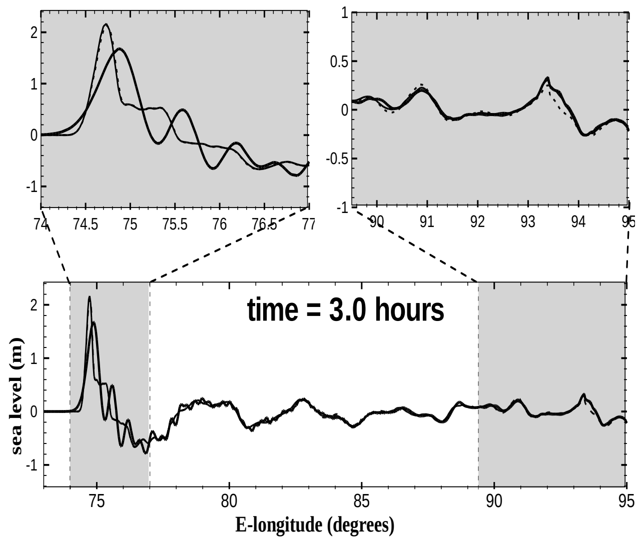

Figure 5 Spatial profiles along line C1 at t = 3 hours simulated using NLSW model (thick lines) and WNB model (bold lines)

The dispersive effect is proportional to the water depth, so the dispersive effect at the west part of the source is stronger compare to the east part. The dispersion effect at the west is also enhanced through longer distance of propagation. At the east direction, the computation of wave pattern by NLSW model and WNB model is not significantly different. Beside shallowness of water depth at this area, the dispersion effect did not have enough time to develop because of short distance propagation.

Spatial profiles of sea surface along transect line C1 as shown in Figure 4 is presented in Figure 5 at time 3 hours tsunami propagations to visualize more detail of the dispersion effect. Generally, agreement between the dispersive and nondispersive model is very good but after long distance propagation to the south-west direction the advantage of dispersive model is remarkable. Initially, free surface profiles produced by WNB and NLSW models are not significantly different. But after long time and long distance propagation through relatively deep water, the front face profile is gradually different. The tsunami front face is oscillated and changed by the dispersion effect. According to Figure 5, at time t = 3 hours the WNB model yields at least three waves of tsunami front face at the south-west direction along line C1 with the wavelength of first, second, and third waves are 141, 83, and 64km, respectively, measured from trough to trough. The average water depth is $h \approx 5$ km, therefore the corresponding values of kh for the three waves are 0.2206, 0.3747, and 0.486, respectively. According to the value of kh, the second and third waves are categorized as intermediate water wave. Hence, the NLSW model is less accurate for this case. Although the second and third waves are categorized as intermediate water wave, the approximation of dispersive term in WNB model still give accurate estimation of wave speed because the values of $kh < 1$. The leading wave height at this time is over predicted more than 20 % by the NLSW model.

At the east part, the agreement between NLSW and WNB model results are quite good. When tsunami wave entered runup phase, nonlinear interaction with complex bathymetry strongly influenced the dispersion effect. Horillo et al. 2006 pointed out that the dispersion consideration in the numerical models is necessary for accurate prediction for the cases of tsunami entered continental shelf, bays or harbors in which tsunami produced oscillations through the resonance. However, there are no established coastal observations which clearly represent dispersion mechanism.

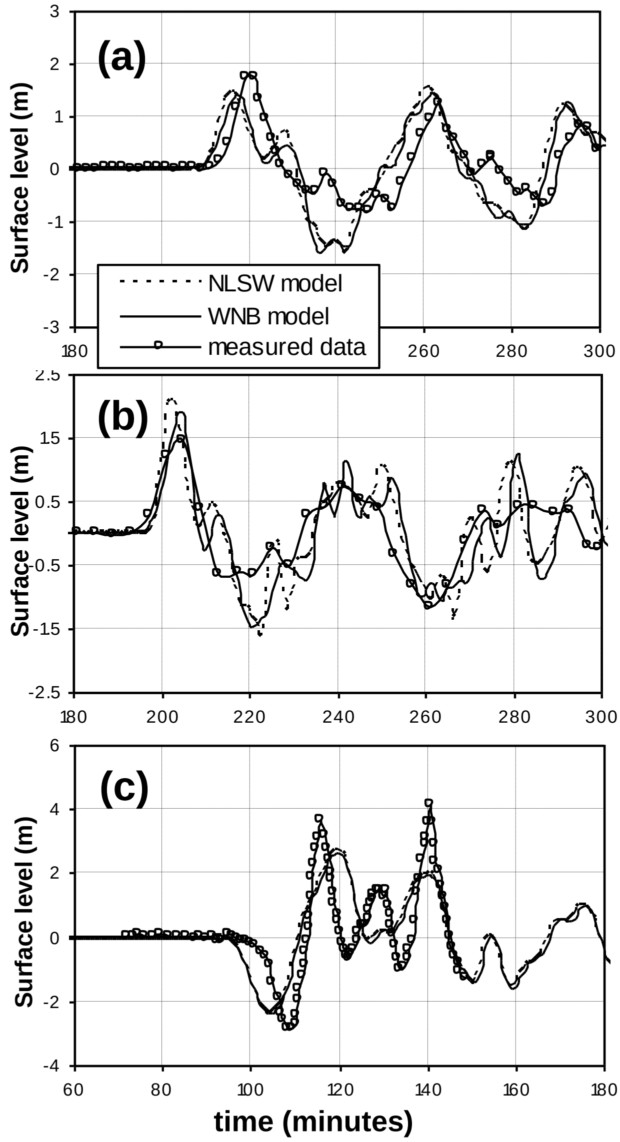

Figure 6 Comparisons of temporal sea level between measured data (as published in Grilli et al., 2007) and model simulations at: (a) Hannimadhoo (b) Male, and (c) Merchator yacht

Following Grilli et al. 2007, measured data of tsunami elevations around simulation domain are compared to the model results. Only three gauges locations are discussed here, two tide gauges at the Maldives: Hannimadhoo (73.17^0E, 6.77^0N) and Male (73.54^0E, 4.23^0N), and one by a Belgian yacht ''Merchator'' at Nai Harn Bay (SW of Phuket). The measured data is digitized from Grilli et al., 2007. All of model simulations overpredicted of tsunami arrival times at all locations. Generally, the simulated and measured time history of tsunami elevations agree very well in all tide gauges as shown in Figure 6. It is noted that because of coarseness of bathymetry data used here, the locations of tide gauges are not perfectly match between models and observations.

At the Maldives as shown in Figure 6 (a and b), it can be seen a good agreement between observed and model results. General pattern of temporal variation of sea levels are match with observations data for at least three waves. After long distance propagation, the dispersion effect is noticed at those gauges. However, the bathymetry effect is reduced the dispersion effect created by WNB model, hence, similar results are obtained by NLSW model and WNB model but the NLSW model over predicted of maximum height compare to WNB model and measured data.

In Figure 6(c), the NLSW and WNB models give the same results. Compare to the observations data of yacht Merchator, the profile is not match. Local coastal topography effect is not resolved very well by the models, so the time shift is different between models and measurement. Maximum height is underpredited by the models. Therefore, finer grid resolution at the east area is needed for better estimation.

CONCLUSIONS

Numerical simulation of the December 26, 2004 Indian Ocean tsunami has been performed using dispersive and non-dispersive wave models (WNB and NLSW models, respectively). Comparisons of simulation results using the two models notified the dispersion effect especially through oceanic tsunami propagation. Simulation results using the two different model equations showed that the NLSW model is quite reliable for practical purpose because this model gives consistent results compare to WNB model and observations data. However, including the dispersive terms will improve accuracy of the prediction.

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STUDY ON FLOOD CHARACTERISTIC IN SIBU TOWN, SARAWAK, MALAYSIA

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ABSTRACT

Sibu Town located in the Mid Rajang River-130km from South China Sea and 60km upriver from the mouth of Rajang River. Rajang River basin can be divided into Upper Rajang, Mid Rajang and Lower Rajang with 760 km in total length with areas of 51,237 km^2 and the longest river in Malaysia. Sibu Town is one of the large flood prone areas in the Sarawak State. Flood in Sibu Town mostly occur during heavy monsoonal rainfall coinciding with occurrences of King Tide's disturbances. Consequently, a study is carried out to understand the flooding history in Sibu Town, Sarawak. To indentify the flooding scenario, rainfall and tide data are collected from Department of Irrigation and Drainage (DID), Sarawak and Sarawak Marine Department. The principle objective of this study is to find out characteristic features of tidal influences over Sibu Town. Sibu Town is sited on low-lying area (2m-5m MSL) and is covered with peat in that exposed to ground subsidence. Ground subsidence causes adjustment on drainage gradient that inundated Sibu Town from the backwater effect. The survey results indicated that overflowing flood water from Rajang River and Igan River submerged part of Sibu Town. A number of case histories are presented to define the flood characteristic of Sibu Town. Among the selected case studies are January 12 to 15, 2003 flood event whereby it was caused by extreme rainfall, January 25 to 31, 2004 where Sibu Town was flushed by tidal water and December 26 to 29, 2008 which was caused by extreme rainfall coinciding with King Tides. In the nut shell, tidal influences are the root of contributing flooding in Sibu Town.

Keywords: *Post-flood analysis, Tidal influences, Sibu Town, Rajang River, Peat*

INTRODUCTION

Floods are most costly natural disasters. Heavy rainfall for several hours or days caused when the strength of the stream is so high it flows out from the river channel, particulary at bends or meanders and causes damage to homes and businesses along the river. Flash floods occur suddenly when drainage system is blocked or rising water along a stream or low-lying area. The most devastating environmental issue facing the world today is the global warming which raising the sea-level that causes flooding to planet earth. Global temperatures are already higher compared to the past millennium (Mann et al., 1999) with an increase in the range of 1^{0}C to 3^{0}C and the increase is accelerating even faster than scientists had predicted (Ramanathan, 2006). Ocean is the only viable reservoir of internal heat that could have caused the atmosphere to warm. On the other hand, observations by Wang and Chameides 2007, show that the heat content of the ocean has increased over the past few decades as illustrated in Figure 1 causing ice-berg at hemisphere to melt and hence raising the sea-level. After a brief summary of relative sea-level changes and tidal influences of river which might contribute to flooding phenomena in Malaysia.

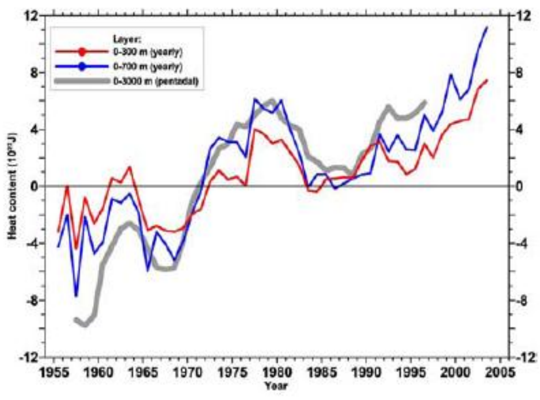

Figure 1 Change in heat content of ocean 1995 to 2005 (Wang and Chameides, 2007).

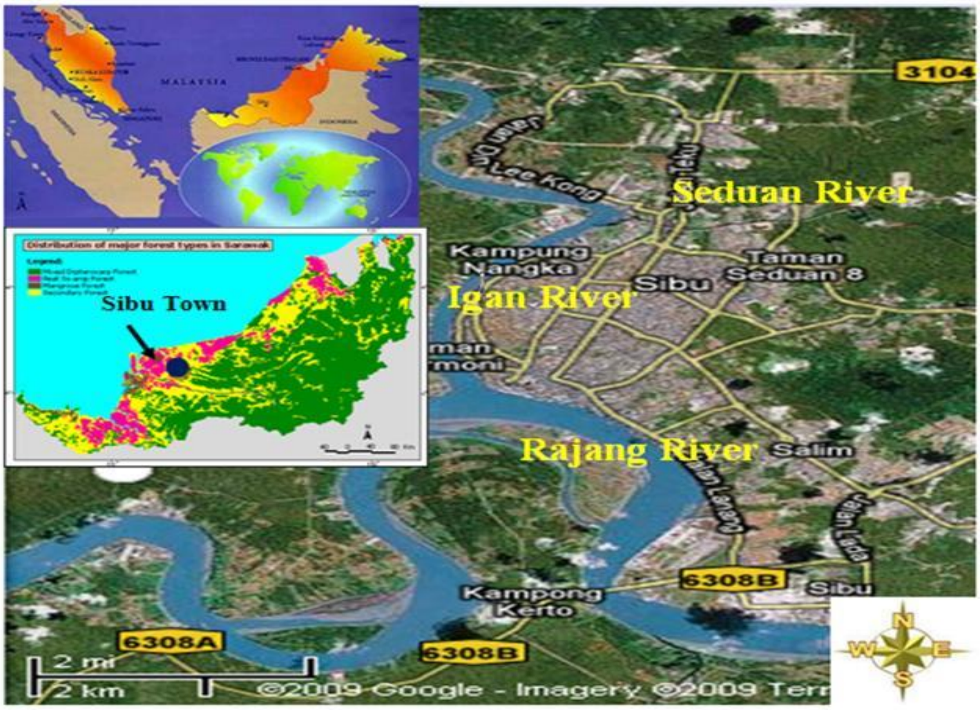

Figure 2 Sibu Town is bounded by Rajang River, Igan River and Seduan River (http://maps.google.com).

Malaysia is fortunate to be freed from natural disasters such as earth quake, volcano and typhoon. The most severe natural disaster experienced by Malaysian is flood. Flooding is ranked the most destructive disaster in the world, caused extensive damages to the world over the past years resulting in human losses and extensive economic damages (Environment Agency, 2001). In Malaysia, floods are regular natural disasters especially in Sarawak which happen nearly every year. Sarawak encountered rainfall 3905.0mm annually in Year 2007 with annual total surface water runoff about 306 billion m^3 (DID, 2007). Most floods occur are a natural result of cyclical monsoons during the local tropical wet season that are characterized by heavy and regular rainfall from October to March (Ho, 2002).

According to Kazuo et al. (1996), there are two main types of floods. The first type is the flood where water running into a river from a drainage area towards flooded river over the embankment or river dike into the inland area, because of shortage in the water-carrying capacity of the river due to small cross sectional area of river or waterlogged soil-peat. The second type is the flood which consists of water that overflowed from the inland drainage channels before reaching to the river and that was discharged from the sewerage conduit lines. The main objective in this paper is presenting flood type occur in Sibu Town with three significant case studies.

STUDY AREA

Sibu Town is the capital of Sibu District in Sibu Division, Sarawak, East Malaysia and is located at the confluence of three rivers namely Rajang River, Seduan River and Igan River (Figure 2). Home to more than 250,000 people of various races, religions and origins, Sibu Town is located in the Mid Rajang River-130km from the South China Sea. As the longest river in Malaysia, the Rajang River has also a large catchment area. The Rajang River Basin can be divided into Upper Rajang, Mid Rajang and Lower Rajang with 760km in total length with areas of 51,237km^2.

SOIL CHARACTERISTICS OF SIBU TOWN

Sibu Town is swampy areas which undergo substantial formations of peat soils compared to other parts of Sarawak. In Sarawak, about 1.66 million hectares are covered with peat swamp which is 13% of the State's total land area as demonstrated in Figure 3 (Tie and Kueh, 1979).

Peat formations in some parts of Sibu Town are as deep as 10 meters. Peat soils which is classified as 'soft soils', with more than 75% organic content (Tang, 2009), present a challenge for infrastructure development. According to Tan (1993), lowland peat is more extensive and occurs in low-lying poorly drained depressions or basins in the coastal areas.

However, tropical lowlands performed their major function in holding high capacity of water which serve as reservoirs of fresh water, stabilize water levels, reduce storm-flow and maintain low-flow (Safford and Maltby, 1998). On the other hand, peat areas contributed to excessive rates of land subsidence, ranging from 2 to 5cm/day (Wösten et al., 1997), due to the drainage system. In Sibu Town, peat covers an extensive area as shown in Figure 4.

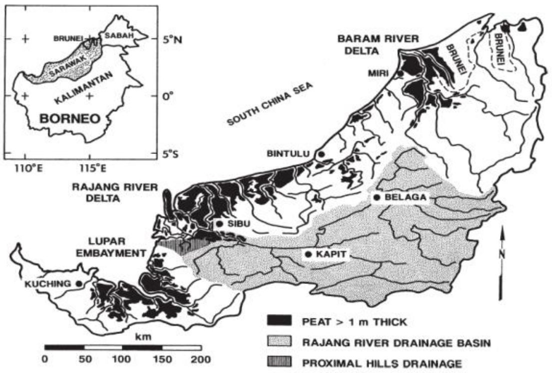

Figure 3 Major peat-forming in Sibu where the peat deposits more than 1m deep (Staub et al., 2000).

The quaternary geology of Sibu Town is illustrated by Lam (1998) as shown in Figure 5 and nine auger holes are carried out from east to west to understand the peat profile. Besides, Hassan et al. (2003) undergone twenty six auger holes crossing from north to south of Sibu Town as demonstrated in Figure 6. Through the understanding of the quaternary geology, soft soils condition of Sibu Town can be recognized and physical characteristics of the peat influence by hydrological behavior can be identified. Melling (2009) stressed that the peat lands tend to subside via consolidation and oxidation upon drainage loading. Therefore, drainage system was designed to create flood-free conditions and to eliminate waterlogging (Lim, 1994) and prevent backwater effect from river tidal influences due to subsidence..

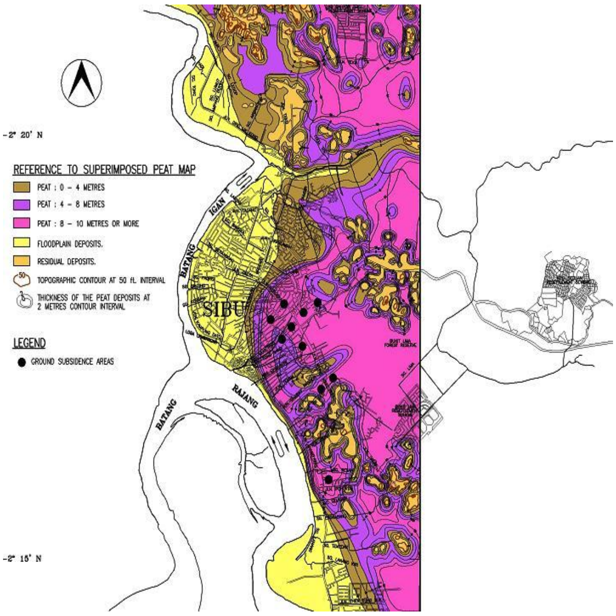

Figure 4 Sibu Town covered on peat with respect to depth of peat (Lam, 1998).

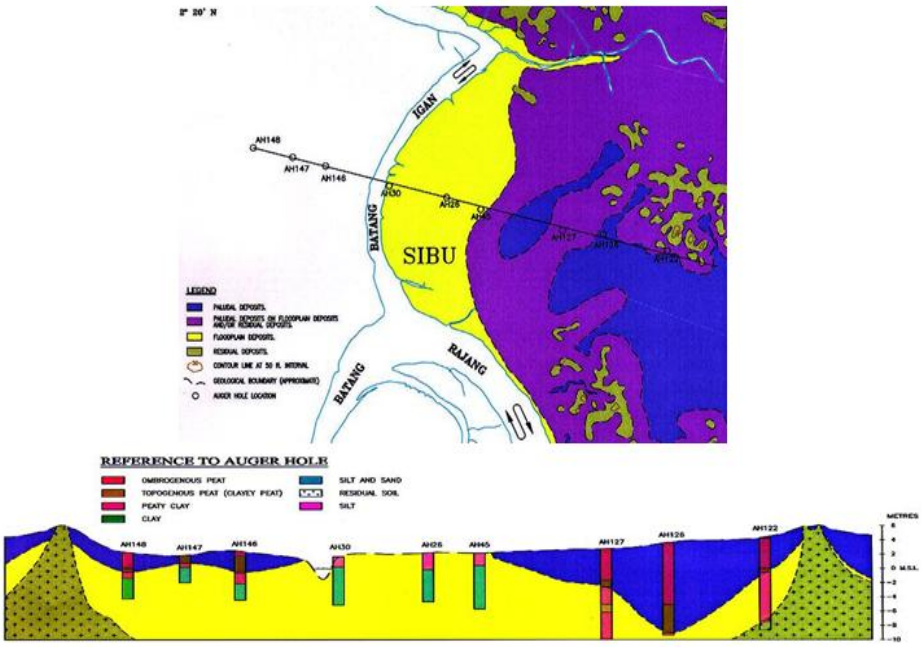

Figure 5 Cross-section of Sibu Town from east to west (Lam, 1998).

POST-FLOOD CHARACTERISTIC OF SIBU TOWN

Flooding has been major threat to Sibu's community since October 1955 where the flood height reaches 5 feet. Floods in Sibu Town were documented for a long historical record as tabulated in Table 1.

A long historical record of flooding is documented in the archives since 1963 whereby the flood height reaches 20 feet. After 38 years, in February 2001, whole Sibu Town was flooded to 1 to 2m deep. In January 2004, Sibu Town was hit by the disaster at the record of 1m deep. Then, December 2007, 1.5m deep of water affected most area in Sibu Town is inundated. After half a year in July 2008 flood again attached Sibu Town where many low areas are covered with water to about 0.3m deep. Sibu Town faced massive amount of rainfall totaling an incredible 4,196.5mm for the whole January that was blamed for the February 2009 flood.

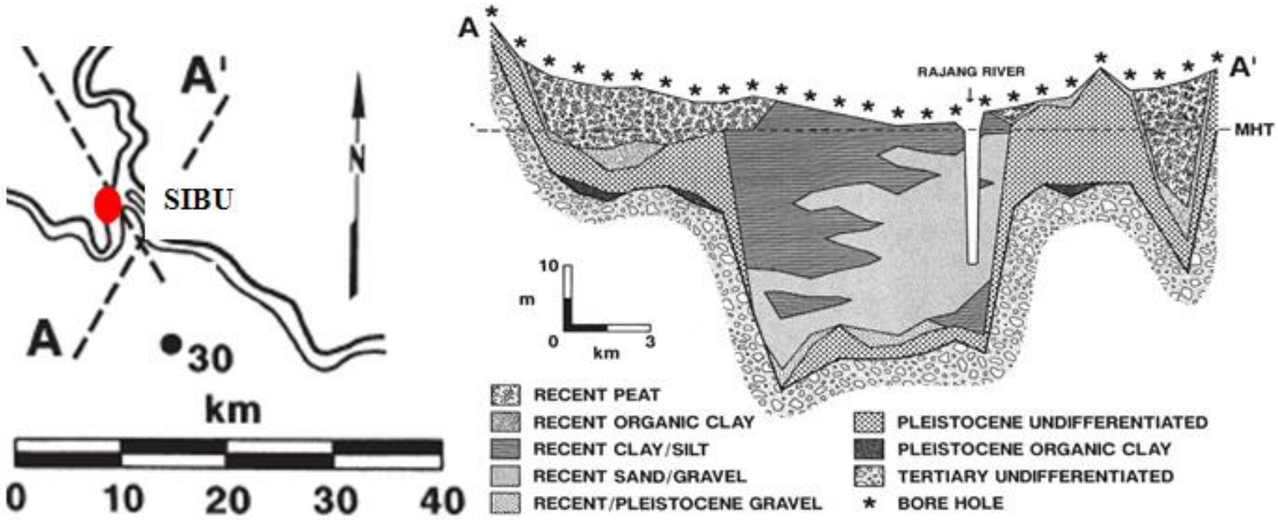

Figure 6 Cross-section of Sibu Town from north to south (Hasan et al. 2003).

Furthermore, the inundation was aggravated by the occurrence of the King Tide especially on January 30 and 31, 2009 when low-lying areas and roads were under at least 3m of water. These major flooding had caused undesirable adverse effects that lead to damage of property and loss of life. In Jun 2009, the flood was coincided with King Tide, which had flooded most of local residents along the Rajang River.

Recently, flood attached Sungai Merah area on November 14, 2009 with 0.5m deep. These devastating scenarios are imaged in Figure 7. Hence, investigation had to be conducted to analyze the flooding in Sibu Town.

Table 1 Historical flood events recorded in Sibu Town, 1993-2009.

Events	Affected Flood Areas	Flood Height
Dec 1993	Sibu Town	1-8feet (0.3-2.4m)
Nov 1997	Sibu Town	0.6-0.9 m
Feb 2001	Whole Sibu Town	0.1-2 m
Mac 2002	Sibu Town	0.1-0.3 m
Jan 2003	Sibu Town	0.3-1 m
Jan 2004	Sibu Town	0.3-1 m
April 2005	Sibu	0.1-0.3 m
Dec 2007	Sibu Town	0.3-1.5 m
July 2008	Lanang Road, Tiong Hua Road, Hua Kiew Road and Ulu Sungai Merah	0.1-0.3 m
Dec 2008	Sibu Town	0.3-1 m
Jan 2009	Sibu Town	1-2 m
Source: Department of Irrigation and Drainage Sarawak http://www.did.sarawak.gov.my		

FLOODING EVENTS

The Storm of 12 January to 15 January 2003

Sibu Town is covered with peat soil and the peat swamps are waterlogged most of the year and drainage is needed to make it suitable for land uses. The rainfall runoff was not fully drained due to several conditions such as poor maintenance on the drainage, undersized drainage and culvert, siltation, ground subsidence that causes adjustment on drainage gradient and low-lying areas (2m-5m MSL) as illustrated in Figure 8.

Storm on January 12 to 15, 2003 is a typical example of flood event that dealing with problems that caused by precipitation and runoff, particularly during periods of excessively high rainfall. Flash flood area in Sibu Town was recorded in Table 2 (DID, 2003) due to abundant rainfall recorded at 146mm on January 13, 2003 (Figure 9) where the discharge to the nearby river was maximized.

Figure 7 Inundation of Sibu Town.

Figure 8 Current situations that causes flood to Sibu Town

Table 2 Flood survey on January 13, 2003 at 08.30-14.00 hours.

Location of Residence	Highest Flood Level (m)	Flood Area (m^2)
Jln. Tun Abg Hj. Openg	0.23	30
Jln. Apollo	0.44	100
Jln. Ulu Sg. Merah	0.92	620
Jln Pedada	0.3	53
Jln. Belian	0.28	260
Jln. Hua Kiew	1.28	780
Jln. Foochow	0.32	120
Jln. Aman	0.31	55

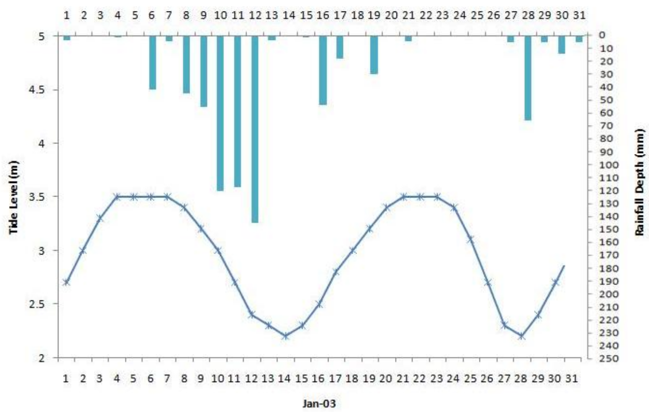

Figure 9 Tide level and rainfall intensity on January 2003.

The Storm of 25 January to 31 January 2004

Sibu Town is flushed by tidal water which designated in Figure 10 showing that during high tide influences will affect the residential area along the shoreline. Thus, high tide coincided with extreme rainfall will submerged the area of Sibu Town.

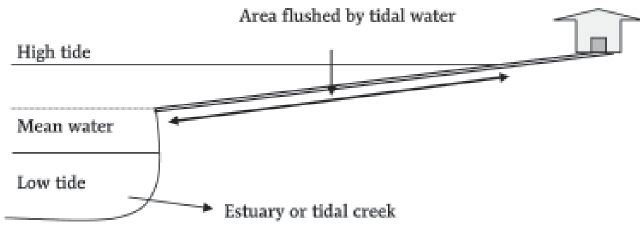

Figure 10 Schematic diagram of intertidal area of Sibu Town.

High tide occurs in January 25, 2004 that shows Sibu Town was inundated (Figure 11). With tide level of 3.5m MSL (Figure 12), part of the Sibu Town was submerged with water because of relatively flat and low-lying floodplain. Flood survey carried out by DID 2004 was documented in Table 3.

Table 3 Flood survey on January 26, 2004 at 11.25-12.25 hours.

Location of Residence	Highest Flood Level (m)	Flood Area (m^2)
Jln. Tun Abg Hj. Openg	0.15	250
Jln. Apollo	0.3-0.45	100
Jln. Ulu Sg. Merah	0.55	300
Jln Pedada	0.3	1000
Jln. Belian	0.25	1000
Jln. Hua Kiew	0.6	1000
Jln. Foochow	0.4	200
Jln. Aman	0.7	50

Figure 11 Inundated Sungai Merah area on January 2004.

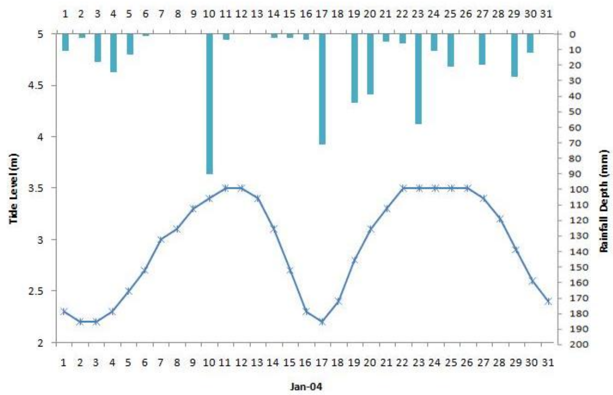

Figure 12 Tide level and rainfall intensity on January 2004

The Storm of 26 December to 29 December 2008

For the past decade, Sibu Town is frequently submerged by water during monsoon season (Figure 7). Heavy localized rainfall at Upper Rajang River from December 24 and 25, 2008 coinciding with King Tide causes Sibu Town flooded. Figure 13 showing the high tide of

3.73m MSL on December 27, 2008 with 93mm rainfall depth triggered low-lying areas of Sibu Town (Figure 14). The worst affected was at Jalan Salim to Stabau areas whereby 10km of the road was submerged and maximum flood depth was between 0.6m to 0.9m and otherwise tabulated in Table 4 (DID, 2008). The devastating disaster receded and returned to normal condition on December 30, 2008 when tide level and rainfall intensity trimmed down.

Table 4 Flood survey on December 27, 2008 at 10.00-12.25 hours.

Location of Residence	Highest Flood Level (m)	Flood Area (m^2)
Bukit Assek	0.35	650
Jln. Belian	0.37	100
Jln. Hua Kiew	0.31	180
Jln. Lanang	0.18	100
Jln. Aman	0.28	400

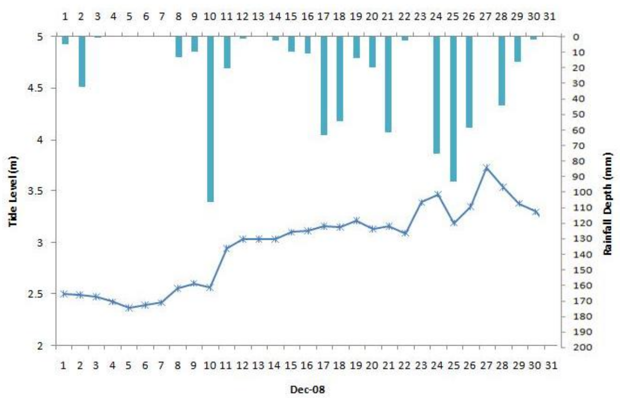

Figure 13 Tide level and rainfall intensity on December 2008.

CONCLUSION

This study had found that high tide coincided with extreme rainfall causes Sibu Town inundated. From the past flood records, tidal influences indeed were the major contribution to Sibu Town flooding. With Sibu Town covered with peat soil, the excessive subsidence rates result in a pronounced drop in elevation of the land reducing the efficiency of the drainage system. In addition to tidal influences and ground subsidence, Sibu Town is exposed to flood when monsoon rainfall struck. Therefore, stormwater management plan should be established and implemented to solve flood in Sibu Town.

Figure 14 Inundated of Kampung Bahagia area with maximum flood depth of 0.67m.

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The authors would like to express their gratitute to the Department of Irrigation and Drainage, Sarawak (DID) Sibu Office, and would also acknowledge the Research and Innovation Management Centre, Universiti Malaysia Sarawak for all invaluable assistances in conducting this research for a Master degree Student in the Best Management Practice for Flood Mitigation in Urban Peatlands Environment.

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THE IMPLICATION OF PEATLAND BUILT ENVIRONMENT IN URBAN DRAINAGE SYSTEM: CASE STUDY OF SUNGAI MERAH AREA, SIBU, SARAWAK

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ABSTRACT

The main purpose of this project is to conduct an analysis to the flooding of Sungai Merah residential area, Sibu, Sarawak. The total catchment area is approximately 13.74ha with relatively flat and typically of a low-lying floodplain which covered with peat. Poor maintenance, severe conditions and undersized culvert on the current drainage system in Sungai Merah residential area causes flooding to the area in addition to the water-logged soil. Post-flood forensic analysis of Sungai Merah residential area presented an approach using InfoWorks Collection System (CS), coupled with its embedded Geographic Information System (GIS) applications, to identify hydrology of the drainage pattern. The digital map featuring Sungai Merah area was used to create GIS map using ArcMap from Arcgis 9. Hydrology and hydraulic data collected is used for model calibration and verification for 2.4km-long of drainage network in Sungai Merah residential area during December 26, 2008 and February 26, 2009 flood events. InfoWorks CS is satisfactorily capable of providing a clear picture of flood event through model simulation. Besides, excess rainfall do not influence the surface-runoff of peatlands which been verified by InfoWorks CS. From the study, the root of flood in Sungai Merah area is triggered by the backwater from Seduan River and the current existing drainage is fail to manoeuvre the current situation. Furthermore, InfoWorks CS demonstrates its capability for flood inundation modelling on Sungai Merah area. Thus, it is recommended that further improvement on the drainage network and floodplain in Sungai Merah residential area to create a better understanding of the drainage's flowpath.

Keywords: *Peatland, Urban Drainage, Flood, InfoWorks CS*

INTRODUCTION

Peat soils are identified as "soft soils" with more than 75% organic matter content (Tang, 2009). Compared to mineral soils, peat has a much higher infiltration capacity, drainable pore space and hydraulic conductivity (up to 30m per day) of the surface (approximately first 1 metre) of peat layer but have lower capillary rise, bulk density and plant-available water (Wösten et al., 2003). In Malaysia, 1.7 million hectares or 63% of peat swamp are in delta and coastal plains of Sarawak. In Sarawak, approximately 1.66 million hectares or 13% of the state's total land area are covered with peatlands (Singh and Bujang, 2003). The aerial extent of peat swamp forest in Sarawak is shown in Figure 1. About 90% of these peat areas are classified as deep peat with peat layer of more than 1m in depth (Tie and Kueh, 1979).

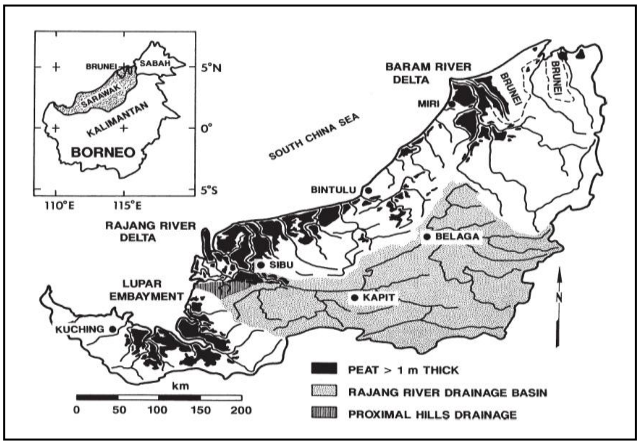


Figure 1 Peat swamps in Sarawak (Staub et al. 2000).

The lowland peat swamps in Sarawak are purely rain-fed and waterlogged most times of the year. Drainage is the leading principle of the water management practice in order to curb flooding by evacuation of excess rainfall within a period of time which is mainly removed by surface runoff. Furthermore, variation in tidal level may have a direct and consequential bearing on the water level in drainage. Therefore, forensic investigation is the key to identify the causes of the floods in peatland.

BACKGROUND OF THE PROJECT AREA

Sibu Town is the capital of Sibu District in Sibu division, Sarawak with its confluence of three major rivers namely the Rajang River, the Seduan River and the Igan River. The research site (Figure 2) is located at Sungai Merah, Sibu, Sarawak which is about 5km from Sibu Town.

Sungai Merah is located on Seduan catchement with an area of 116.6km^2. Water level measuring gauges are also located at Sungai Merah, which record water level continuously in every interval of 30 minutes.

The project area is fairly flat and relatively low-lying with ground levels ranging from below 2.0 to 3.0 MSL. Its locality is located in the central part of Seduan catchement. The peat's properties covers Sungai Merah residential area with a shear stress of 4.87kPa, compressibility index of 1.045 and bulk density of 0.08g/m^3 (Ting, 2009). The shocking floods in December 26, 2008 and February 26, 2009 had struck the middle and lower part of Seduan catchement due to extreme rainfall with addition to high tidal events.

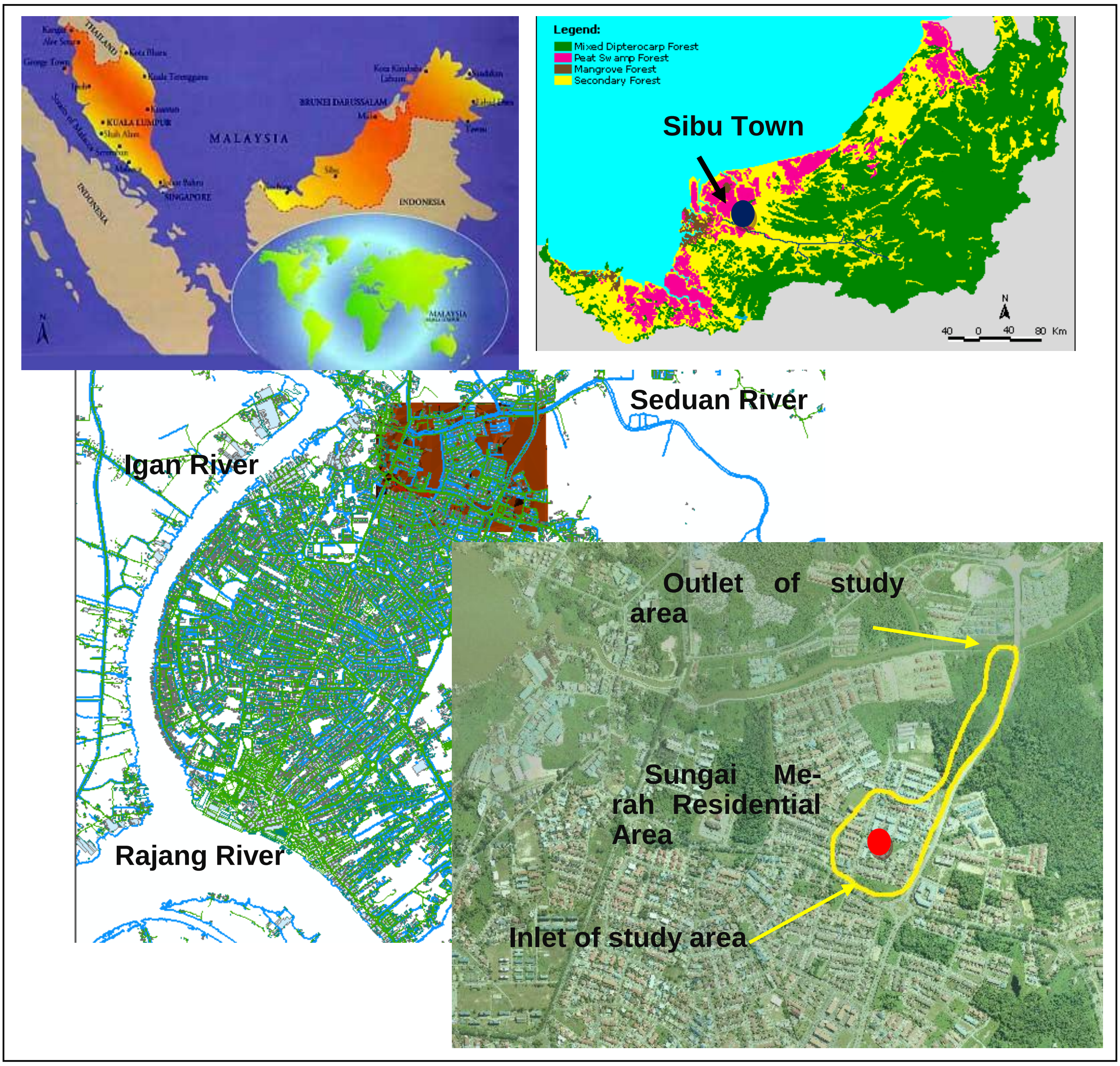


Figure 2 Location of the study area.

The urban catchment of Sungai Merah covers an area of 13.74ha of residential area. Sungai Merah residential area is facing frequent flood, whereby water rises and subsides in matter of hour. Flood might be caused by poor maintenance of existing drainage or from earth drain which has waterlogged soil. Figure 3 highlights a few conditions of existing river and drainage.

Figure 3 Current condition of existing drainage and contributing drainage system

The objectives of conducting this study are the reconstruction of December 2008 flood to analyze and comprehend floods behaviors in Sungai Merah area, studying the hydrology of the drainage pattern in Sungai Merah area and lastly engaging a comprehensive analysis of the performances on the exisiting peatlands drainage system for future development purposes.

RESEARCH METHODOLOGY

The research involved data collection, model development, calibration, verification and analysis (Figure 4). Nowadays, technology such as computer software namely InfoWorks, MOUSE, MIKE and the SWMM Models are used to develop computer models in order to study on the drainage or sewer system and river flow.

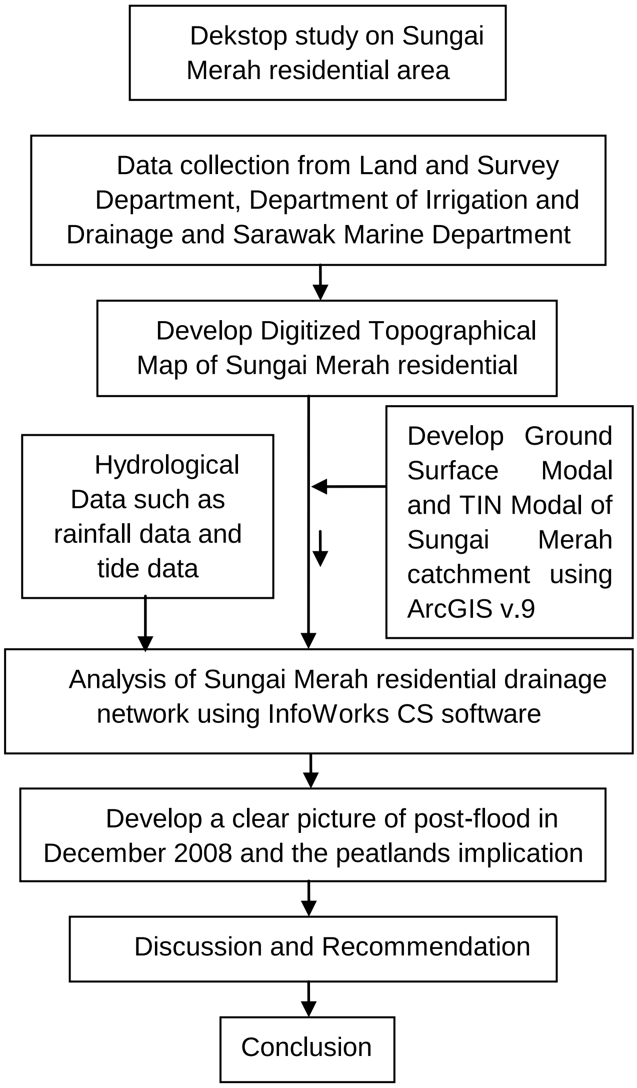


Figure 4 Flowchart of research methodology.

InfoWorks Collection System (CS) is used to develop 1-Dimensional Urban Drainage System (Figure 5) with its embedded GIS applications modeling Sungai Merah catchment. InfoWorks CS supports the input of all network data from models such as HydroWorks, DHI/MOUSE and SWMM (InfoWorks CS Technical Review, 2009).

Data required in the model development comprises of hydrology data such as the rainfall data and tide data from the Department of Irrigation and Drainage (DID), Sarawak. Apart from that, catchment characteristic, soil type and hydraulic data (water level, discharge and channel manning roughness coefficient) is taken into consideration.

The United States Soil Conservation Service

(SCS) Method is preferred for rainfall-runoff analysis in the model simulation. This analysis is being adopted because of its simplicity and applicability to those watersheds of ungauged catchment with minimum hydrologic information of soil type, land use and treatment, surface condition, and antecedent moisture condition (AMC) (Leow et al., 2008).

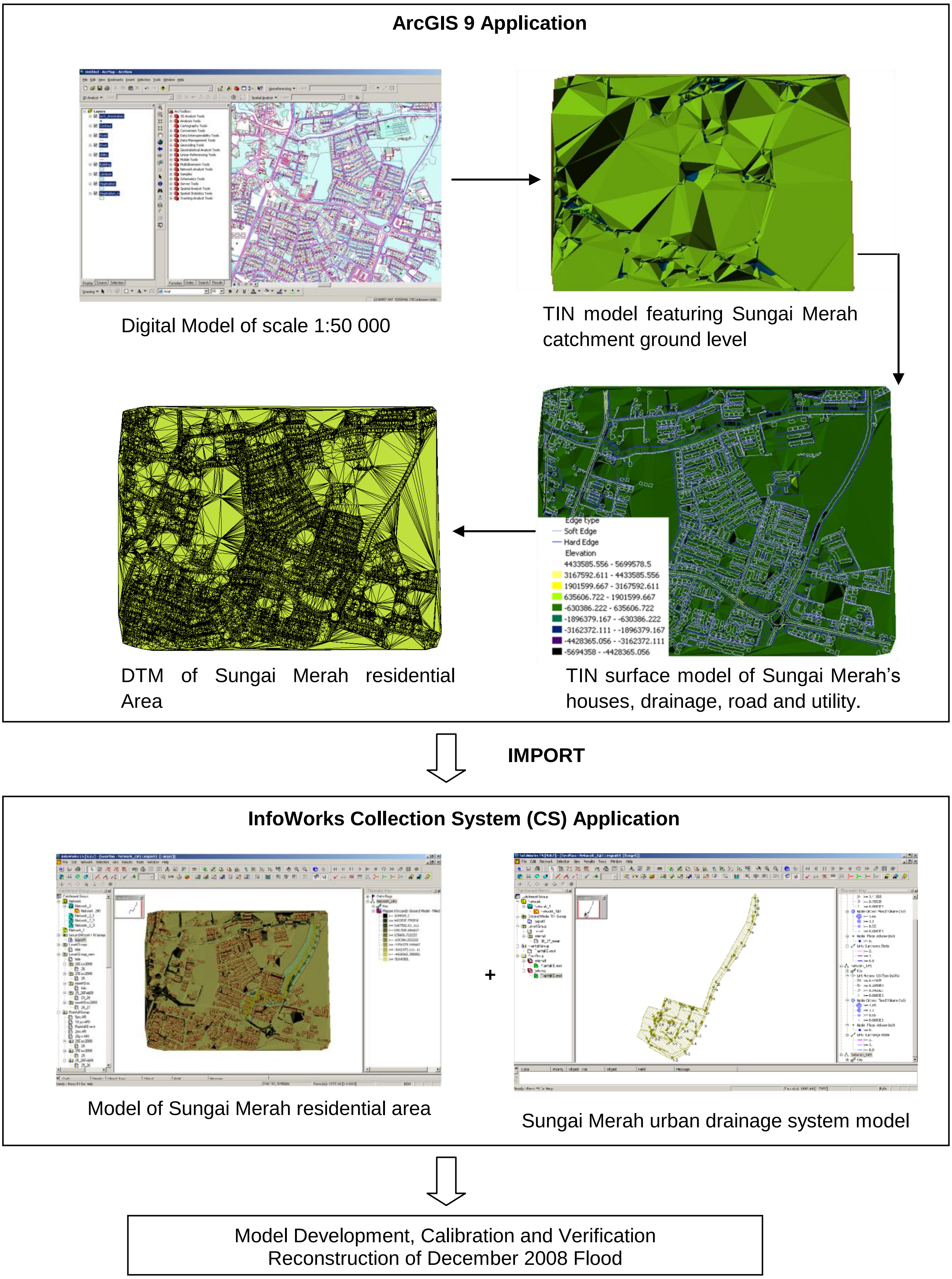


Figure 5 Schematic diagram of model building.

Hydrodynamic of Sungai Merah residential drainage network is simulated using numerical modeling. The hydrodynamic modeling used to predict the flood depth and performance of the existing drainage system.

MODEL BUILD-UP

Sungai Merah catchment and its floodplan-7.68ha were modeled with 1.3km-long drainage network using InfoWorks CS. A 1:50 000 scaled digital topographical map of 5m contour intervals featuring Sungai Merah area which is requested from the Land and Survey Department, Sarawak. In addition, 1:10 000 scaled Seduan River sounding is bought from Sarawak Marine Department and digitized using ArcGIS 9.

The Sungai Merah Catchment modeling first took place with ground modeling of Sungai Merah residential area using Geographic Information System (GIS) technology. GIS later displayed terrain features of Triangulated Irregular Network (TIN) dataset. The digital map featuring Sungai Merah area was used to create GIS map using ArcMap from ArcGIS 9. The TIN model was exported to InfoWorks CS as a Digital Terrain Model (DTM) where the ground surface information was used for network building. The resulting TIN consisted of approximately 125,000 triangles based on contour and mass points.

InfoWorks CS version 9 was used in this study. The model is a hydrology and hydraulic mode, which has its capability in urban drainage components (Liew et al., 2008). Sustainable Drainage System (SUDS) components were also included in the model necessary in small scale residential area. Firstly, DTM is exported into InfoWorks CS through its implanted GIS tool-Geographical Plan and later used to generate and display ground level contours, drainage, roads, buildings and ultility of Sungai Merah catchment. The sub-catchment of each compartment of housing areas was delineated based on available contour lines and inventory data. Nodes and conduits are then digitally placed along the existing drainage to form drainage network.

RESULTS AND DISCUSSION

Calibration and Verification

The model was calibrated against flood level of a selected historical flood event on February 26, 2009 whereas model verification-event on December 26, 2008 is tabulated in Table 1 and illustrated in Figure 6 and Figure 7. Additionally, runoff from the sub-catchment is calibrated and verified for both events as listed in Table 1 and shown in Figure 8 and Figure 9. The calibration method was made by adjusting certain network component to obtain the effect of the model. This scenario was due to lack of information on the areas and flood records. Relevant information such as flood depth was obtained from local authorities. Among the adjusted parameters are the SCS Curve Number (CN=87), Manning coefficients, η (η=0.03) and catchement slope. The selected parameters of certain network component can be adjusted by percentage to view the effect of changes on the model.

Table 1 Results of model calibration and verification.

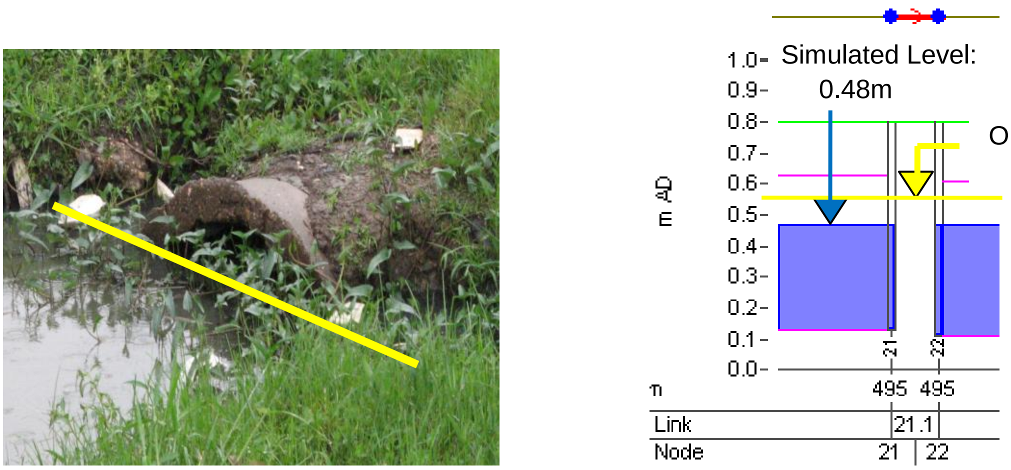
Event	Peak Water Level (meter)		
	Observed	Simulated	Differences
February 26, 2009	0.55	0.48	0.07
December 26, 2008	0.60	0.53	0.07
Event	Peak Runoff (m^3/s)		
	Calculated	Simulated	Differences
February 26, 2009	$5.13x10^{-4}$	$5.37x10^{-5}$	$2.3x10^{-5}$
December 26, 2008	$9.48x10^{-3}$	$9.50\ x10^{-3}$	$2.0x10^{-5}$

Peatlands Implication on Drainage network

Two different types of flood scenarios were simulated in Sungai Merah drainage system namely internal flood and external flood. Internal flood is the scenario, where heavy rainfall was occurred and there was no tide (normal water level). The flow and the velocity of the existing drainage network were observed whether the drain can cater for the amount water runoff during high intensity storms. External flood is the scenario, where heavy rainfall is occurred in coincidence with the high tide.

The peatlands are abundant with extensive water-logged soils (Gore, 1983). Research done by Ong and Yogeswaran 1991, stated that the high infiltration, water holding and transmitting capacity of peat influences the relatively small fluctuations in the water table.

Besides, as external flood, it is influenced by King Tide levels along Seduan River with extreme rainfall intensity.



(a) Calibration and verification point (During normal flow)

(b) Observed and simulated water level during February 26, 2009 (Long section)

Figure 6 Calibration result for Sungai Merah area during February 26, 2009.

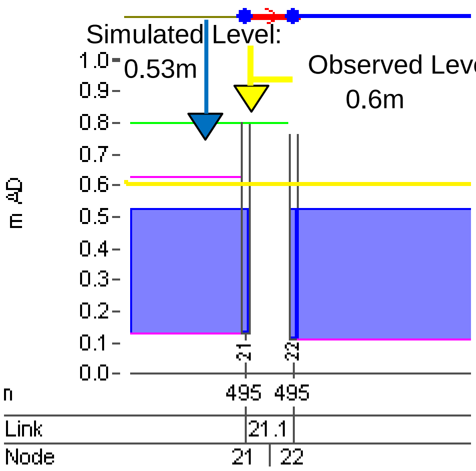


Figure 7 Verification result for Sungai Merah area during December 26, 2008 (Long section).

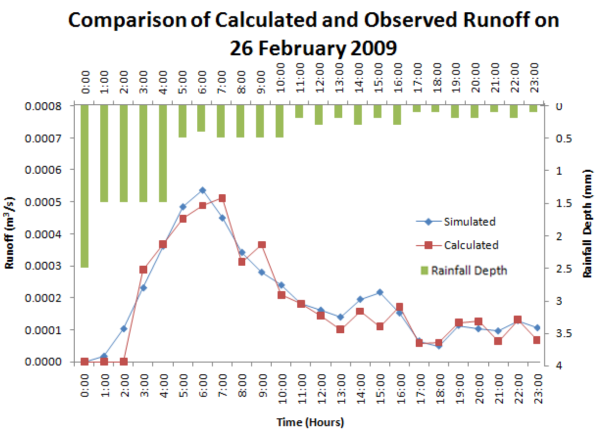


Figure 8 Model calibration (Runoff event on February 26, 2009).

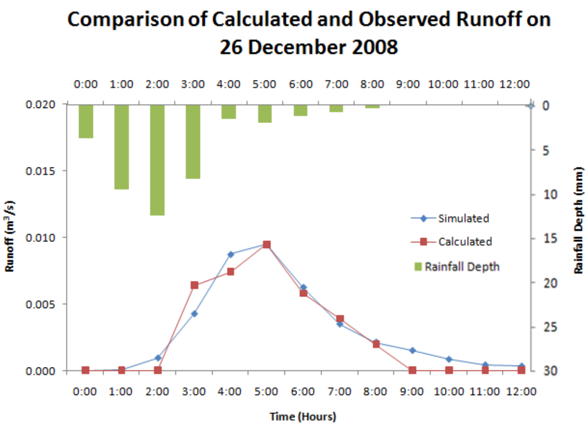


Figure 9 Model verification (Runoff event on December 26, 2009).

From the simulation that has been carried out, results demonstrate that the most critical scenario is when the heavy rainfall and fluctuation of water levels in Seduan River coincided. This will affect the water level in the drainage and causes flooding to the Sungai Merah residential area. In the nut shell, flooding in Sungai Merah low-lying areas depends much on the tide influences.

The simulation results (Table 2) offers a way to identify the problems, sources of flooding and potential problems to Sungai Merah resident. The results were taken from the culvert in Figure 6(a) whereby the inlet and outlet is connected to the earth drain.

Table 2 Comparison of flow, velocity, surface-runoff and average flood depth for internal and external flood.

Events	Internal flood (influence by heavy rainfall)	External flood (influence by heavy rainfall and high tide)
Peak Flow (m^3/s)	0.21	0.14
Peak Velocity (m/s)	0.156	0.111
Average Flood Depth (m)	0.31	0.44

The simulation results (Table 2) offers a way to identify the problems, sources of flooding and potential problems to Sungai Merah resident. The results were taken from the culvert in Figure 6(a) whereby the inlet and outlet is connected to the earth drain.

During internal flood, the 0.21m^3/s of flow in drain with 0.156m/s in velocity is higher than external flood of which the flow is 0.14m^3/s with a velocity of 0.11m/s as illustrated in Figure 10 and Figure 11. This study strongly suggests that the influences of backwater effect from the Seduan River significantly affect the flood in Sungai Merah area. Thus, present studies by Ritzema and Wösten 2002, confirmed that in the lower-lying areas, drainage may be possible only during low-tides.

Furthermore, Ritzema and Westen 2002 and Holden et al. 2006 added that excess rainfall will not be removed as surface runoff but mainly as groundwater runoff for peatlands area. The surface-runoff (Figure 12) of Sungai Merah area is tabulated in Table 3. The result is verified using InfoWorks CS as shown in Figure 13. In addition, the model demonstrates that the Sungai Merah area will still be flooded due to internal flood resulting from excessive rainfall which is not influence by high tide. The impact from high tide will make the flood in Sungai Merah area more dreadful. Hence, fundamental aspect of flood in Sungai Merah area is triggered by the Seduan River's backwater as demonstrated from the comparison results of the two events as stated in Table 2.

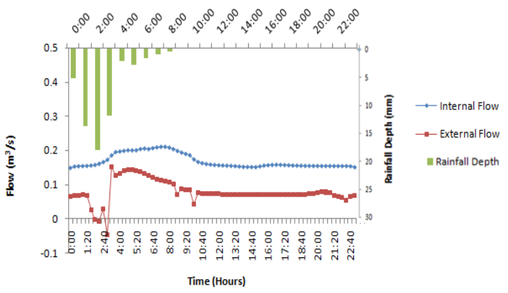


Figure 10 Comparison of flow for internal and external flood in December 2008.

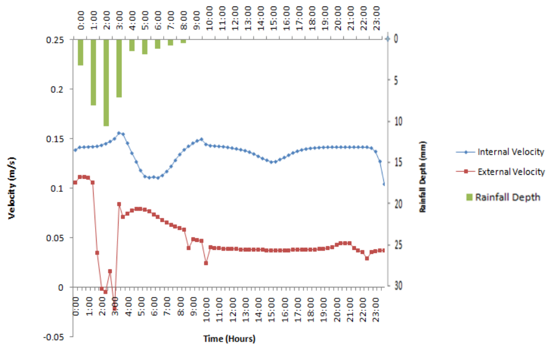


Figure 11 Comparison of velocity for internal and external flood in December 2008.

Table 3 Comparison of surface-runoff for internal and external flood.

Events	Internal flood	External flood
Surface-Runoff (m^3/s)	0.011	0.011

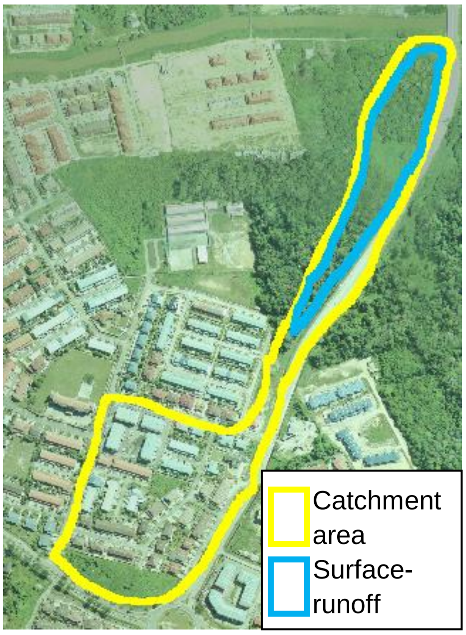


Figure 12 The location of the surface-runoff in Sungai Merah area.

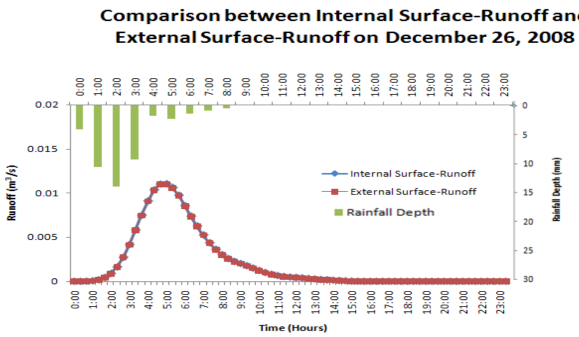


Figure 13 Comparison of surface-runoff for internal and external flood in December 2008.

Therefore, the results simulated using InfoWorks CS is believed to be sufficiently strong to provide information of flood in Sungai Merah area. In this study, InfoWorks CS has successfully identified the implication of peatlands on flood. Hence, further improvement on the drainage network system in the Sungai Merah area can be studied for a better implement.

CONCLUSION

The simulation demonstrates its capability for flood study on urban storm drainage in peat lowlands area. The current results of simulation give a clearer picture of the drainage flows, velocities, surface-runoffs and flood depths of an area along with tide level from the river channel. Further improvement on current existing drainage system in Sungai Merah residential area needs to be reconsidered in order to endure extreme rainfall and King Tide from Seduan River. The created model also allows better understanding of the drainage's flowpath for future development and research work. However, simulation on larger study area, where more observed hydrological flood data are available is recommended for better understanding on the drainage behavior on the peatlands environment.

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RESPONSE POLICIES TO THE IMPACT OF CLIMATE CHANGE ON SMALL ISLAND TOURISM (Case Study: Kepulauan Seribu Tourism Area)

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ABSTRACT

Indonesia, as the largest archipelagic country in the world, has both big and small islands. There are many islands which are categorized as small islands. Based on their natural and cultural potential, some of these small islands have been developed for tourism destinations. In some remote small islands, tourism is the main economic generator of economic sustainability of the area and the population. In the last ten years, the earth has been facing problems of climate change, which can be identified from air temperature, rainfall intensity, humidity, and wind variabilities. Many countries or regions have already faced the impact of climate change, while many other countries or regions might face the same problems in the future. Small islands will also face the impact of climate change through physical phenomenon such as sea level rise and tidal wave, storm, intensity of rainfall. All of these changes might influence the attractions potential of the island and therefore it would change the intensity and pattern of tourist visitation, which finally influence the life and economy of local inhabitants.Tourism sector in small islands in Indonesia are also vulnerable to climate changes. Therefore, to reduce the climate change impact on tourism, particularly small island tourism, there should be structural and non-structural approaches, including policies related to the socioeconomic, cultural, and political condition. This article will identifies the policies in response to potential impact of climate change on the tourism in small islands so that it can reduce the negative impact and protect tourist and local population from the hazard.

Keywords: *climate change, impact, small island tourism, response policy*.

INTRODUCTION

Tourism is one of the largest and fastest growing economic sectors (Hamilton, J. M, et al., 2005). UNWTO (2006, 2009) states that number of international arrivals have increased from 25 million in 1950 to 808 millions in 2005 and to 924 million in 2008.

International tourism represents approximately 7% of the worldwide export of goods and services. For more than 80% of countries in the world, tourism is one of the top five export categories, and for around 40% of countries, it is the main source of foreign exchange earnings. Some 11% increase in global revenues generated annually by international tourist arrivals is above the rate of growth of the world economy (Becken and Hay, 2007).

Tourism is related to climate. Favourable climatic conditions in destinations areas can became key attractions for tourists. Climate is important factor for the success of beach and small island destinations.

Weather can spoil vacations, while climate can damage holiday destinations. There are many small island tourism destinations which might be a vulnerable to the climate change. Until present, the research on the impact of climate change on small island tourism destinations particularly in Indonesia is very limited. Therefore it is important to study the impact of climate change on small island tourism; and then to prepare adaptation and response policies/programs to minimize the impact.

The Seribu Island, particularly Bidadari Island, was selected as a case study of a small island tourism area.

GLOBAL CLIMATE CHANGE

Climate change has become one of the world's main issue and one of the most significant challenges to humanity in this century. The term Climate Change (IPCC, 2007) refers to any change in climate over time, whether due to natural variability or as a result of human activities

Climate change is affecting human life and tourism sector as well as several other economic sectors. Until 2005 the tourism literatures pay little attention to climate or climate change.

Based on the observation since 1958, the carbondioxide levels on the atmosphere are increasing which then stimulate global air temperature (Gore, 2006). Global greenhouse gas (GHG) emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. During 1850-2005 global air temperature increased 0.76^{0}C on average. Based on the data of air temperature since 1850, 11 of the last 12 years (1995-2006) were periode with the highest average air temperature (IPCC, 2007).

Analysis of observational data from various countries indicated an increase in surface air temperature. The IPCC (2007) report stated that air temperatures are rising across all small island regions. By 2100 the largest increase is expected in the Mediterranean of between 1.20^{0}C and over 7^{0}C followed by the Caribbean and the Northern Pacific with a roughly 1^{0}C to over 4 ^{0}C increase.

The annual and seasonal ocean surface and island air temperatures have increased by 0.6 to 1.0ºC since 1910 throughout a large part of the South Pacific while to the northeast where decadal increases of 0.3ºC to 0.5ºC in annual temperature have been observed since 1970. The increases in surface air temperatures have been greater in the Pacific than global rates of warming (World Bank, 2000).

The projections of global warming indicate a warming trend for all small island states ranging from an annual mean change of 1.98°C in the Pacific Ocean to a change of 2.10°C in the Indian Ocean by the 2050s. Sea surface temperatures are projected to increase by 1°C (UNFCC, 2007; SEM, 2007).

In Southeast Asia and the South Pacific, significant increases have been detected in the annual number of hot days and warm nights, with significant decreases in the annual number of cool days and cold nights. Almost all observation stations have exhibited increases in the frequency of hot extremes and decreases in cold extremes significantly (UNFCC, 2007; SEM, 2007).

Climate change is also marked by the changes of air pressure and rain intensity. Observation on rain intensity of Indonesia (1979 to 2006) showed that average of rain intensity was increased 2-3 %. Some stations showed increases in annual rainfall from extreme events whilst some showed decrease in the number of rainy days.

The IPCC (2007) report also indicated sea level projections for this century to rise 1.8 mm per year during 1961-1990 and between 0.09 to 0.88 m per year for the period of 1990-2100. In the last 100 years, water sea level averagely has risen in between 10 - 25 cm.

The impacts of climate components change are as follows (Republic of Indonesia, 2007; IPCC, 2007):

1. Increased air temperature:
   a. Increased fire risk.
   b. lost of biodiversity.
   c. increased on diseases risk.
2. Rainfall intensity.
   a. changed in planting seasons.
   b. increased on floods and landslides risks.
   c. increased of drough and food scarcity.
3. Sea water rise.
   a. coastal areas inundation and erosion
   b. Intrusion of sea water.
   c. small islands disappearanced.
4. Sea water temperature:
   a. Lost of biodiversity.
   b. Fisheries.
5. Wind/Storm.
   a. disturb transport activities.
   b. damaged infrastructure.
   c. Increase in food scarcities.
   d. disturb economic activities.
   e. disturb distribution of good and services.
   f. lost of lives.

Indonesia is prone to disasters, many of which relates to climate components. During 2003-2009, there were more than 1,500 disasters and more than 50% of which were related to climate components (such as flooding, landslide, storm, drought, and forest fire). Floods and storms accounted for 70% climate-related disaster, while drought, landslides, forest fire accounted for the rest (305). Some of the disaster caused degraded natural ecosystem, and thousand of victims (Republic of Indonesia, 2007).

During El Nino years, 8 reservoirs in Java have produced electricity below normal capacities. El Nino has also caused serious problems to coral reef ecosystems where 90-95% of coral reefs at the depth of 25 meters have experienced coral bleaching (Republic of Indonesia, 2007; UNDP, 2007).

SMALL ISLANDS AND TOURISM

The definition of small islands is usually based on two criterias i.e the size or area and the number of population. Based on area, Department of Marine and Fishery-Republic of Indonesia (2002), and also UNESCO (1990) have categorized an island as a small island if the area is less than 10,000 km^2, while according to Brookfield, it is 1,000 km^2 (Beller, 1990). Beside area, categorization of small island is also based on the number of population which is < 200,000 person (Republic of Indonesia, 2002), or < 500,000 person (UNESCO, 1990), and < 100,000 person (Beller, 1990). Other specific characteristics of small islands are ecologically separated from mainland, have a clear physical boundary, isolated from main island habitat, and are not capable of influencing hydroclimate.

In several cases, small islands have a specific environment. Small island experiences wave action from all sides, and tend to have small water catchment area so that much freshwater or runoff and sediment lost into the sea (Beller, *et.al*, 1990). Small islands also have a social, economic, and cultural conditions, which are specific compared to the mainland.

Based on its type, small islands can be distinguished into mainland, volcanic, and atoll. Each type has specific biophysical conditions which should be considered in the sustainable management of small islands.

Small islands could also be categorized into (IPCC, 2001): independent small island states, islands that are considered to be part of another region (e.g. Singapore in Tropical Asia, Bahrain in the Middle East), islands that constitute part of a larger country (e.g. the thousands of small islands of Indonesia), islands that are administered by a metropolitan country, such as the United Kingdom, the United States, France, or The Netherlands.

The majority of small island states in theworld are concentrated in four tropical regions: the tropical Pacific Ocean, Indian Ocean, and Caribbean Sea and the Atlantic Ocean off the coast of West Africa. Some small islands are found outside these areas, e.g Cyprus and Malta, which are located in the Mediterranean Sea (IPCC, 2001).

The climates of most small islands are generally moderated by the maritime influence, with lower maximum and higher minimum temperatures than continental land masses at the same latitude. Most small islands also have distinct seasonal patterns of rainfall and temperature. Some islands in the Pacific and Indian Oceans and the Caribbean Sea periodically are subjected to the devastating influences of tropical cyclones (IPCC, 2001).

In many small islands, agriculture and fisheries are the main economic activites. There are two types of agriculture system used, i.e. subsistence agriculture for providing their daily food supply and cash crop agriculture for their income revenue.

Tourism is one of the important economic components of small islands. Tourism provides new opportunities, employment and economic benefits to small island communities. Tourism development could be used as a strategy by several small islands to attract investment in order to support economic development. Tourism also contributes to the economic growth of many small island, which offer tourism attractions to visitors if they do not have any other alternative to support economic development.

Many remote small islands are highly dependent upon revenue earned from tourist arrivals and through tourist-related activities. In Carribean, tourism earnings have a significant share for the foreign exchange earnings where travel and tourism accounts for 14.8% of GDP, 12.9% of employment and 14.6% of total exports. Oceania also has a similar economic profile with GDP shares of 11.7%, employment 12.4% and exports of 16.9% (Nurse, *et al.,* 2009).

IMPACT OF CLIMATE CHANGE ON SMALL ISLANDS

Whether the existing extreem climate condition is a climate change phenomenon or only climate variability, climate change has affected various sectors and development activities. In many countries, climate change has caused not only disadvantages and damages but also a number of victims. The impacts are felt mostly in developing countries like Indonesia.

Climate changes, which are indicated by the changes of air temperature and rainfall intensity, have caused many impacts in many regions. The changes of rain intensity have caused a flooding or inundation, while the long dry season has caused a drought. In agricultural sector, the changes of rainy season pattern have influenced production through changes of growing season in many areas of Indonesia.

It was observed that sea water level in Jakarta Bay increased 0.57 cm annually. It is predicted that by the year of 2050 all coastal areas in Indonesia will rise about 0.28-4.17 meters, which will flood or inundate coastal areas (Tempo, 2007).

Some important projected impacts of climate change on human settlements (Sudradjat, 2008) are:

1. Millions of people are projected to suffer from flooding more regularly due to sea level rise.
2. Poor communities are mostly vulnerable particularly those concentrated in high risk areas.
3. The most vulnerable societies are generally settled in coastal and river flood plains.

Several destination areas, such as small islands, have experienced an impact of climate change component such as high air temperature, high intensity of rainfall, storm. The main impact is destructions of tourism attractions and supporting facilities which caused decreasing of visitors.

Several small island states reported that parts of their islands were submerged. New Guinea, for example, reported that seven of their small islands in Manus Province are sumerged. In Kiribati, three small islands are also submerged, while 30 others are beginning to disappear. Kiribati is not the only small island states which lost their island from the earth. It is predicted that 14 small island states from 44 members of small island states are going to submerge due to the rise of sea water level (IPCC, 2007).

In Pacific Ocean, the threat of sea water level rise has been faced not only by Kiribati but also by Seychelles, Tuvalu, and Palau. While in the Indian Ocean, there is Maldives which will be loosing all their small islands. Therefore, all population of Maldives (369,000 person) will have to be relocated. Vanuatu also faces the same problems where they should relocate their population (212.000 persons) to other small islands. However, this state still have other empty small islands so they do not need to rent an island from other states (IPCC, 2007; Verebalavu, 2008).

In Pacific small islands, the climate change affects coastal areas, water resources and human settlement. Changes in temperature, rainfall and sea water rise have accelerated coastal erosion, saline intrusion into freshwater lenses and increased flooding from the sea which has large large impacts on human settlements (Penehuro, 2007). While less rainfall coupled with accelerated sea-level rise compound the threat on water resources, a 10 percent reduction in average rainfall by 2050 is likely to correspond to a 20 percent reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati (Penehuro, 2007).

Tourism in Fiji Island is highly vulnerable to climate change. The future impact is degradation of natural systems, e.g. coral reefs and forests (Penehuro, 2007). A small island with relatively high land (such as Viti Leru, Fiji), may suffer from annual agricultural losses between \$20 million and \$50 million by 2050 which is equal to 3 per cent of Fiji's GDP. Low lying islands such as Kiribati's Tarwa group may be facing average annual losses between \$8 and \$16 million a year which equal to around 17 per cent of Kiribati's current GDP. As a result of droughts, there will be loss of soil fertility and degradation due to more extreme rainfall (IPCC, 2007).

Climate change had increased the frequency of storm events (IPCC, 2001). It can be seen in the last several years through more big hurricane (Jeannie, Dennis, Emily, Frances, Ivan, and Katrina), tornados, and typhoons (10 typhoons in Japan in 2004). Tropical Cyclone Ofa (in 1990) changed the Pacific island from a food-exporting country to island which dependent on imports for two years (IPCC, 2007).

Briguglio (1993) who developed a "vulnerability index" for different categories of nations (based on export dependence, insularity and remoteness, and proneness to natural disasters) concluded that small island states was more vulnerable than any other group of countries to projected climate change impacts. On a scale from 0 (lowest vulnerability) to 1 (highest vulnerability), a score of 0.590 (the highest index) was derived for the small island group. Based on Briguglio's index, 9 of the 10 most vulnerable countries are small islands.

Pernetta (1988, in Watson, 1998) ranks Pacific islands in terms of their vulnerability to sea-level rise, taking other factors (such as elevation) into consideration. Based on his classification, small island such as the Marshall Islands, Tuvalu, and Kiribati would suffer "profound" impacts, including disappearance in the worst-case scenario; "severe impacts," resulting in major population displacement, would be experienced by the Micronesia, Nauru, and

Tonga; "moderate to severe impacts" would be experienced by Fiji and the Solomon Islands; and "local severe to catastrophic" effects would be experienced by Vanuatu and Western Samoa.

Sea-level rise and accelerated beach erosion, degradation of coral reefs (including bleaching), and the loss of cultural heritage on the coasts through inundation and flooding could reduce the attractiveness of small island to tourists. Increases in the frequency or intensity of storm also affect the tourism industry. For example, in Barbados, 70 per cent of the hotels are located within 250 m of the high water mark. This could place them at inundation zone and risk of major structural damages (UNFCC, 2007).

World Travel and Tourism Council (2008) predicted that contributions of tourism to GDP and employment in Carribean and Oceania in 2018 will be declining due to the impact of climate change or other factors (Nurse *et al*., 2009). As an example in the Jamaican tourism industry, expected losses as an impact of climate change are US$ 70.9 million and US$ 353.7 million if the necessary mitigation and adaptation strategies are not implemented. Other case is wind, storm extreme rainfall and flood caused by hurricane Mitch that have also destroyed several tourism areas in Carribean islands. As result, many tourists redirected their visit to other safer tourism destinations areas. The recovery program of casualties caused by hurricane was predicted around $ 22 million or around 3.1% from GDP (http://www.oceans atlas.org).

Several areas of Indonesia (Yogyakarta, Sukabumi, Simalungun, Bandung, Kudus, etc) were also badly hit by storm which caused damages to houses, buildings and trees. Storm also hit tourism area of Pangandaran (south east West Java), Anyer, Sukabumi, Kuta, Ancol and other tourism areas. All those case had resulted in damages, injuries and death.

SMALL ISLAND TOURISM OF INDONESIA

Indonesia is one of the largest archipelago countries in the world with 17,508 islands. Most of the islands are small islands located in remote areas and have no name. The daily economic activities of most population in Indonsia's small island depend on traditional agricultural and fishery activities. Most of the populations live in poor condition with a relatively low income. Human Development Index of most small islands is also relatively low.

Although in general most small islands have a low natural as well as cultural potency and limitation, there are still many other small islands which have big potencies to be developed to support the development of small islands. One of these potencies is tourism sector. Small islands which have developed tourism activities based on their specific attractions are Karimun, Karimunjawa, Bangka Belitung, Radjaampat, Bunaken, Komodo, Gili Air, Terawangan, Selayar, Nusa Penida, Menjangan, Komodo, Biak, Takabonerate, Seribu, and many other islands.

The Seribu islands, part of Jakarta Capital Special Region, has about 110 small islands which consist of settlement island, tourism island, and non-populated island, etc. Settlement islands consist of 10 islands with the number of population about 25.000 persons. Density of population varies from 50 persons/hectares to 210 persons/hectares. Several islands have a very high population density, which actually over the carrying capacity of the island (Jakarta Dalam Angka, 2007).

There are also several small islands employing tourism as a main economic activity and source of income for most community. The tourism islands consist of private islands and public tourism islands. Private island are owned by individuals usually residents of Jakarta. These private islands are usually used or visited by the owner or their relatives/friend at weekends or holidays.

Public tourism islands consist of island which are managed by private business and island which are managed by local government. Some of these islands have become popular destination tourism area such as Bidadari island, Putri island, Sepa, Ayer, Khayangan, Bira Besar, Kotok Besar, Onrust, Cipir, Matahari island, etc. About 70% of the island are managed by private sectors and are developed for public tourism as well as private tourism activities. Islands which are managed by local government are 25%, which consist of settlement islands, tourism activities, island for heritages, and other island for nature conservation; while about 5% islands have no fixed management. The physical conditions of private and public-private islands are relatively better compared to the island managed by local government (LPPM-ITB, 2000).

Tourism activities have been developed in specific tourism island, which are proposed only for tourism activities, and general settlement tourism area which are mixed with settlements of local ppopulation. Population of Seribu island is a pluralistic community which consists of population from outer islands and several tribes (Jawa, Sunda, betawi, Makasar, Bugis, Padang, Batak, Madura, etc). The quality of human resources is relatively low where more than 65% of population has low education level. More than 70% of population is fisherman who lives below the poverty line (LPPM-ITB, 2000).

Tourism attractions of Seribu islands consist of (Rosyidie, 2003):

a. Beach and sea view panorama (sunrise, sunset, waves, etc), fishery village panorama, tradisional boat traffic, etc. Physical or environmental and aesthetical conditions and sanitation of most villages are poor which make them not attractive for tourism or other visitors.

b. the panoramic view of the under water sea particularly at Seribu Island Sea Water National Park which is rich in sea flora and fauna which can be viewed by visitor by snorkeling or using a specific boat.

c. Flora and fauna in sea as well as land such as variety of fish which attract tourist.

d. Specific leisure activities organized in a certain period such as kite festivals, traditional boat festivals, sea festivals, swimming tournament, other water sport tournament, and open show.

e. Attraction of dynamic marine life such as fisherman with their specifif traditional life (prepare a fish net, fish market, aquaculture fishery, and seagrass culture).

These tourist attractions are spread in several islands. Some island has more tourist attractions with complete tourist facilities, while other islands have very limited tourist attractions and facilities. Beside marine based tourist attraction, Seribu Island also has cultural and historical attractions, such as in Onrust island.

Several types of accommodation are available in Seribu Island with variety of quality and rates. The rate of accommodation is not based on a room but on person, so the cost of staying overningh for a family is relatively very expensive.

In general, the supply of infrastructures and transportation in the tourism islands of the Seribu islands, particularly in tourism resort is relatively better than that in settlement islands. Visitors of Seribu Island consist of tourist from Jakarta and it surrounding cities as well as foreign tourists. But the highest proportion of visitors comes from Jakarta who escapes from daily activities.

The worst environmental conditions (pollution, crowded, etc) of urban areas have also pushed the population to escape and visit surrounding areas which have better and comfortable conditions. The Seribu islands are alternative destination due to its variation of attractions and its isolated location which make them as a suitable place for Jakarta population to escape.

In addition to relaxation, pleasure and enjoying marine atmospheres, there are also tourists who visit the island to do a research, visit relatives, business, and education purposes. The proportion of tourist for pleasures is the highest. The number of exurcionist (those who visit the Seribu islands without staying overnight) is also high particularly during weekend. Peak season period is mostly during July-August and holidays, while January-March is low season due to rainy seasons, tidal wave, and storm.

Islands which have been developed for tourism are 36 islands which consist of 13 islands for public or open tourism island and 23 islands for specific or private tourism island (LPPM-ITB, 2000). The public tourism island is Tourism Island that can be visited by all visitors who proposed to visit Seribu islands without any permision. Area of public tourism island is about 1, 3 hectare to 29 hectares and managed by privates. The distance between the island and Jakarta is between 14 km (Bidadari Island) to 70 km or more than 2 hours by specific speedboat.

Tourism in Seribu islands assist in employment generation, nature conservation as well as cultural preservation. Tourism is also a labour intensive industry with a market for local unskilled employees. Growth of tourism has boosted local economy. Tourism also has a multiplier effect on Seribu island economy including agriculture, small scale and handycraft industries, local entrepreneurs, and financial services. Tourism has improved the standard of living of population in Seribul Islands.

IMPACT OF CLIMATE CHANGE ON SMALL ISLAND TOURISM OF INDONESIA

Among island countries in the world, the most disadvantages are probably faced by Indonesia as a country with the highest number of islands, particularly small islands. Department of Marine and Fishery (Indonesia), it is predicted that by 2030, about 2000 small islands will disappear/submerge if there is no adaptation and mitigation programs for climate change (Koran Jakarta, 2009). Until now, there is no valid data about the number of small islands which were submerged by the rise of the sea water level. Some small islands in Seribu Islands disappeared or submerged because of sea level rise, land slides, and other factors.

Analysis of observational data of Seribu Islands indicated an increase in average surface air temperature (see Figure 1).

In general, the average monthly rainfall of Seribu islands during 2001-2007 was higher than that of 1961-1990 (see Figure 2).

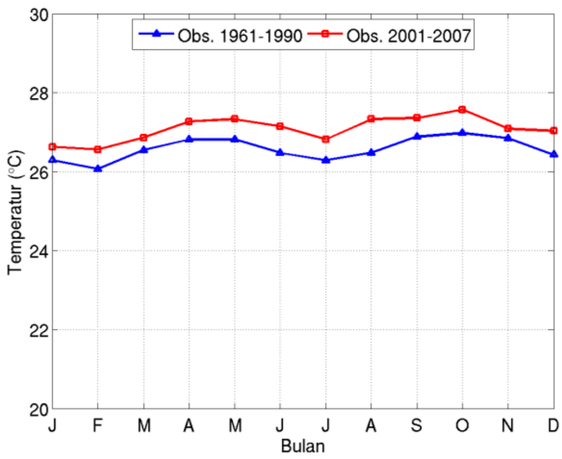

Figure 1 Pattern of average monthly temperature 1961-1990 and 2001-2007, at Seribu island-Jakarta (Source: Rosyidie, et, al, 2009)

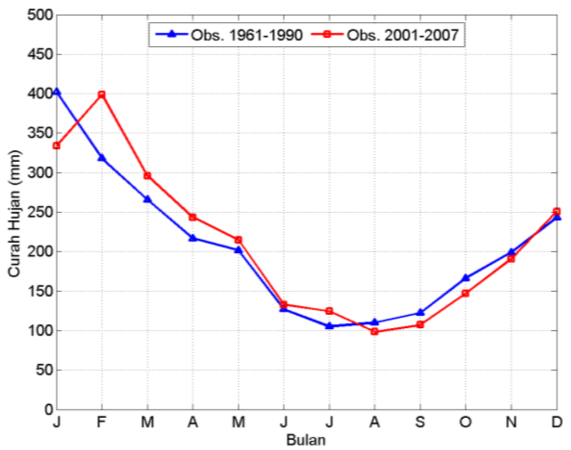

Figure 2 Pattern of average monthly rainfall 1961-1990 and 2001-2007 at Seribu island (Source: Rosyidie, et. al; 2009)

Abration processes occured in almost all Islands. During 1990-2008, about 5 islands of Seribu Island disappeared or submerged (Koran Jakarta, 2009). The area of several islands also decreasing due to abration, while several other islands increased due to sedimentation and reclamation. For example, during 1970-2009 the area of Bidadari Island decreased from 9 hectares to 8 hectares. Climate change could destruct natural and cultural resources which previously become a main attraction of Seribu island tourism. Sea level and air temperature rises could treathen the sustainability of tourist activities and marine biodiversity at the area.

Sea water temperature is also increased in many regions. In Indonesia, water temperature of the sea increased 0.2-2.5 ^{o}C, which affected the life of organisms in the sea. In Seribu island (particularly in Pari island), the rise of sea water temperature has caused a bleaching about 50% of coral reefs. In general, the increase of sea water temperature have also influenced the extinction of coral reef and many species (particularly fish species) with the rate 1000 greater than natural rate (Tempo, December 2007).

Tabel 1 Perception of Tourist on the impact of climate change to pattern of visit

TOURIST PERCEPTION	SERIBU ISLANDS
Role of climate factors in choosing a tourism destination	No influence (78%), don't consider climate factors.
Climate factors which influence in chosing tourism destination	Sea wave (43%), Wind storm (29%)
Sensitivity of tourist in facing climate change at visited tourism destination	No (78%), not significant change/same, most touris visit firstly.
Sensitivity of tourist to physical condition change as an impact of climate change at visited tourism destination	No (89%), no significant change/same.
Influence of physical condition change in choosing tourism destination	No, (89%), depend on tourist wish.
Influence of physical condition change to tourism comfortability.	Yes (76%), weather condition change has disturbed comfortability in tourism activities.
Would tourist revisit destination area next time although there is climate change ?	Yes, 83%.

Source: Rosyidie et al. (2009)

Survey to the visitors of Bidadari Island indicated that most respondents didn't aware about climate change and its impact to tourism activities. Therefore most tourist (83%) will still revisit Seribu island although there will be a climate change (Rosyidie, et al., 2009).

ADAPTATION STRATEGIES FOR THE IMPACT OF CLIMATE CHANGE ON SMALL ISLAND TOURISM

Climate change is costly. It could disturb economic activities and distribution of goods and services in small islands. In order to reduce the risk and impact of climate changes, small islands need mitigation and adaptations programs. The UNWTO (2007) has initiated a pilot projects in Small Island Developing States (Fiji and Mldives), in order to develop and to demonstrate measures that reduce climate related risks in tourism-dependent countries highly vulnerable to climate change impacts, including their beach destinations, tourism-dependent communities and coastal ecosystems.

Response policies to reduce small island's vulnerability depend on the direction of development, technological development, financial support, and public participation. In national level, the central government of Indonesia (Ministry of Public Works) has issued a National Action Plan in Facing Global Climate Change, as a response to minimize country's vulnerability.

For adaptation actions, the cost for each sectors are as follows (UNFCC, 2007):

1. US$ 14 billion for agriculture, forestry and fisheries.
2. US$ 11 billion for water supply infrastructures;
3. US$ 5 billion for treating water borne disease and malaria;
4. US$ 11 billion for dykes and coastal measures; and 8-30 billion $,
5. US$ 8-130 billion to adapt new infrastructure vulnerable to climate change.

Some US$ 28-67 billion of this amount will be needed in developing countries. If no appropriate measures are taken, the total cost and risk of climate change would be approximately 5% of total GDP or about US$ 14 billions each year in Indonesia case. If actions of mitigation and adaptation are taken correctly, Indonesia could reduce the cost of action to become US$ 2.8 billions or 1% of total GDP (Republic of Indonesia, 2007).

Tourist can either adapt or move on to other destination areas when climate in tourism destination areas is change. In order to sustain as tourism areas, Seribu island tourism development requires the best adaptation strategy to minimize the phenomenon of climate change, because tourism is the main source of economic development and source of revenue for the local communities.Therefore, adaptation is a must or no-choice option that can reduce the risks and limit the damaged caused by climate change.

In general, stages of developing adaptation strategies for the impact of climate change in the tourism sector are (Scott and Simpson, 2008):

1. Identification of tourism stakeholders which involve in adaptation process.
2. Screening for vulnerability.
3. Assessment of adaptive capacity.
4. Identification of adaptation options.
5. Evaluation of options and selection of the most appropriate options.
6. Implementation of the chosen adaptation options.
7. Monitoring and evaluation.

Adaptation could also consist of a process of assessing risks, reducing vulnerability, and increasing capacity (Takama, 2008). Adaptation is not only a technology but also involve sociocultural learning process. Therefore, networkings with several institution partners are important as a means of learning to develop adaptation strategies to face the impact of climate change in the tourism sector.

It also important to consider physical constraints and social processes as well as the potential inconsistencies between global, national regional and local which can limits the adaptation policies (Takama, 2008). In order to antiicipate and to reduce the direct as well as indirect impact of climate change, Seribu island tourism manager could apply programs such as environmental conservation, abration reduction concrete block, etc. Seribu island tourism manager, local government as well as community, should cooperate to propose programs in order to support the sustainability of the island, including for tourism, from the impact of climate change.

Seribu island could learn from Pacific island countries (Samoa, Vanuatu and Cook Islands) which have applied capacity building for development of adaptation measures uses a *Community Vulnerability and Adaptation A*pproach (Sem, 2007). The objective of this participatory approach is to understand the nature of community vulnerability, and to identify opportunities for strengthening the adaptive capacity of communities. This approach is a means to encourage a combination of bottom-up and top-down mechanisms that enable local stake holders to engage at each stage of the process.

This strategy eventually will enable the adaptation approach in line with national development planning and local decision-making processes

Barrier for adaptation programs are follows (UNWTO, 2007; IPCC, 2007):

1. Limited data, knowledge, awareness about the risk and impacts of climate change ontourism activities.
2. Limited technological solutions.
3. Limited financial support.
4. Limited coordination between government institutions.
5. Limited skilled people to implement programs.

CONCLUSIONS

There are interactions between tourism and the climate. Climate is a resource for tourism and it is an important element in the tourism product and experience. While climate cause a risk to tourism.

Small island vary in characteristics (geographic, physical, economic, social, and cultural conditions), so it couldn't be generalized.

Tourism plays an important role in the development for many small islands, including Seribu Islands in Indonesia. These small islands usually offer marine attractions (natural and cultural) to visitors. Many small islands in Indonesia do not have any feasible alternatives for economic development. Tourism provides new opportunities, employment, income and other economic benefits to small island communities.

Small islands are vulnerable to the impacts of climate change, particularly in terms of air temperature rises, sea water level rise, rainfall changes, and coral bleaching. Sea water level rise could cause flooding or inundation, erosion, and other coastal hazards, which put tourism and infrastructure as well as settlements at risk. The level of vulnerability is determined by the result of many factors such as physical, economic, and sociocultural factors.

.Since small islands in Indonesia, particularly Seribu Islands, are predicted to be affected by climate change, it is important to assist the manager of small islands or local government to propose adaptation and mitigation actions that can reduce the vulnerability and impact of climate change on tourism development.

Climate change might reduce the contribution of tourism sector in many small islands in Indonesia, particularly in the Seribu Islands. Therefore, it is necessary to support economic diversification towards other income generating sectors.

It is also important to propose sustainable or green tourism development strategy which taken climate change mitigation programs into account.

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CONTRIBUTION OF INTEGRATED GEOPHYSICAL SURVEYS FOR SITE INVESTIGATION IN SEISMIC HAZARDS ANALYSIS

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ABSTRACT

Due to complexity in natural geo materials, comprehensible information relating to subsurface soil and rock properties, such as layers information, physical soil properties and soil dynamic parameters of a site are important aspect in seismic hazards analysis. These properties are able to be investigated using geophysical methods and geotechnical-geological studies. Geophysical methods such as geo resistivity and seismic surface wave surveys are usually combined with geological studies in order to obtain more accurate and reliable results. The objective of this paper is to present a contribution of integrated geophysical surveys, i.e. geo-resistivity and seismic surface wave surveys combined with borehole logs, for site investigation in geohazards analysis. Field measurements were conducted at several selected sites at Muhammadiyah University Yogyakarta (UMY) campus, Bantul Indonesia, which was taken as a case study in this paper. The dynamic soil properties at site were measured using non-destructive seismic method of Multi-channel Analysis of Surface Wave (MASW) method. Twenty four geophones were located on ground in order to measure surface wave propagation. By inversion of experimental dispersion curve, a 2-D shear wave velocity profile was obtained. Geo resistivity survey conducted by LKPT UMY (2006) was employed to develop the cross-section map. The results are able to investigate the discontinuity and cavities at layered media. The cross sections were then correlated using site information which was collected from borehole logs. Combination between geo resistivity and MASW survey provide the useful information for site investigation of geohazards analysis.

Keywords: *geophysics, geo resistivity, MASW, site investigation, geohazard*

INTRODUCTION

Huge loss of lives, housing, facilities and public infrastructure increased significantly due to seismic hazards in last decade, particularly in Indonesia. Seismic hazard of earthquakes has mainly contributed catastrophic hazard consequences and this hazard caused thousands of people lost their lives.

For this reason, nowadays, engineers study comprehensively on the system and technique in seismic hazards analysis. The seismic hazard analysis is concerned with getting an estimate of the strong-motion parameters at a site for the purpose of earthquake resistant design or seismic safety assessment (Gupta, 2002). The analysis also produces micro zoning maps to carry out the detailed site-specific studies by estimating the strong-motion parameters for applications in the earthquake-resistant design of common types of structures. The zoning maps are also useful for land-use planning, assessing the needs for remedial measures, and estimation of possible economical losses during future earthquakes (Trifunac and Todorovska, 1998). In order to develop the accurate micro zoning map, correct information of soil data and geological structure need to be collected.

Naturally, geologic conditions, for instance, irregular topography, steep slopes, faulting, and geo material properties of a site is complex structures, therefore, comprehensible information relating to subsurface soil and rock properties, such as layers information, physical soil properties and soil dynamic parameters of a site are becoming important aspect in geo hazards analysis. These properties are able to be investigated using geophysical methods, e.g., geo resistivity and seismic surface wave surveys.

The main objective of this study is to present the contribution of integrated geophysical surveys, i.e., geo resistivity and multi-channel analysis of surface wave (MASW) surveys combined with borehole logs, in site investigation for purpose of seismic hazards analysis. A case study was conducted at several sites inside Muhammadiyah University Yogyakarta (UMY) campus, Bantul Indonesia. Some borehole data were used to correlate the geo resistivity plots for generating 2-D cross section of site location. From MASW survey, 2-D profile of soil dynamic properties, i.e., the shear wave velocity, shear modulus and damping ratio were obtained. Finally, a correlation of the shear wave velocity from MASW measurement and an empirical model of soil bearing capacity were also presented herein.

SITE OF INVESTIGATION

Geological Condition of Yogyakarta

Yogyakarta region and the vicinity are located as part of the mount Merapi area and Yogya-Bantul plain that extends toward to the south coast (Rahardjo et al., 1995). The geology formation in this region is dominated by recent deposits of Merapi volcano namely as young volcanic deposits of Merapi Volcano and sedimentary and inter-bedded volcanic rock deposit namely as Sentolo Formation.

The young volcanic deposit can be divided into two formations. The lower part of the young volcanic deposits as Sleman formation and consist of sand and gravel inter-bedded by andesite boulders. The upper part as Yogyakarta formation and consist of inter-bedded of sand, gravel, silt and clay. The thickness of these formations is identified from several bore log data obtained at different location. The Sentolo formation is found at depth approximately of 58 m. This formation consists of limestone and marly sandstone. The stratigraphy of Yogyakarta region can be seen in the Figure 1.

Location of Study

The location of study was chosen in the Muhammadiyah University Yogyakarta (UMY) campus. Rosyidi et al. (2008a) conducted visual observations on structural and geotechnical damages in the UMY campus after the Yogyakarta earthquake, 27 May 2006.

Based on the geological condition, i.e., rock formation (Figure 1) and compilation of visual observation of the structural and geotechnical damages, a geological map and estimated underground faults for location of the study at UMY campus and surrounding area is shown in Figure 2 (Rosyidi et al., 2008b).

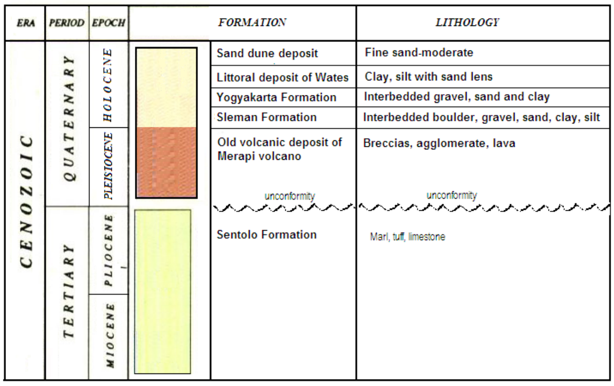


Figure 1 Structure of Yogyakarta basin (MacDonald & Partner, 1984; with modification)

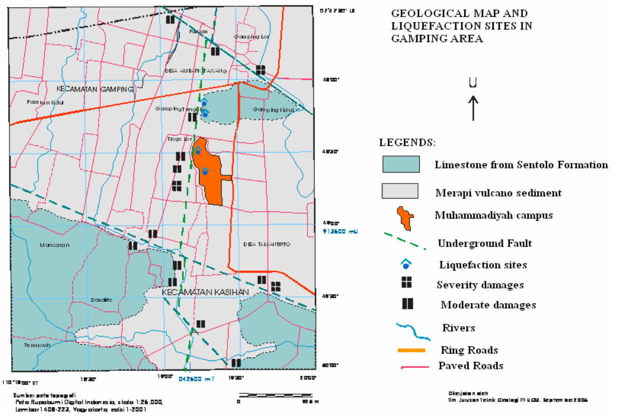


Figure 2 Underground fault lines locations near observed liquefactions in the study area

From Figure 2, some predicted underground cracks and faults closed to the damaged area were drawn with the direction of north to south (NS) located in the western of the UMY campus.

A soil investigation using geo resistivity and drilling test were carried out in this area by LKPT UMY (2006), and underground faults analysis of selected site were conducted by Rosyidi et al. (2008b). Both investigations are described in the following sections.

Geo Resistivity

Electrical resistivity or geo resistivity is a non destructive method that has been widely employed in site investigation. Roth and Nyquist (2003) described theoretical background and detail procedure of resistivity method.

Resistivity data were collected from the resistivity-meter of Oyo McOhm 2115. Whereas, field measurement was employed using the Wenner configuration (Figure 3). In this configuration, the distance between each current and potential electrode must be to be equal (Figure 3).

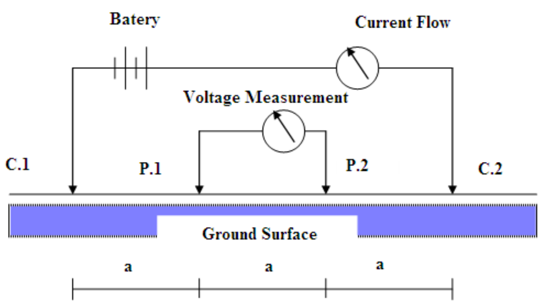


Figure 3 Wenner configuration used in the geo-resistiviy measurement

As described in Rosyidi et al. (2008b), geo resistivity measurements were conducted on 10 sites. Raw data from the measurement was then analyzed using PROGRES software. Consequently, the forward modeling and inverse modeling was employed in order to calculate the correct resistivity value with minimum error.

Borehole

The subsurface lithology of the area was determined from six observation boreholes drilled to a maximum depth of 40 m below ground level. The drilling equipment of TOHO type UD-5 was used in this study. Standard Penetration Test (SPT) was also carried out in the same location of borehole in every 1.50 m of drilling. An example of the boreholes correlation was presented in Figure 4.

Based on geotechnical investigation from six borehole logs and the knowledge of the geology area, it is found that the soil stratification in the study area is categorized as sedimentary sandy soil with variable layers of sands to gravel at the boundaries of the Sleman and Yogyakarta formation. The boundary between these two formations cannot be distinguished obviously. These layers overlay the bedrock formation or basement which is commonly found between 58 to 75 m (Figure 4). From borehole logs that located at northern part, this bedrock formation, Sentolo formation, is found at depth about 37.5 m. This formation consists of limestone rock.

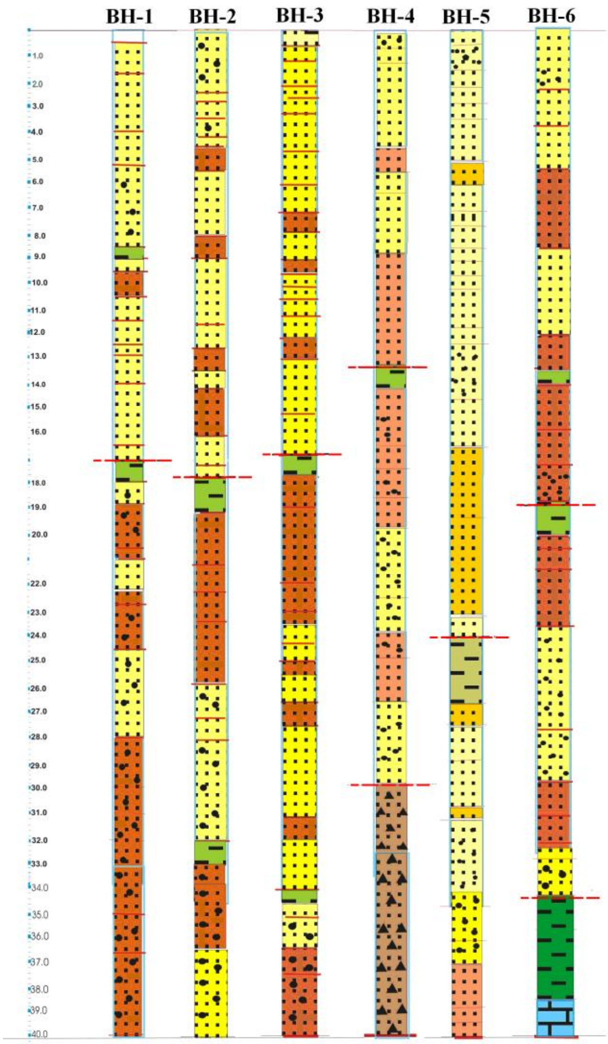


Figure 4 Borehole logs correlation at study area (Rosyidi et al., 2008b)

MASW METHODS

Field Measurement

Multi-channel Analysis of Surface Wave (MASW) method was developed by Park (1995). This method is an advanced technique from the Spectral Analysis of Surface Wave (SASW) method developed by Nazarian and Stokoe (1984). All the procedures in the data collection and data processing of MASW method are adopted from Park et al. (1998, 1999), and Penumadu and Park (2005) as described in Figure 5.

In this study, MASW survey was conducted at three different locations representing as three different parts of UMY campus, i.e., northern, middle and southern part. At each location, three different measurement points of the survey were conducted. Twenty four receivers of 4.5 Hz vertical geophone were deployed along a linear survey line with receivers connected to a multichannel recording device (seismograph) (Figure 6). Seismograph used in this measurement was OYO Mac Seis 24ch. Each channel is dedicated to recording vibrations from one receiver. One multichannel record consists of a multiple number of time series or seismic traces from all the receivers in an ordered manner. A heavy sledge hammer with weight of 16 lb (7.3 kg) was selected as source.

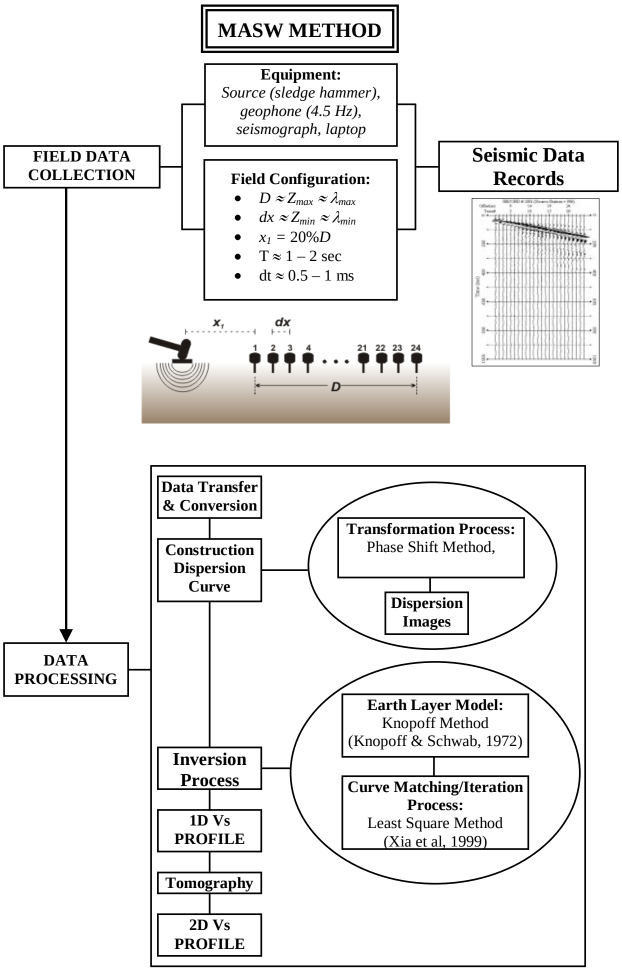


Figure 5 Schematic of MASW field configuration

Nevertheless, two types of parameters are considered to be most important, i.e., the source offset (x) and the receiver spacing (d_x) (Figure 6). The source offset needs to set up in proportion to the interest depth of investigation (z_{max}). Park and Miller (2005) recommended a conservative rule of thumb that would be $x = \gamma z_{max}$ with γ=0.5. However, very often γ can be as small as 0.1 (Park et al., 1999). The receiver spacing (d_x) may need to be slightly dependent on the average stiffness of near-surface materials. A rule of thumb that $d_x \approx 1.0$ m is often used in most surveys over soil sites. In this study, field measurement configuration for the source distance to the first geophone (x) and receiver spacing were 5 m and 1 m, respectively.

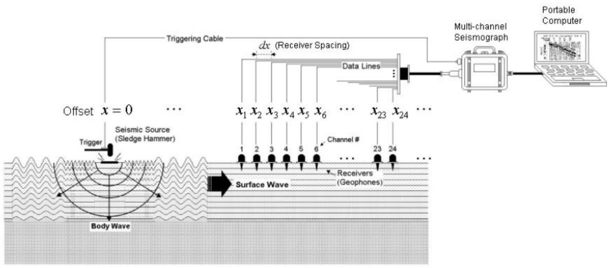


Figure 6 Schematic of MASW field configuration

As a result from field measurement, Figure 7 shows an example of the seismic traces measured from MASW survey at UMY campus site. For optimum data set, a record length of 1000 ms on seismic trace was chosen to cover investigations of soft to hard material.

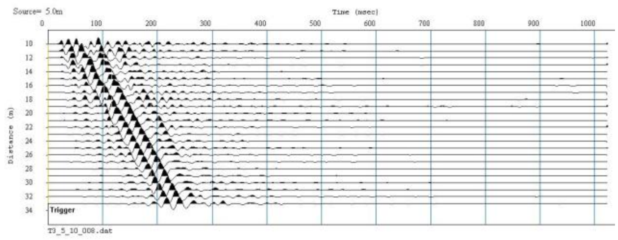


Figure 7 Seismic data collected from this study

Data Processing

Data processing consists of three steps, i.e., 1) preliminary detection of surface waves, 2) constructing the dispersion image panel and extracting the signal dispersion curve, and 3) back-calculating Vs variation with depth (Park and Miller, 2005). The preliminary detection of surface waves examines recorded seismic waves in the most probable range of frequencies and phase velocities.

Consequently, construction of the image panel is accomplished through a 2-D (time and space) wavefield transformation method that employs several pattern-recognition approaches (Park et al., 1998). This transformation eliminates all the ambient cultural noise as well as source-generated noise such as scattered waves from buried objects (building foundations, culverts, boulders, etc.).

The experimental dispersion curve is then associated with surface wave energy in the frequency-wavenumber (*f*-*k*) domain from a 2-D Fourier transform. This curve shows the relationship between phase velocity and frequency for seismic waves including fundamental and higher modes propagated horizontally and directly from the impact point to the receiver line (Park and Miller, 2005).

The algorithm of 2-D transformation in discrete Fourier transform (DFT) for multi-channels data from MASW survey can be expressed as:

$$U(f_i, x_n) = \frac{1}{M}\sum_{m=0}^{M-1} u(t_m, x_n)\, e^{(-j2\pi f_i t_m)} \quad (1)$$

where, $j=\sqrt{-1}$, $t_m=m\Delta t$, $f_i=i\Delta f=i/[(M-1)\Delta t]$ and $x_n=n\Delta x$. The discretization and truncation in time domain may cause frequency aliasing and leakage in the spectral analysis. However, this aliasing and leakage can be avoided by appropriate number of Δt and the anti-aliasing filter in the acquisition unit (seismograph).

The necessary experimental dispersion curve, such as that of fundamental-mode Rayleigh waves, is extracted from the energy accumulation pattern in this dispersion curve. Consequently, the extracted data from an experimental dispersion curve is used as a reference to produce the one-dimensional (1-D) shear wave velocity (Vs) with depth in the inversion process. In the inversion process, a profile of a homogeneous layer extending to infinity in the horizontal direction is assumed.

Based on the initial profile, a theoretical dispersion curve is then calculated using Knopoff method (Schwab and Knopoff, 1972). The theoretical dispersion curve is ultimately matched to the experimental dispersion curve of the lowest RMS error based on an optimization technique of least square method which was proposed by Xia et al. (1999). The iteration process inside inversion process can be automated with reasonable constraints.

2-D Shear-Velocity (Vs) Mapping

A 2-D Vs map is constructed from the acquisition of multiple records of 1-D Vs profile with a fixed source-receiver configuration and a fixed increment (d_C) of the configuration. A small increment (d_C) is required when horizontally variation plot is expected. In most soil-site applications, total receiver spread length is set up in ranging of 10-30 m that will give an optimal d_C in the range of 5-15 m (Park et al., 2001).

A 2-D Vs map is then obtained from multiple 1-D Vs profiles with a particular fixed increment (d_C) of the configuration by using tomography interpolation. In this study, all the seismic records are processed using a computer software program of SurfSeis version 2.01 that developed by Kansas Geology Survey (KGS) Texas.

Shear Modulus

The dynamic shear modulus (G) of the soil profile can then be easily determined from the following equation:

$$E = 2\frac{\gamma}{g}V_S^2(1+\mu) \quad (2)$$

$$G = \frac{E}{2(1+\mu)} = \frac{\gamma}{g}V_S^2 \quad (3)$$

where, E is the elastic modulus, g is the gravitational acceleration, γ is the total unit weight of the material and μ is the Poisson's ratio. Nazarian and Stokoe (1984) explained that the modulus parameter of material is in the maximum at a strain below about 0.001 %. In this strain range, modulus of the materials is also taken as constant.

RESULTS AND DISCUSSION

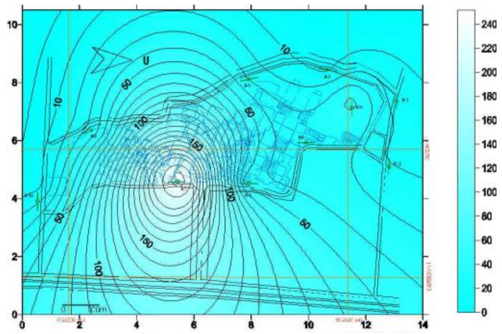
Geo resistivity Results

The resistivity value on observed sites was determined from the geo resistivity measurement. This value shows the resistivity in each subsurface rock layer under the center point of geoelectric measurement. From the results, it was found that the resistivity varies particularly that of the rock layer which was found to be uncertain. The conversion and correlation between these values and current geological condition obtained from borehole tests was then employed to obtain the correct resistivity values of the sites.

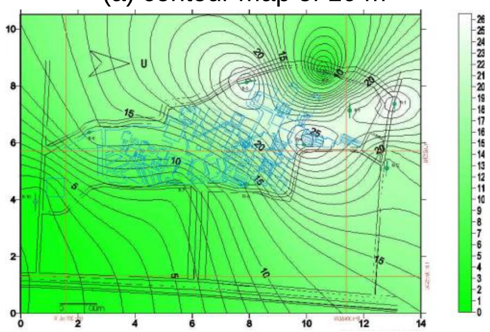
Based on borehole-log conducted in selected locations (Figure 4) crossing the geo resistivity line, the subsurface rock can be correlated to the resistivity values as follow:

1. Subsurface soil to the depth of 2 meter has various resistivity values to 1000 ohm-meter, particularly in very dry soil.
2. Clay material has resistivity value in the range from 0.45 to 4.0 ohm-meter
3. Igneous rock has resistivity values in the range from 193 to 744 ohm-meter.
4. Sand with gravel from fine to coarse grain has various resistivity values in the range from 7.0 to 26 ohm-meter.
5. Massive sandstone has resistivity values in the range from 20 to 78 ohm-meter.
6. Sandstone with gravels has resistivity values in the range from 42 to 100 ohm-meter.

Contour maps of resistivity were developed for subsurface interpretation. This map represents the lateral distribution of rock resistivity at particular depths. Figure 8 shows two examples of contour map at depth of 10 and 20 m from geo resistivity measurement.



(a) contour map of 10 m



(b) contour map of 20 m

Figure 8 Contour maps of resistivity value for subsurface interpretation

Underground Fault Detection

Based on compilation and analysis between geo-resistivity measurement and geotechnical observation of boreholes, geological cross sections on observed location of the south-north (SN) direction is illustrated in Figure 9. The cross section was generated from resistivity measurement from the southern to northern part of the campus. It was then combined with borehole data from BH-1 and BH-7 for developing the correlated cross section. This cross section (Figure 9) shows the geological stratification in the eastern part of study area in UMY campus. It is also shown that material layers with the resistivity values greater than 700 ohm-meter were detected. The material was estimated as volcanic *braccia* or igneous rock layer from sedimentation of Merapi Tua formation.

From the resistivity distribution map, it is shown that this rock layer is found at the depth of 10 m and then vanished at 20 m (Figure 8). The extreme change of contour pattern of the resistivity value represents the existing ground cracking or underground faults in direction of west to east (WE) in the southern and northern area.

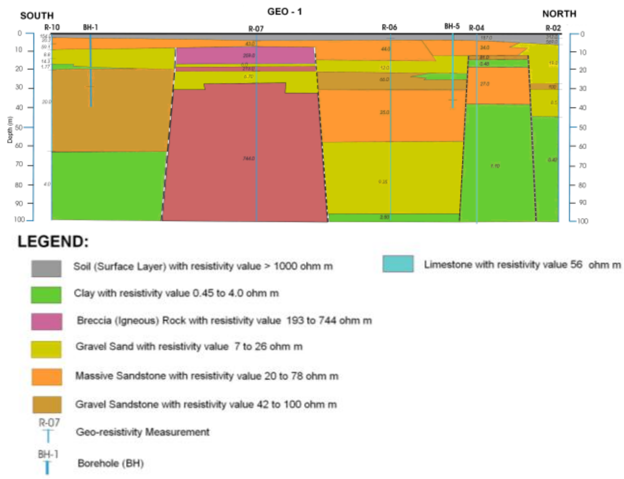


Figure 9 Geological cross section from South to North (SN)

Shear Wave Velocity Profile

In the shear wave velocity analysis, series of seismic data for three locations (nine measurement points) were transformed from time to frequency domain. By using *f-k* analysis, the phase velocities of surface wave for each frequency and their amplitudes were calculated and then were plotted in the experimental dispersion curve as shown in Figure 10, 11 and 12 for three different locations, respectively.

From these curves, the seismic wave events, i.e., fundamental mode, higher modes and body wave interference are clearly visualized. In MASW, construction of dispersion curve only considered the fundamental mode of surface wave.

identified at approximately depth of 30 m. Based on nearby borehole log and geo resistivity result, the hard soil layer is identified as gravel sandstone.

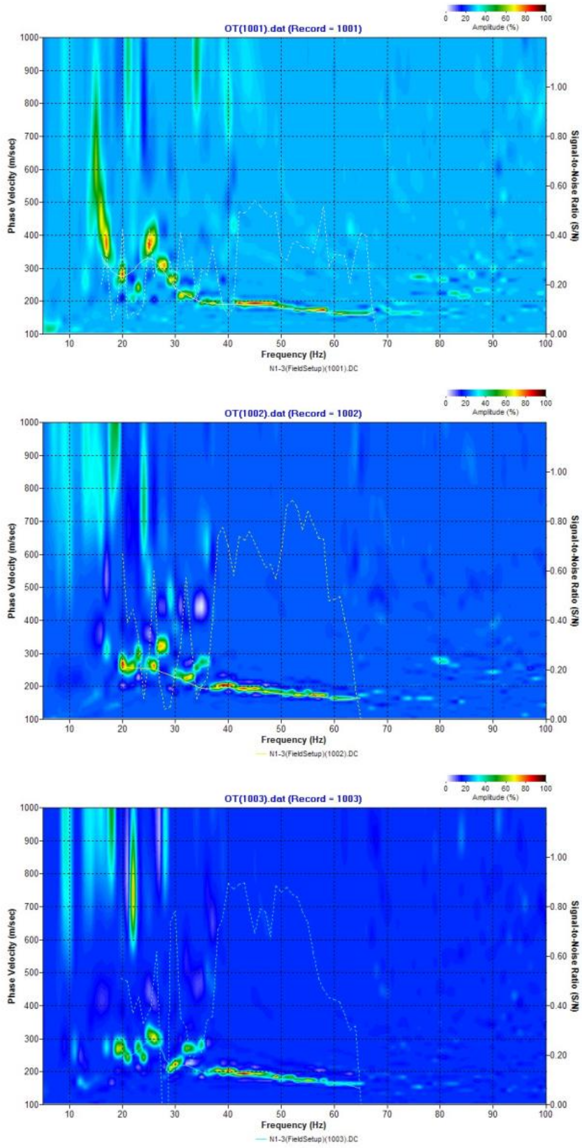


Figure 10 Experimental dispersion curve for location 1 at the northern area of UMY campus

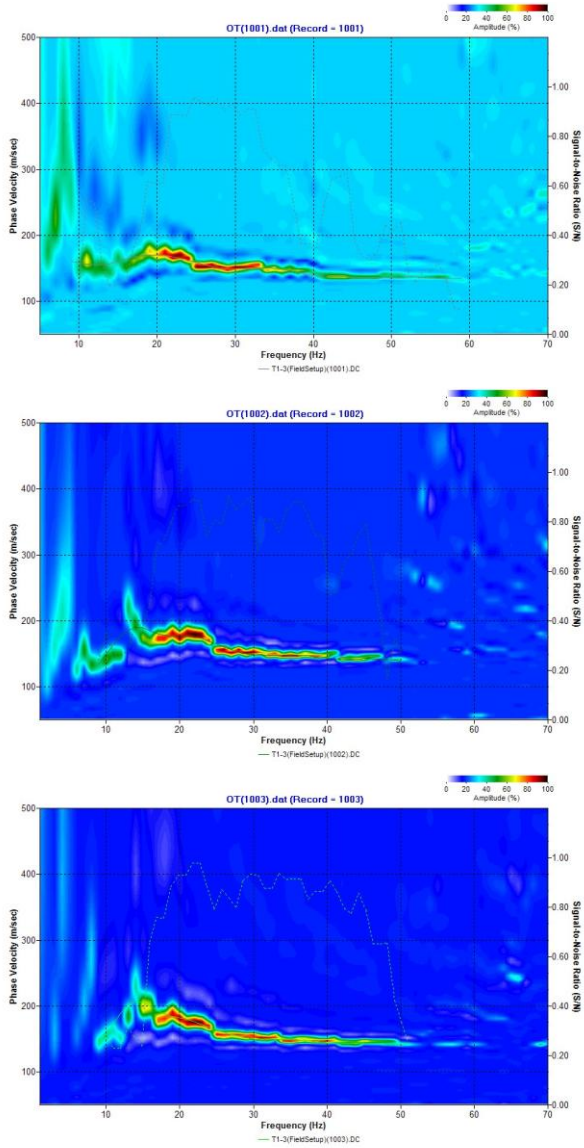


Figure 11 Experimental dispersion curve for location 2 at the middle area of UMY campus

From Figure 10, the experimental dispersion curve was generated from the fundamental mode in frequency range of 20 – 60 Hz with lower and highest phase velocity is 160 m/s and 330 m/sec. The maximum wavelength at the lowest frequency is then found to be about 16 m. Thus the estimated maximum depth of soil profile that can be effectively investigated is about 8 m (half of the wavelength).

At the middle (Figure 11) and southern (Figure 12) part of study area, the phase velocity ranges of sites were found to be from 140 – 210 m/s and 120 – 400 m/s, respectively. Particularly at the southern area, interference of the higher modes at low frequency is clearly detected with the velocity of about 500 – 1000 m/s in the experimental dispersion curve (Figure 12). It indicates that the hard soil layer is

Using the phase velocity and frequency information in the dispersion curve, a 1-D shear wave velocities (Vs) profile is then obtained by the inversion process. An example of 1-D Vs profiles for location 3 which were calculated from dispersion curves (Figure 12) is shown in Figure 13.

Therefore, the inversion of the dispersion of subsequent movement of the source to geophone array then produces the final two dimensional shear wave velocity profile of Figure 14. This 2-D Vs profile was calculated by tomography correlation on three different profiles with the fixed increment (d_C) of 5 m.

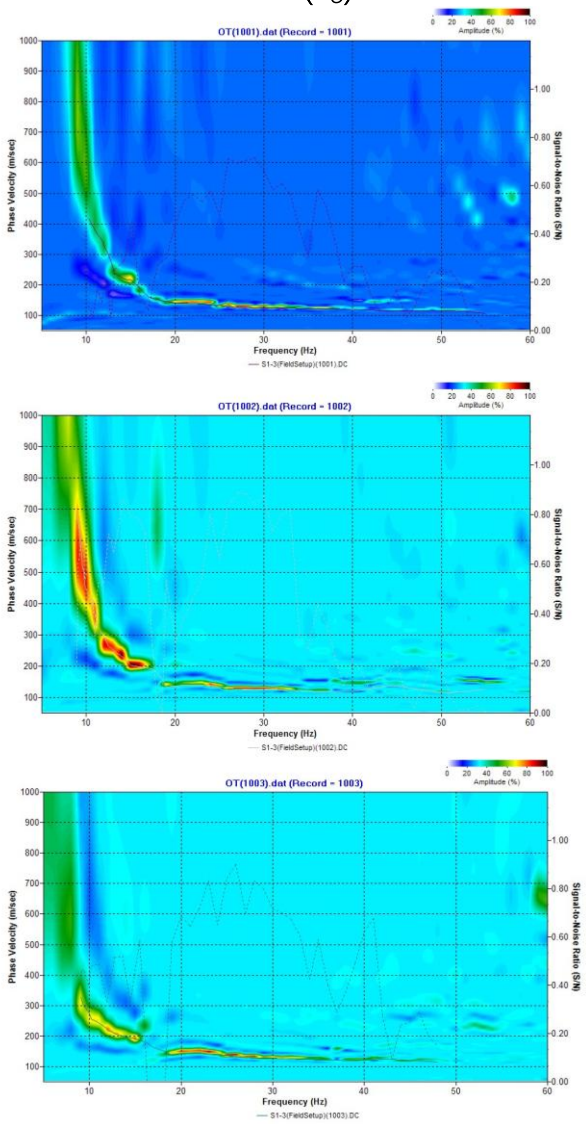


Figure 12 Experimental dispersion curve for location 3 at the southern area of UMY campus

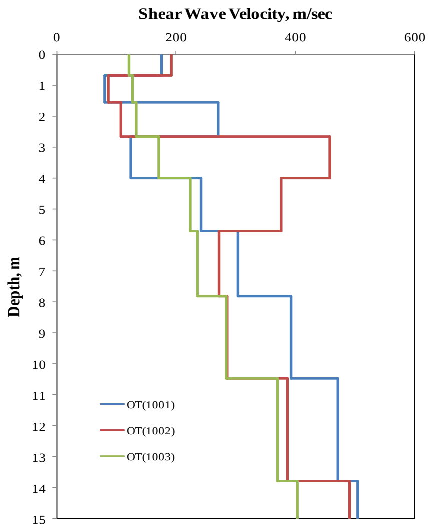


Figure 13. 1-D shear wave velocity profile for location 3 at the southern area of UMY campus

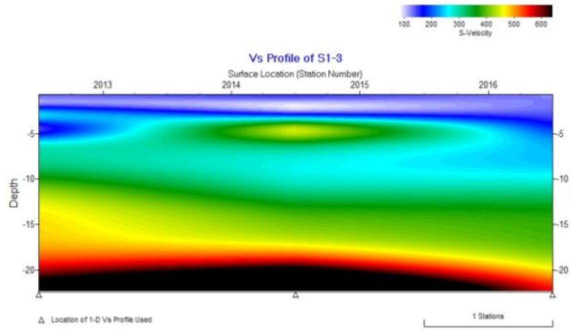


Figure 14 2-D shear wave velocity profile for location 3 at the southern area of UMY campus

The accuracy of the result is evaluated from the root mean square error (RMSE) is used to measure 1-D shear wave velocity profile of earth layer model. The distribution of average RMSE of shear wave velocities from 2-D Vs is shown in Figure 15.

From the RMSE results, it is presented that the highest RMSE of 30 m/s was found in 1-D Vs profile of OT(1002) at the depth of 5 – 10 m and 15 – 25 m. It is due to the effect of a hard or stiff soil layer trapped by softer layers. However, these RMSE are still acceptable compared to average Vs values at observed depth. The calculated maximum deviation was found to be 8 %.

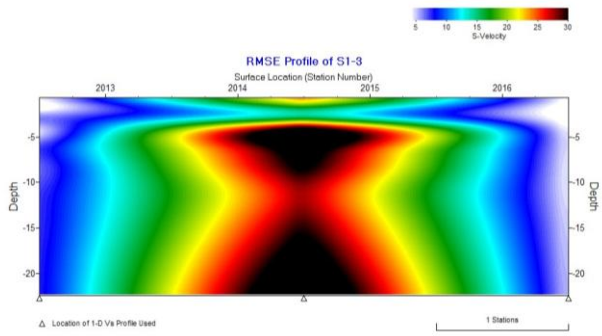


Figure 15 2-D RMSE profile for location 3 at the southern area of UMY campus

Based on the shear wave velocity data, the value of in situ dynamic shear modulus can be obtained by using Equation 3. Figure 16 presents the 2-D plot of the dynamic shear modulus (G in MPa) at observed location in the southern area of UMY campus. From this figure, vertical and lateral variation of the dynamic shear modulus at observed location can be clearly shown.

Finally, a relationship between the soil bearing capacity in terms of N value of Standard Penetration Test value and the shear wave velocity can be obtained by using Rosyidi (2009) empirical model for sandy materials. Figure 17 shows the correlation between the shear wave velocity obtained in this study and the empirical model (Rosyidi, 2009). From this figure, the both shear wave velocities increase generally with depth. The shear wave velocities from MASW are generally larger than shear wave velocities obtained from correlated N values.

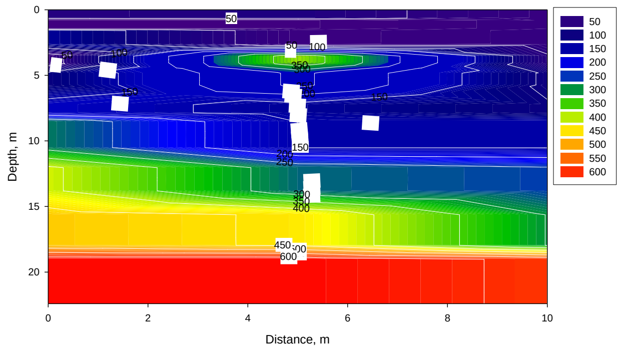


Figure 16 2-D shear modulus profile for location 3 at the southern area of UMY campus

CONCLUSIONS

This paper presents the integrated geophysical surveys, i.e., geo resistivity and multichannel analysis of surface wave (MASW) implemented in site investigation. The compilation and analysis between geo-resistivity values and geotechnical investigation of boreholes successfully generates the 2-D cross section of study area. The cross section of geological conditions on observed location can be generated well by both investigation techniques. The cross section also presents the observed ground surface and underground fault lines. One and two dimensional shear wave velocities profiles can be efficiently estimated by MASW method. Based on the 2-D shear wave velocity profile, lateral variation of dynamic shear modulus can be obtained. The use of MASW method as an alternative non-destructive method is found to be one of the foremost cost effective options to estimate in situ shear wave velocities and soil stiffness in terms of the dynamic shear modulus. Finally, from this study, compherensive soil information from the 2-D cross section (geo resistivity and borehole log) and the 2-D shear modulus profile, the information of soil layers and its classification, the shear wave velocity, the shear modulus and the faults location at observed area can be simultenously analyzed. These data are useful for seismic hazards analysis in terms of ground response prediction at ground surface and soil column.

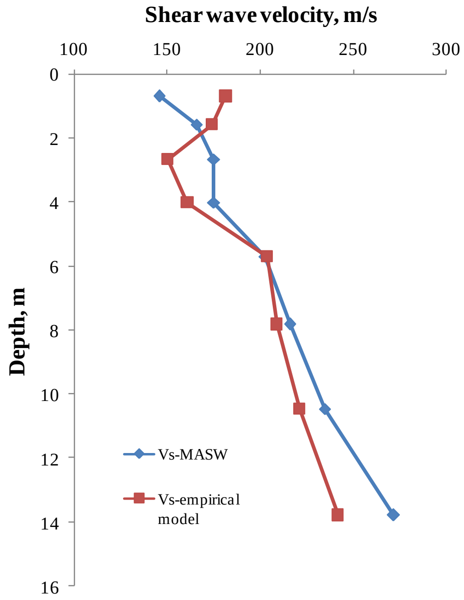


Figure 17 Comparison of the shear wave velocity profile from MASW measurement and empirical model from Rosyidi (2009)

ACKNOWLEDGEMENT

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POPULATION DENSIFICATION IN COMPACT CITY CONCEPT AND VULNERABLE RISK OF DISASTER

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ABSTRACT

This study emerges as an answer of the exhortation of sustainable city development, which often uses compact city strategy as one of the most popular strategy. Compact city concept proposes to minimize the use of energy by improving population density of the city center. Despite of minimizing the use of exceed energy, this idea has several vulnerable risks. Undoubtedly, the idea of high or optimal population density will improve various risks if the area is struck by earthquake or other disasters. This paper aims to describe the correlation between those aspects; density and disaster risk, in a theoretical framework. The earthquake cases which happened in the Bantul Ditrict in 2006 empirically strengthen the evidence. The lesson learned from those disasters is that it may happen anytime, including the increase of risks in high density areas. As a consequence, the implementation of compact city strategies needs to be accompanied with efforts to minimize disaster risks both on buildings as well as environmental scopes.

Keywords: *sustainable urban form, city compactness, population density, resilience city, vulnerable risk*

THE DEVELOPMENT OF COMPACT CITY CONCEPT

Sustainable development has become an integral part of city development in the world. Custom declaration of the United Nations in Rio de Jeneiro, which is known as the 21st Agenda, also emphasizes the importance of sustainable development in various sectors, particularly in residential sector (UNEP, 2008). In this case, sustainable development in residential sector, which covers city development and other supporting construction industries, is dedicated to improve social, economic and environmental conditions. On its development, the 2001 Custom Declaration of UN-Habitat in Istambul as well as Summit Conference in Johannesburg on Sustainable Development which is held on September 2002 have specifically stressed the need of ongoing consideration on housing, residential, and city in general.

Regarding the importance of sustainability consideration, several alternative strategies have been emerging. One of the most popular recently is compact city strategy. Many develop countries have started to adopt this strategy (Jenks, et al., 1996, Williams, at al., 2000). Meanwhile, developing countries are still struggling on their early stage to overcome social-economic basic problems (Burges and Jenks, 2001). The motivation of compact city strategy itself is based on the need of sustainable city (environment) concept. Its main implications are the efficiency of citizens' daily activities, less use of energy, the improvement of citizens' socio-economic with a more rigid city, and so on. Unfortunately, many areas adopt this strategy without considering the local characteristics and implement it as a top-down policy (Jenks et al., 1996).

In general, Roychansyah et al. (2005) mention 6 important factors as compact city attributes. Those attributes directly represent the role of compact city as an immediate transformation of sustainable development concept. Respectively, they are: population densification, activities concentration, public transport intensification, city's optimal size and access, citizens' welfare target, and a process to compact condition (see Figure 1). Those attributes should support each other to create a compatible condition with the efforts to perform sustainable development (economic, social, environmental) to gain a synergy among higher city population density in an ideal form, concentration of all city activities, intensification of public transport, and improvement of citizens' socio-economic welfare for better city life quality.

Tabel 1 Benefits and losses of compact city development based on its attributes (Roychansyah et al., 2004)

Attributes	Benefits	Losses
Population densification	Appropriate infrastructure/facilities provision; services and goods are more equitably distributed; varied and culturally enriched lifestyle; social vitality and economic viability	Reduced quality of life in the future, including health condition; costly development (if as new development); overcrowded conditions; increased vulnerable risks
Activity concentration	Agglomeration economies; reduce urban travel demand and time; agricultural land/open space preservation; overcome environmental degradation; energy efficient land use; low cost economic performance	Higher land and property price; reduced in present amenities; reduced affordable housing; maintenance/operation cost increase; poorer access to green space
Public transport intensification	Better public transport; lower energy consumption for transport; reduce car mobility and car dependency; increasing access and travel choice	Environmental quality/ acceptability; higher congestion and pollution
Access and city size	Accessible scale for all modes; reduce travel distance; accessible services and facilities; appropriate of development control	Centralization grip; network and communication handicap
Social welfare target	Social interaction/segregation; reduced social diversity (support social equity); reduced crime	Reduced living space; displacement; privacy reduction

However, because of the limited case and principle that compact city is a long process; compact city in theory still often becomes a debate. Table 1 above represents the benefits and losses which are often claimed in a discussion of the strategy, except the last attribute (process toward compact condition) (Breheny, 1992; Williams et al., 2000). For population densification attribute, its benefit is appropriate and equal city infrastructure and facilities provision. High density will also create better relationship in a community and less production cost of economic activities.

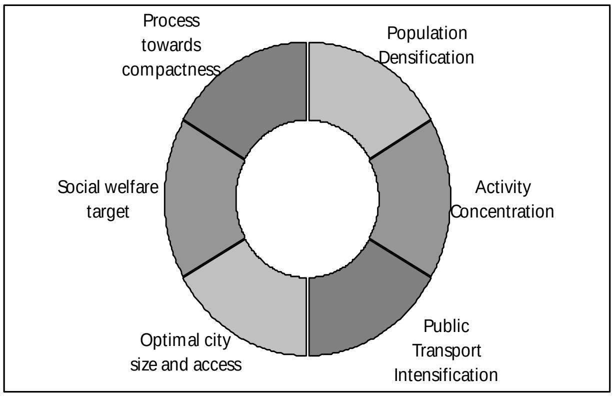

Figure 1 Attributes of compact city and their balanced roles in achieving sustainable development

Kampungs as integral urban structure in Indonesian cities are vital component if this concept would be initiated. It may need a strategic attempt through a comprehensive policy using *kampung* as focus area of development that encompasses several intensive developments based on their characteristics. Related factor such as high population density should be as main consideration of implementation compactness (Roychansyah, 2008). Initial works should be conducted to examine this concept up into realization, such as how to cope with higher risk of the high density habitation.

POPULATION DENSITY AS AN ENTRY POINT

As stated before, each of the attributes has an important role in creating sustainability through the compact city strategy. However, population densification is a fundamental and productive attribute for the initial step of the strategy. The increase of population density which is planned to be high or suit an area's optimal value, for instance city center, city multi function district, or transit area, is believed to be a compatible effort for sustainability target. For instance, high density of an area (city) will significantly cut the need of energy and allows pedestrians and bicycle to take part in city mobility (Newman dan Kenworthy, 1999).

As illustrated in Figure 2, density has a significant correlation with the emerged conditions. From sustainability perspective, the higher the density (based on its limit capacity), several concepts can be obtained (Elkin et al., 1991). For example, high density will lead to a social cohesiveness aspect. This condition will create suitability aspect; and in turn increases the performance of productivity aspect. It is also believed that density or high density have enormous effect toward efficiency aspect, for instance in facility provision. In that case, accessibility and affordability aspects will automatically improve.

Regarding the regulation on density, as shown in Table 2, Jenks and Dempsey (2005) describes the regulation in England. The regulation has been adjusted with the demand of sustainable development. From the table, we can see that the growth of residential function density becomes higher on the last years. Besides the demand of construction sustainability, this density-based construction model is also claimed to be able to directly cut the cost of construction. As described in Table 3, central construction model which requires higher density will suppress construction as well as operation and maintenance costs. It reveals that from the sustainability of economic aspect, density compatibles with the targeted principles.

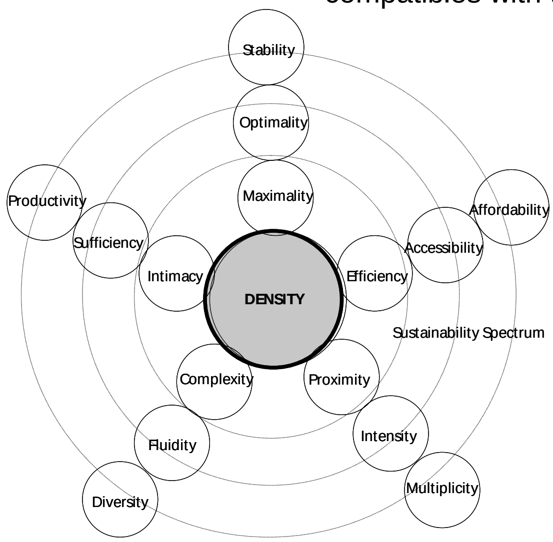

Figure 2 Density and related emerged aspects in sustainable spectrum

Table 2 The growth of building density regulation for housing/flat unit/ha in England (Jenks and Dempsey, 2005)

Year	House		Mixture (house and flat)		Flat	
	Min	Max	Min	Max	Min	Max
1918	20	30	-	-	-	-
1944	25	25	40	60	-	100
1952	15	35	-	-	40	70
1962	30	75	50	75	-	115
1970-1980	-	35	-	-	-	-
1999	35	40	-	-	-	-
2000	30	50	-	-	-	-

Tabel 3 The cost of each construction model (Litman, 2002)

Cost	Random	Nodal	Central
Population per ha	66	98	152
Construction cost (billion USD)	54.8	45.1	39.1
Operation and maintenance cost (billion USD)	14.3	11.8	10.1
Total cost (billion USD)	69.1	56.9	49.2
Save percentage compare to random	-	17%	29%

DENSITY VERSUS DISASTER RISK

In this section, where disaster risk becomes the main perspective, density will have a different dimension. High density, both population and building of an area or city, is seen as a condition which create higher disaster risk and victims. The higher the density of an area, the higher the vulnerable risk is (read for example Kidokoro, 2008). High urbanization in urban areas makes housing condition exceed its capacity limit and maximum density condition. On the other side, this improper housing condition triggers vulnerable condition toward disaster such as flood, landslide, and fire.

Moreover, natural disasters such as earthquake is also threaten all the time. The law of area uniformity can be used to check whether a particular area is considered to be a (natural) disaster vulnerable area. According to Mekvichai (2008), in such condition, the combination of disaster risk which is triggered by human and nature will be higher.

Pelling (2003) discusses the risks of disaster in urban area in detail. However, he does not relate high density with higher disaster risk in particular. He only notes that the bigger a city with more population, the higher the disaster risk is. Preparaредness factor, including facilities and social condition, are the resilience factor of the city in facing disaster. Furthermore, Cross (2001) mentions the importance of disaster risk identification through the results of his study on various city size. His study implicitly reveals that relatively dense or big city has a particular disaster risk.

Figure 3 Typical condition of high density residential (The example is taken from residential kampung along Code River in Jogjakarta)

Such dense environmental condition also commonly happen in traditional residential of developing countries, including Indonesia. Traditional village (kampong) residential, for example, has a unique characteristic on the high number of its inhabitants (McGee, 1996; Patton and Subanu, 1988). According to Jefferis-Nilsen (2009), population density is one of the factors which increase the risk of disaster of a particular area besides location of hazard, building structure and construction, construction materials, the understanding level of the citizens toward hazard potential, the preparedness of the society and government, and adequate education on disaster. Thus, physical consequences of such dense residential model include the number of inadequate building structure or impermanent, limited circulation space, limited environmental infrastructure service; especially water, and limited free space for evacuation. If a disaster strikes such a dense area, evacuation activities will be difficult to perform, and in turn will increase material and life losses (see Figure 3).

LEARN FROM THE JOGJAKARTA EARTHQUAKE

The case of Jogjakarta earthquake on May 2006 is used as a tool to support empirical evidence on the correlation between population density and vulnerability of emerging disaster (earthquake). From the previous theoretical review, however, the relation between population density and disaster risk, particularly in assessing vulnerability level of a residential or city is still obscure. In the future, it is hoped that the evidence from those two fatal disasters can be formatted into a strong interaction. Thus, as stated by Quarantelli, E.L. (2003) each area characteristics will finally have a guideline to reduce disaster risk. The guideline covers mitigation, preparation, response, and recovery. Mitigation and preparation phases are the area of risk management, while response and recovery are parts of crisis management.

Referring to the data of casualties dissemination in Figure 4, we can observe that the earthquake in Jogjakarta tends to strike southern (Bantul Regency, DIY) and eastern (Sleman Regency, DIY and Klaten Regency, Central Java Province) parts of the city. The earthquake creates a line pattern from south west to south east direction and ends up in Klaten regency. From the data (Satkorlak DIY Province, 2006), it is revealed that areas which suffer the highest casualties are Bantul Regency (4143 victims) and Klaten Regency (1045 victims). Next on, we will concentrate on the data of Bantul Regency. From Figure 4, we can see that in Bantul regency there are three districts which suffer more than 500 casualties (Bambanglipura, Jetis, and Pleret), 7 districts with 100-500 casualties (Banguntapan, Bantul, Imogiri, Piyungan, Pundong, Pandak, and Sewon), 1 district with 50-100 casualties (Kasihan), and the rest districts suffer less than 50 casualties (see Table 4 below).

From Table 4 below, we obtain evidence that on each of the categorization, area which has the highest density level suffer from the worse housing damage. This tendency is significantly found in Categorization A (districts with casualties >500 people) where Jetis district located and Categorization B (district with 100-500 casualties) where Sewon and Banguntapan districts are categorized. From the data, it is clear that areas or districts which are grouped into categorization A and B are the center of the earthquake. Thus, high density does significantly affect the number of casualties and material losses. We can imagine what will happen if the earthquake strikes Jogjakarta city which has 10 times density level than Bantul regency (15,600 people/km^2).

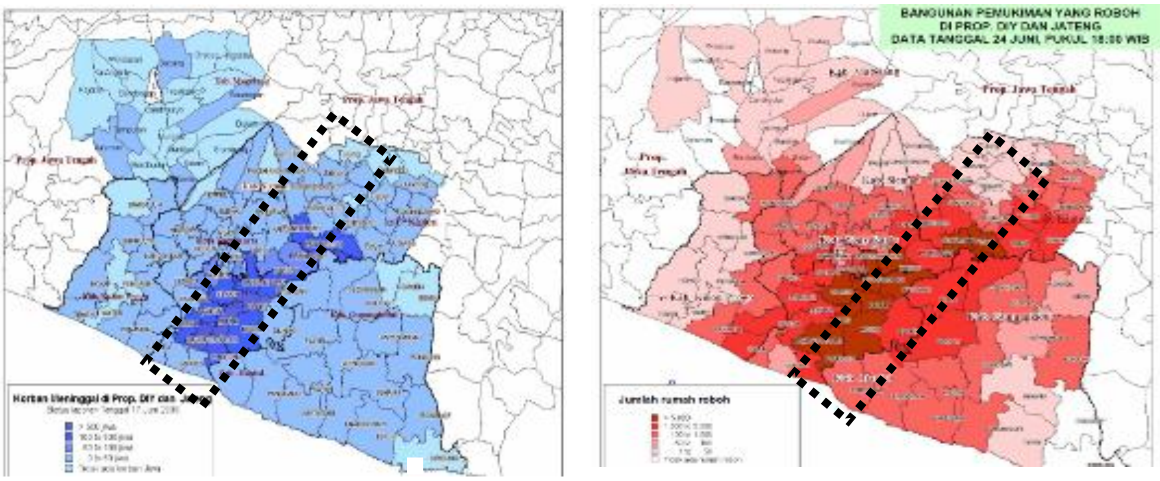

Figure 4   Map of casualties' dissemination (left) and building condition (right) Jogjakarta earthquake (adapted from data of Satkorlak DIY Province, 2006)

Table 4   Districts in Bantul Regency and area categorization based on the number of casualties (Adapted from Data of Satkorlak DIY, 2006)

No.	District	Area (km2)	Number of citizen (people)	Density (people/ km2)	Totally damaged	Badly damaged	Minor damaged
	Categorization A: Districts with casualties >500 people						
1.	Bambanglipura	22.70	42,832	1,887	6,587	2,732	816
2	Jetis	24.47	49,581	2,026	11,356	2,810	664
3	Pleret	22.97	34,133	1,486	8,139	2,322	1,438
	Categorization B: Districts with casualties 100-500 people						
4	Banguntapan	28.48	77,532	2,722	5,557	8,232	7,452
5	Bantul	21.95	58,207	2,652	4,708	7,338	3,301
6	Imogiri	54.49	56,562	1,038	5,664	5,354	11,781
7	Piyungan	32.54	37,979	1,166	5,514	4,801	3,135
8	Pundong	23.68	33,011	1,394	6,793	1,903	500
9	Pandak	24.30	48,353	1,990	2,966	5,760	4,069
10	Sewon	27.16	76,099	2,802	8,281	8,496	6,004
	Categorization C: Districts with casualties 50-100 people						
11	Kasihan	32.38	78,044	2,410	1,790	4,657	11,946
	Categorization D: Districts with casualties <50 people						
12	Dlingo	55.87	36,698	647	1,377	3,360	4,720
13	Kretek	26.77	30,946	1,156	1,121	4,665	2,486
14	Pajangan	33.25	30,135	906	1,228	2,216	2,610
15	Sanden	23.16	33,995	1,468	97	2,052	4,650
16	Sedayu	34.36	43,563	1,268	243	1,800	4,591
17	Srandakan	18.32	29,242	1,596	342	3,054	3,506
	Total	**506.85**	**796,863**	**1,572**	**71,763**	**71,732**	**73,689**

CONCLUSION: TOWARDS A DISASTER ADAPTIVE COMPACT CITY

This paper briefly describes compact city strategy as an approach which is believed to be able to realize a city concept which accommodates several principles of sustainability. Designing a more physically compact city which is economically productive and socially positive, a lot of aspects needs to be elaborated. The attributes of compact city play essential roles in leading the needed policies to accommodate some principles of the compact city type. One of them which can be used as an entrance is population density. It means that motivating the citizens to live, work, and do activities in a planned and easy accessed area of a city is the priority.

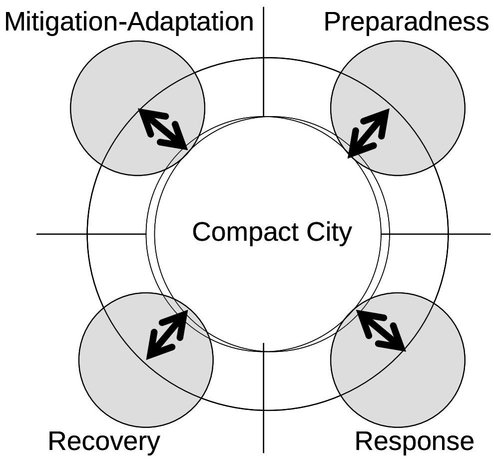

Figure 5 Strategy of disaster risk reduction in compact city which needs to be adjusted with the existing compactness attributes

Contrary, high density of an area naturally indicates vulnerability toward natural disaster, particularly those which exceed its carrying capacity limitation. High density is also considered as a trigger factor of man-made disaster. Based on the discussion above and supported by brief data of casualties' number in Jogjakarta May 2006 earthquake in Bantul regency, it was clear that there was a strong correlation which needs to be considered. We can see from the data that areas with high density tended to suffer greater losses than those with less density when a natural disaster strikes.

The idea of compact city in increasing population density, along with activities concentration (mixed-use development), becomes a particular challenge in facing this natural disaster. Characteristics of the efforts to alleviate disaster risk in a city which applied compact strategy also have to be strongly considered (Figure 5). Here, strategies to enable sustainability value to be contextually implemented in various areas, including disaster susceptible ones, become a big challenge. Uniformity aspect of disaster which can be predicted, although roughly, may provide information for anticipation. The idea of compact city is eligible and may become main alternative with some adjustments on disaster anticipation. Space and building qualities are the compensation of this high density (see Uytenhaak, 2009). Quality in this sense covers various aspects of safety, pleasure, and sustainability of the city.

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PEDOGENESIS APPROACH TO EVALUATE THE SOIL CREEP PRONE AREAS IN KULONPROGO HILLS, JOGJAKARTA-INDONESIA

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ABSTRACT

Soil creep is one type of mass movement that very rare creating lost of life. However, soil creep has created a large economical lost in Kulonprogo due to it destroyed the Van der Wijk Canal. The function of that canal is irrigating the agriculture land of Kolonprogo lowland. Therefore, it is very essential to understand the soil creep processes in order to find the main controlling factor of soil creep in the study area.

The methods applied in the research were field survey completed with some laboratory test of some soil materials. Topographic transects acrossed hills slope were done to understand the soil units distributions. Soil profile description and soil material sampling for laboratory analysis were carried out following the transect surveys. The soil laboratory test was intended to identify the characteristic of clay which include swelling and shrinking capacity as well as the clay mineralogy through X-ray diffraction method. The data of landuse type and land management in the study area were also being collected. The soil creeps were evaluated based on the soil development and land management to determine the main controlling factor.

The soils in the study area have been developed to the direction of vertic soils. The clay developments were not showing yet enough smectitic clay formation. The relatively thick soil layers overlaying on the dipping layers of clayey sandstone become the natural factors that control the soil creep. Another controlling factor was the land management. The wetting and drying of agriculture land become another factor that made the soil creep become more active.

Key Words*: pedogenesis, soil creep, agriculture land, land management*

INTRODUCTION

There are several types of landslide (Figure 1). Based on their speed of movements, landslides are classified into fast and slow movement. The soil creep belongs to the slow movement of landslide. The speed of soil creep is varies from view cm/hours upto some m/years. Therefore, some soil creep is not clearly recognized in the field. They can only be recognized based on the indirect signature such as cracks, decline of trees, and other soil microtopography.

Landslide creates both economic and life lost. There is no doubt that landslide creates damages on all infrastructure installed on the land surface being sliding. The landslides are able to create the collapse of buildings, bridges, trees, and other human life facilities. Therefore, landslide is often create lost of life when it brokes houses and/or other human life facilities. The landslides that create lost of life usually belong to the group of fast movement landslide (Sartohadi, 2008). While, the landslides that only create an economic lost are usually belong to slow movement landslide (Piracelly, 2007).

Soil creep creates problems on agriculture land. The terrace collapse is often initiated by soil creep (Figure 2B). The irrigation canal is also often broken by the soil creep. The irrigation water can not move to the long distance as predicted. The creep becomes more intensive when the management of agriculture land is not suitable with the physical condition. Wetting and drying of agriculture land may create strengthen the swelling and shrinking of soil and the slow down movement become more intensive.

Figure 1 Types of landslide in kulonprogo

Kulonprogo has been suffered by soil creep. The lower slope of hilly areas in several subdistricts of Kulonprogo has soil creep problems. Areas of surrounding the Van der Wijk canal located in Kalibawang, Girimulyo, Nanggulan, and Sentolo sub-dsitrict are suffered by soil creep (Figure 2A). Moreover, the soil creep has made the the Van der Wijk canal collapse several times. The Van der Wijk canal is the main irrigation canal that irrigates most of low land agricultural land in Kulonprogo District (Goenadi *et al.*, 2003).

Based on the real problems occurred in Kulonprogo, the goal of this paper is to find the main controlling factor of soil creep of the study area. To achieve that objective, some objectives are formulated as: (1) to investigate the soil development, (2) to evaluate the soil creep hazard of some locations along the Van der Wijk canal, (3) to study the correlation between soil developement and soil creep hazard.

STUDY AREA

The litological situation of Kulonprogo is embodied by several rock formations. It ranges from Tertiary limestone, volcanic rocks as well as the calcareous sedimentary rocks. The Quaternary sediments cover the lowland plain part of Kulonprogo District. Some of those Tertiary rock formations were uplifted to perform the current morphology. During the uplifting process, the process of magmatic intrusion had been happened. The plutonic rocks become the core of mountaineous and hilly areas of Kulonprogo rough topography. The magmatic intrusion had been created the formation of heavily altered rock under the surface of montains and hills. The occurrence of such rock stratigraphy makes the Kulonprogo montains and hills, in general, have high degree of landslide hazard (Sartohadi *et al*., 2008).

The climatic situation of Kulonprogo as it is located in the tropical region, has rainy and dry season consequtively in a year. The rainy season is started in October and it is ended in March. The rain is sometimes happen during the dry season as an effect of orographic weather. The heavy rain usually occure in the periode of December-January where usually most big landslide in Kulonprogo is usually happened. The long period of dry season has made the soil become significantly dry upto the deep profile. This situation has initiated the deep soil cracks in the montains and hills areas. The heavy rain that sometimes comes in the beginning of rainy season may be wetting the deep profile and swell the soil. Therefore, some landslide also occurs in the beginning of rainy season (Figure 2C).

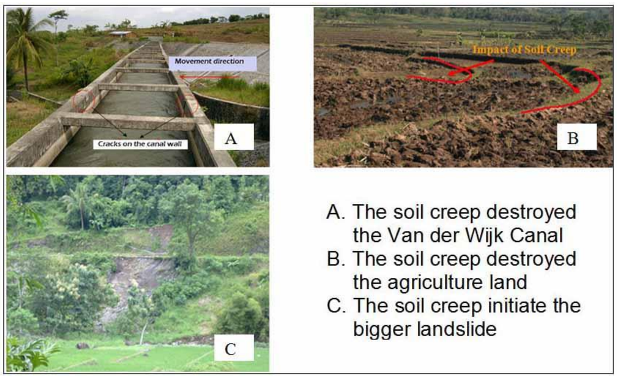

Figure 2 Some inrivonmental impact of soil creep

The soils in the montains and hilly areas of Kulonprogo are mostly developed on some weathered volcanic rocks and calcareous rocks. The high base content due to Ca-cations from both calcareous rocks and Ca-plagioclast of volcanic rocks has been creating the formation of swelling clay. This swelling clay is usually well developed in the deep soil profile and/or in the lower part of montains and/or hills. The occurrence of such clay types creates high potential of landslide in the montains and hills areas of Kulonprogo.

The landuse of Kulonprogo, particularly in the montains and hills area are dominated by dryland agriculture and fores. The wetland agriculture is only located in the area surrounding of break of slope where the small spring and seepage water are usually occur. Due to the increasing number of population and the high economical demand, the agricultural activities in the montains and hill areas become more intensive nowadays. Landuse conversion from forest to agriculture land as well as dry agriculture land to wet agriculture land was common happened during last three decades. Those intensive agricultural practices are suspected as triggering factor of some landslide events in Kulonprogo. Moreover, new road construction and new housing types with concrete and bricks wall become trend in the mountain and hills areas. To build such human life infrastructure must be initiated by land laveling or slope cutting. Those activities were triggering some landslide events in the settlement areas and/or along the new road construction (Sartohadi and Putri, 2008).

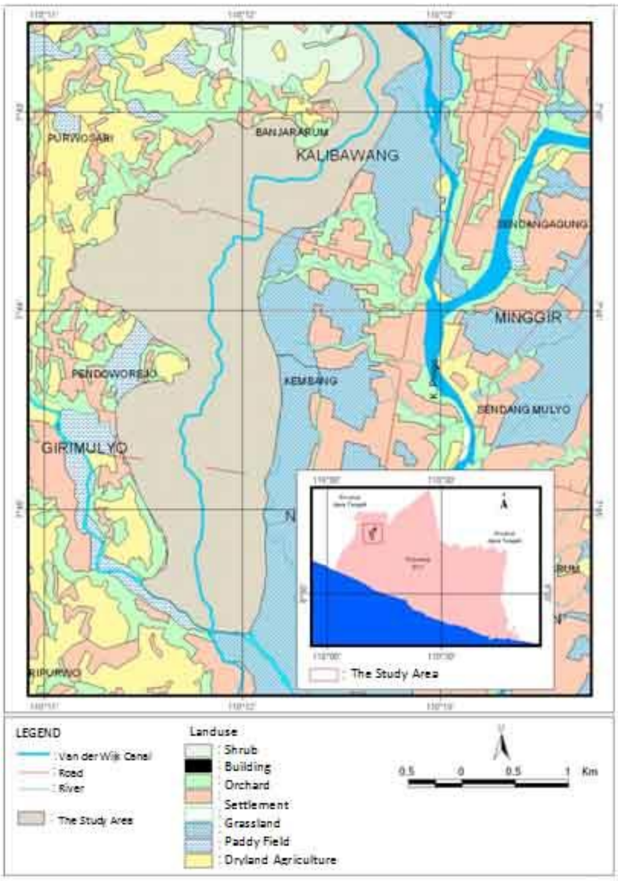

Figure 3 The location of the study area

The study area discussed in this paper is mainly located along the Van der Wijk irrigation canal where it across the lower slope and foot slope areas of some hilly areas (Figure 3). The Van der Wijk Canal is very important infrastucture for agriculture installed in the study area. The other area located in the upper slope of the hilly and montaineous areas will not intensively be discussed in this paper due to its sparse spatial distribution of soil creep. The other area located in the Kulonprogo Hills such as in Sentolo, Temon, Pengasih, and Kokap, were observed during the fieldwork but they were not intensively discussed.

METHOD

The field data was collected based on the land unit build based on the landform and landuse. They were overlaid to separate the agriculture and non agriculture land. More over, the agriculture land is divided into two, dry and wet agriculture land. The landform was evaluated based on geomorphological point of view. The consideration of morphology, morphostructure, morphochronology, and morphoarrangement aspects of landform become main factors for landform delineation. The study area is mainly focused on the lower slope and foot slope area where most of intensive soil creeps are occurred. The free transect method to observe the soil variations were done for every land unit. The analysis of soil variation within every land unit was applied to determine the location of detail soil description of soil profiles. Land management practices of the agriculture land were also taken into note during the field work.

The soil laboratory test was done based on soil samples taken from the representative soil profile. The laboratory test was intended to collect data of swelling and shrinking capacity, the base status as well as cation exchange capacity, the pH, and organic carbon content. The soil texture as well as clay extraction was carried out prior the clay type analysis. The clay type was determined based on the X-Ray defreaction method combined with cation exchange data.

The soil development analysis was based on evaluation of some soil characteristics mainly related to the swelling and shrinking capacity. The normal soil profile development analysis such as soil horizon development was not applied because in the soil creep prone area most of the soil profile development will be in the initial stage. The soil texture, soil struckture, soil depth, and slope inclination as one of main external morphology charactерristics were applied for soil development evaluation. While the soil-cracks, COLE (Coeficient of Linear Extensibility), clay content, and clay types were applied for soil creep hazard evaluation. The scoring method for those some soil soil characteristics were applied for soil development and soil creep evaluation. Table 1 –10 shows the data classification applied in the soil development and soil creep evaluation. The Sturges (1926) method was applied to classify the soil development stages and soil creep hazard.

Table 1 Slope angle classes.

Nr.	Description	Slope Angle (%)	Score
1	Good	< 9	1
2	Moderate	9 – 15	2
3	Poor	> 15	3

Table 2 Soil's texture classes.

Nr.	Description	Soil Texture	Score
1	Good	Sandy – Sandy loam	1
2	Moderate	Loam- Clay Loam	2
3	Poor	Clay	3

Table 3 Soil's structure classes.

Nr.	Description	Soil Structure	Score
1	Good	Single grain, platty, crumb	1
2	Moderate	Granuler and fine blocy	2
3	Poor	Blocky, Columnar	3

Table 4 Soil's depth classes.

Nr.	Description	Soil Depth (cm)	Score
1	Good	< 60	1
2	Moderate	60 – 90	2
3	Poor	> 90	3

Table 5 Clay's content classes

Nr.	Description	Clay Content (%)	Score
1	Good	< 20	1
2	Moderate	20 – 35	2
3	Poor	> 35	3

Table 6 Clay type classes

Nr.	Description	Clay Types	Score
1	Good	*Kaolinite*	1
2	Moderate	*Ilite*	2
3	Poor	*Montmorillonite*	3

Table 7 Cole classes.

Nr.	Description	COLE	Score
1	Good	< 0,03	1
2	Moderate	0,03 – 0,09	2
3	Poor	> 0,09	3

Table 8 Width of soil crack classes

Nr.	Description	Width of soil cr (cm)	Score
1	Good	< 5	1
2	Moderate	5 – 10	2
3	Poor	> 10	3

Table 9 Depth of soil crack classes

Nr.	Description	Depth of Soil Crack (cm)	Score
1	Good	< 10	1
2	Moderate	10 – 30	2
3	Poor	> 30	3

Table 10 Land use classes

Nr.	Description	Landuse	Score
1	Good	Orchard	1
2	Moderate	Dry land Agriculture	2
3	Poor	Rainfed-Irigated Paddy Field	3

The Sturges Method (1926):

$$\text{Class Interval} = \frac{\text{Max Score} - \text{Min Score}}{\text{Number of Classes}}$$

The correlation between soil creep and soil development was evaluated based on cross table method. The qualitative correlation between soil development stages and soil creep hazard classes were observed manually. The explanation of those correlations was based on the theoretical and facts found during the field work. Conclusion and recommendation of how to manage the factors controlling the soil creep in the study area were formulated based on both the field and soil laboratory data supported with established theory.

RESULT AND DISCUSSION

The Land Unit of the Study Area

The landforms of the areas concerned in this study are lower slope and foot slope of volcanic brecia hills and calcareous sandstone hills. The slope variations within that landform are due to the variations of surfacial materials coming from the slope down-ward movement. At the head scarp the slope is relatively steeper, while at the toe the slope is relatively gentler. The landuse variation in this study was only divided into two classes, agriculture land and non agriculture land. Those two classes of landuse are proposed for evaluating the two land management practices. Therefore, the landunits of the study area are listed in the Table 11.

Table 11 Land units of the study srea

Nr.	Landunit	Description
1	HS1BA	Lower Slope - 9%-15% - Agriculture Land
2	HS1CA	Lower Slope - > 15% - Agriculture Land
3	HS1BS	Lower Slope - 9%-15% - Non Agric. Land
4	HS1CS	Lower Slope - > 15% - Non Agriculture Land
5	HS2AA	Foot Slope – 3%-9% - Agriculture Land
6	HS2BA	Foot Slope - 9%-15% - Agriculture

		Land
7	HS2AS	Foot Slope - 3%-9% - Non Agric. Land
8	HS2BS	Foot Slope- 9%-15% - Non Agric. Land

The Degree of Soil Development

The study area is located in the lower slope of hilly areas. The slope is dominated by gentle slope (< 15%). Some steep slope is only located on the ancient landslide scarp. Conversely, the lower slope angle (< 9%) is located on the ancient landslide toe.

The soils of the study area are mostly developed from the colluvium materials. It is mixed materials of sandy to clayey materials transported from the upper slope. The mixed material was still clearly observed during the soil profile description. Some stone are scatered randomely within the soil profile. Moreover, the soil is sharply lying on the parent rock. All those materials that perform soil parent materials were sedimented under the shallow sea water environment during the upper Tertiary; therefore, the soils of the study area are relatively equal containing clay and sand. The higher clay content shows the more developed soils.

The soil structure of the study area is dominated by coarse granuler and or fine blocky struckture. The influence of clay content to the soil structure performance in the study area is likely dominant. The relatively low soil organic content has no significant effect to the soil structure in the study area. Therefore, the soil structure is relatively easy collapse due to high content of soil moisture.

The soils of the study area are mostly lying on the gently dipping sandy rock layer. The dip is parralelle with the slope. Therefore, the soil is always found in limited soil depth. The deep soil layer is only located in the local depression where it is usually an ancient landslide sediment.

The degree of soil development in the study area belongs to the moderately developed. It is due to the development of soil structure, soil depth, and soil texture. The development of clay fraction already exists but it still containing sand. The soil structure is also already developed but it is still not stable yet due to high moisture content. The soil depth is not yet performs deep soil. Based on the USDA soil taxonomy, the soils of the study area are mostly belonging to the Great Groups of Vertic Eutrudepts and Mollic Udarents. Those two Great Groups give more effidence that the soils of the study area are still in the beginning process of soil development.

The Degree of Soil Creep Hazard

The soil cracks of the study area were measured directly in the field. They were measured both on the soil surface and in the soil profile. The crack measurement in the surface was intended to establish the crack width and the measurement in the profile was intended to figure the crack depth. The crack width of the soils in the study area ranged from 1,5 – 7 cm (Figure 4). While the crack depth ranged from 25 – 67 cm (Figure 5). However, based on the soil profile description in some representative location, there were no slicken side properties. Only one soil profile shows the signature to slickenside development but it is not yet perfect enough.

The potential for swelling and shrinking was also evaluated based on soil laboratory method. The soil sample was moistened upto the liquid limit then it was dried. The linear changes were measured as COLE value. All the soil samples taken from the field shows that the COLEs are belong to moderate class. The result of laboratory test shows that there was slightly difference with the field measurement. The uncontrolled moisture condition of the soils under the natural condition may become the factor that controls the differences of both measurements. The topographic position controls the differences of soil moisture between lower and upper slopes.

Figure 4 The soil surface cracks during dry season

The clay development was not yet clearly to the direction of montmorilonit clay formation. Only small portion of clay content belong to montmorilonit clay. The occurrence of montmorilonit becomes a key for soil creep evaluation due to its high capacity of swelling and shrinking. The montmorilonit clay may adsorb water upto 3 times of its volume. The higher content of montmorilonit clay is the higher capacity of soil to swell and to shrink when the soil moisture is changing (Buol *et al.*, 1997).

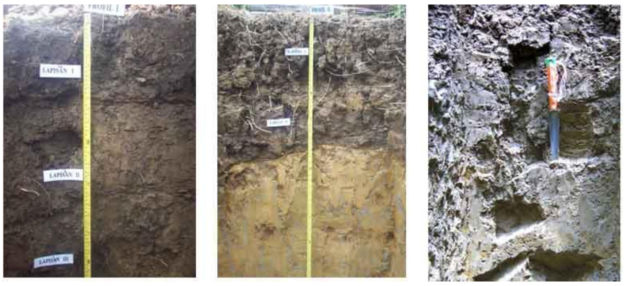

Figure 5 The soil cracks within the soil profile

The land management of the agriculture land, i.e, wetting and drying the soil for paddy plantation had made the swelling and shrinking become more intensive. The mudding processes during the land preparation for paddy and drying during the dry season and/or during the harvest time had made the soil cracks become wider. The siginificant differences of land management between agriculture and non agriculture land can be clearly observed on the damage of Van der Wijk canal. The damage of that canal is usually located adjacent to the agriculture land. The soil creep located above the canal has been pushing the canal wall down-ward. In some point, the whole canal body is shifted downward due to soil creep.

The soil materials are lying on the hard rock basement. The rock basement is slightly declining (±10%) down-ward. The contact between soil material and underneath parent rock acted as slicken plane (Hardiyatmo, 2006). The wet rock surface become slippery and the soil become easily moving down slope (Picarelli, 2007). The soil movement is natural in the non agriculture land while in the agriculture land is slightly accelerated. In this research the speed of soil movement was not measured carefully. However, the relative movement as an indication has been observed on the damages of Van der Wijk canal and other infrastructure such as small bridges.

Overall evaluation of soil creep hazard of the study area can be categorized as moderate. Some point has more intensive movement compared to another but the difference is not so significant. The differences are perhaps due to the intensity of landuse. The soil creep located in the Banjarharjo Vilage is the most serious one. It destroys the Van der Wijk canal. The ground movement was only 2-3 cm/year (Gunadi *et al.*, 2003), see Figure 2.A.

The Correlation between Soil Development and Soil Creep Hazard

Most of the soil development of the study area belongs to the moderate class and the soil creep hazard as well (See Table 12). Only one site has low soil development. It is doe to the limited soil depth. On the other hand, the degree of soil creep hazard also has one site that belongs to high class. It is doe to its high soil depth. The deeper the soil has higher potential of soil creep to create damage on the infrastructure installed on that area.

Most of the degrees of soil development are coincide with the degrees of soil creep hazard. There are only two sites that have exception. The moderate soil development coincides with high degree of soil creep hazard. The soil in that location has very deep class of soil depth but it soil texture is skeletal clay. Perhaps it is only in the matter of classifying the soil texture during the soil development evaluation. When it was classified as clay soil texture, the soil development might belong to high soil development class. However, the occurance of significant amount of gravels and stones in the profile made that soil profile could not be classified as high developed soils (Buol *et al.*, 1997).

The other factors that might make the soil creep hazard belong to the high class is land management. The landuse of that area is agriculture land for paddy field. During the land preparation for paddy, the soil is modified into mud. While during the harvesting time the soil has to dryed. Those two extreme situation between maximum wet and dry soil have made the soil creep become more intensive. In the same landform unit but under different landuse, the soil creep hazard still belongs to moderate class.

Table 12 Soil development and soil creep

Nr.	Landunit	Soil Development	Soil Creep
1	HS1BA	Moderate	Moderate
2	HS1CA	Moderate	Moderate
3	HS1BS	Moderate	Moderate
4	HS1CS	low	Low

5	HS2AA	High	High
6	HS2BA	Moderate	High
7	HS2AS	Moderate	Moderate
8	HS2BS	Moderate	Moderate

Source: data analysis

CONCLUSIONS

Based on the results and discussions, the conclusions can be formulated as below:

1. The soil creeps in Kulonprogo Hills are located in the footslope and footplain areas, where the slopes are usually gentle ranges from 3 – 15%. They are distributed in several Kecamatan (Sub-district) in Kulonprogo: Temon, Kokap, Sentolo, Nanggulan, Girimulyo, and Kalibawang. In the steeper slopes, the other types of landslide predominant.
2. The degree of soil development in the study area in general belongs to moderate class. Some exception occur in the location of ancient landslide sediment where the soil depth is higher than the other locations
3. The degree of soil creep hazard of the study area in general belongs to moderate class. An exception occurs in the land unit HS2AA where the soil creep is accelerated by the agricultural practices. In the similar land unit that have similar soil and slope characteristics but it has non agricultural landuse type, the class of soil creep hazard still belong to moderate class
4. There are correlation between the degree of soil development and soil creep hazard. The more developed soil tends to have higher soil creep hazard.
5. The soil characteristics in the soil creep prone area are: (a) having slope inclination of >5% - 15%, (b) overlaying the gently dipping impermeable rock layer, (c) having +10% of montmorilonite clay, (d) the deeper soil will have higher degree of hazard, and (e) the landuse is wet agriculture land.

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APPENDIX

Result of X-Ray Diffraction

Clay Types	Sample Number									
	a	b	c	d	e	f	g	h	i	j
K/H	50	65	55	50	40	75	65	65	60	60
S/M	25	15	25	15	25	10	20	20	20	30
Q	10	10	10	15	20	+	+	+	+	+
C	+	+	+	+	+	+	5	5	5	+
F	15	5	10	15	15	10	10	10	15	10

Note: 1). K/H = Kaolinite/Halloysite; S/M = Smectite/Montmorillonite; Q = Quartz; C = Cristobalite; F = Feldspar
2). the units are in %

DOME HOUSE FOR EARTHQUAKE VICTIMS AT NGELEPEN JOGJAKARTA THERMAL COMFORT IN WARM HUMID TROPICAL CLIMATE

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ABSTRACT

This paper is an evaluative study based on a review of thermal comfort aspect of the dome houses for earthquake victims in the Ngelepen, Jogjakarta. The purpose of this paper is to evaluate the dome houses in terms of building design criteria for warm humid tropics. This paper is one step from the evaluation of research activities towards the dome houses thoroughly empirically.
The method of evaluation is done by theoretical studies of secondary data about dome houses gathered from several sources. From this study concluded there is a presumption that the use of concrete materials is not an issue for the achievement of thermal performance warm humid tropical climate. However, there is a presumption that the thermal performance of residential space in the dome houses Ngelepen will not fit with thermal comfortable criteria in warm humid tropical because some of the following: (1) The form of a compact monolithic dome, which will result in high value of thermal capacity and low value of heat loss building, (2) non orientation-dome shape would make it difficult for controlling the orientation of solar radiation in the dry season; (3) Limitations on monolithic opening system that will reduce the opportunity for space cooling by convection, (4) There is no sun and eaves shading will increase the entry of solar heat radiation, especially in the dry season and rain in the rainy season.

Keywords*: dome houses; thermal comfort; warm humid tropics; form of building; building envelope, Opening, shading; thermal capacity, heat loss, solar radiation, rain*

INTRODUCTION

1. Background

An earthquake measuring 5.9 on the Richter scale or 6.2 on the Richter scale have occurred in Jogjakarta on May 27, 2006. The quake's epicenter occurred at coordinates dan110 8.007 ° South Latitude, 286 ° East longitude at a depth of 17.1 km (Ministry of Energy and Mineral Resources) or the coordinates of 8.26 ° latitude and 110.31 ° longitude at a depth of 33 km (BMG) (Wikipedia, 2008).

This earthquake has killed 6234 people and destroyed so many homes. Help from abroad coming in large numbers. One aid is the dome houses in Ngelepen (Sengir), Sumberharjo Village, Prambanan District, Sleman District .. This dome houses the assistance of WANGO (World Associate of Non-Government Organization) and DFTW (Domes For The World Foundation) (the South & South, 2007).

Figure 1. Location of the epicenter May 27, 2006 in Jogjakarta (Wikipedia, 2008)

This project was supported by a single donor Muhammad Ali Alabar owner of Emaar Properties Dubai, United Arab Emirates (Sofian Blue, 2008).

Plan a circular dome houses with dome-shaped roof. Materials made of concrete. Space is divided into two floors with no ventilation holes in the walls and eaves of the apex of the dome. In its development a few houses have been modified. Addition of porch and side of the village buildings have been carried out.

Home as a place to live events will require fundamental requirements. These requirements are the requirements for safety and comfort requirements. The question then is whether these requirements can be met by the dome houses in Ngelepen?

Figure 2. Complex dome houses in Ngelepen (National Geographic in Eeghout, 2008)

Figure 3. Interior dome houses Ngelepen (DFTW, 2008)

Figure 4. Modification of the dome home by residents until November 2007 (Liz, 2008)

Safety requirements are met through the fulfillment of construction feasibility. Feasibility of construction of the dome houses must have been evaluated through testing in a study conducted by DFTW. This project is a project supported by DFTW an institution with the mission of improving human life through the introduction and development of monolithic domes and ecoshells (DFTW, 2008). Yet how is comfortable with the requirements? Does the dome houses can fulfill it?

Comfort requirements include requirements for movement, sensory and thermal. Based on Fanger (1982), it is known that the thermal quality of space will determine the ability of human beings. Sugini (2007) based on Vitelg & Smith (1946) in Altman & Stokol (1987) concluded that the ability to be determined by a thermal comfort is the ability to include intellectual ability, perspsual and other capabilities in general. Besides the thermal quality of space is also largely determine the quality of health and biological functions of body organs.

Based on the above description can be concluded that an evaluative study of the dome houses based on thermal performance space is necessary. The results of this study will need to be input on practical aspects for the government of Sleman and DFTW as well as in the theoretical realm in control engineering in particular and building science in general. The results of this study will be very useful and important for the development of the dome houses next step.

Study of thermal performance in the dome houses Ngelepen becomes important to do because based on engineering knowledge of the thermal control of buildings, form, space and building envelope in the dome houses seem to conflict with the design criteria for warm humid climate. Warm humid climate is a climate zone that includes areas that includes the Ngelepen in particular and Indonsia in general. So that the results of this study will be very important in providing input on the extent to which this can be applied to the dome houses in warm humid climatic conditions.

2. Problems

Does the dome houses Ngelepen in accordance with the criteria for thermal quality space on a warm humid tropical climate?

3. Goal

Evaluating the dome houses of Ngelepen based criteria for quality thermal pad space warm humid tropical climate. Complete evaluation must be done in two stages. First step is theoretical with secondary data and the second step is empirical step. In this paper, the author reports the first step.

DESIGN CRITERIA FOR WARM HUMID TROPICAL THERMAL COMFORT

1. Warm Humid Tropical Climate Characteristics and Jogjakarta

Evans, in 1980 the climate divide in several zones. One of them is a warm humid climate. Characteristics of moist warm temperate regions characterized by the following characteristics. Temperatures ranged from 20ºC-30ºC with a temperature difference range between 10ºC-12ºC. Humidity ranged between 60% - 90% with high rainfall up to 1000 mm and equipped with the dry season. Area extends between 15 º and 15 º N latitude.

Based on the statistics can be summarized Jogjakarta in Figures Yogyakara and climatic conditions in Sleman in particular, as seen in the following images. From the characteristics of detail in the images could be concluded that the district of Sleman is included in group warm humid tropical climate.

2. Design Criteria for Thermal Comfort in Warm Humid Tropical Climate

There are four architectural aspects of buildings that provide space influence on the climate. Four things are (1) Effective solar exposure, (2) Solar Heat Gain Effective, (3) the level of conductivity and convection from or into the air and (4) potential ventilation natural in the passive cooling of buildings. Fourthly it is related to the five components of building design (1) building form, (2) orientation and shadowing windows, (3) orientation and color of the walls, (4) the size and place of ventilation and (5) the effects of ventilation conditions in buildings at temperatures Air (Givoni, 1998).

In Evans (1980) described four components of residential buildings that will determine the quality of thermal space. Four components are (1) the form, (2) the skin of the building, (3) opening and (4) site. In this case, a fourth component to be irrelevant to the evaluation criteria included in the search for dome houses. Another relevant criterion is the criterion of one to three.

Shape of the building seen from the following criteria: (1) Criteria proportions or the ratio of surface area to volume, (2) Criteria depth of field that looks at the anatomy of discounted room (single or double bank room), (3) The distance between the angle determined by the requirements of space (space angle) in accordance with climate and latitude location of the building.

Skin of the building will be determined by the material properties of building skin. Building material properties are measured based on the parameters of U-parameter value (the value of the transmission from air to air), solar heat flow factor, time lag or time delay and admittance. These criteria will be escorting an architect in determining the skin type of building material.

Opening of a building is used to achieve not just for the ventilation performance, but also for lighting. These two interests are sometimes brings in a separate conflict in the design. For ventilation interests, then the openings are designed for the purpose of creating air flow which allows the occurrence of convective cooling process. On the other hand, the opening is also designed for the benefit of lighting. In general, openings are intended to include the illumination light will also enter the waste heat of solar radiation. While the waste heat radiation of the sun is not so expected on a warm humid climate regions. An effective way to solve this conflict is by adding horizontal and vertical shading on every opening. With the existence of horizontal and vertical shading as required by the angle of the sun fell, the sun's heat radiation that is not desired can be controlled. Herwagen Dean (2004), detailing the four operational strategies in the design of passive buildings in hot humid climates.

This strategy is (a) the existence of natural ventilation in the interior, (2) shadowing interior from solar radiation, (3) the use of lightweight buildin envelope order to allow for heat transfer at the time of the excess heat, (4) water proof for buildings.

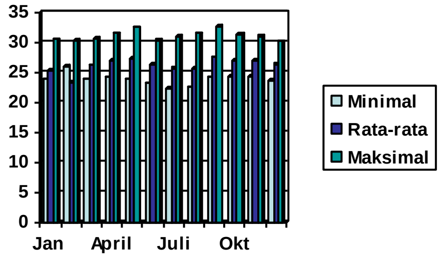

Figure 5. Temperatures in DIY (BPS DIY, 2001)

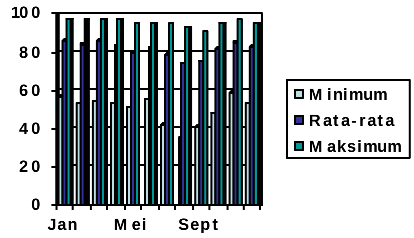

Figure 6. Relative Humidity DIY (BPS DIY, 2001)

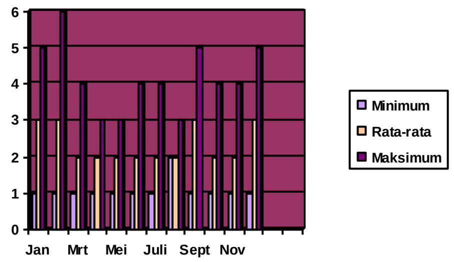

Figure 7. Wind in DIY (BPS DIY, 2001)

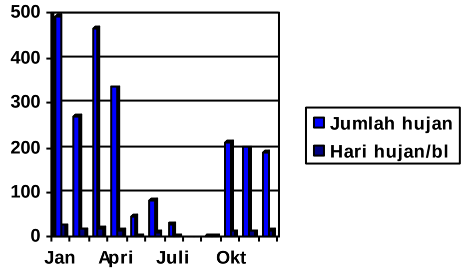

Figure 8: Rainfall and rainy days DIY (BPS DIY, 2001)

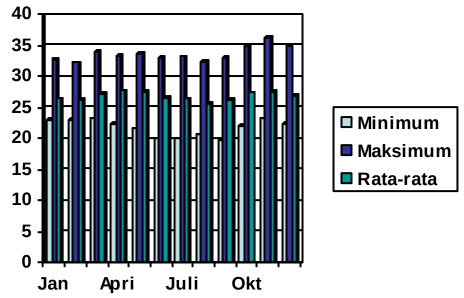

Figure 10. Airports in Sleman Humidity (BPS Sleman, 2002)

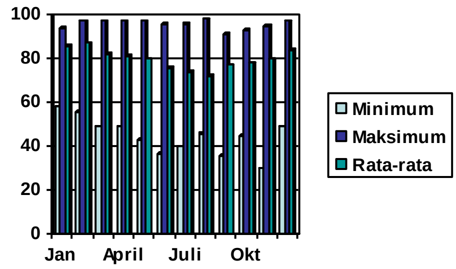

Figure 9. The temperature in Sleman (BPS Sleman, 2002)

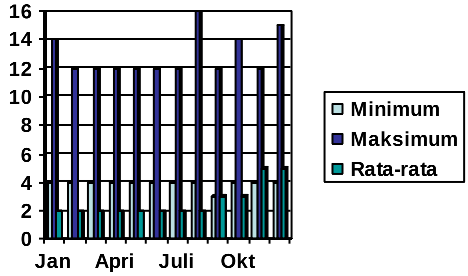

Figure 11. Air Velocity in Sleman (BPS Sleman, 2002)

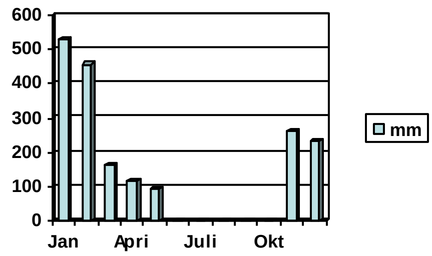

Figure 12. Rainfall in Sleman (BPS Sleman, 2002)

The fourth strategy is more devoted to the protection of construction on humid and wet climate. While the strategies 1 to 3 suitable for use as a criterion to achieve a comfortable space thermal qualities. Three strategies can be developed into building design criteria for thermal comfort in warm humid tropical climate.

REVIEW ON THERMAL DOME HOUSE

1. Building Mass

Building mass a profitable mass for a warm humid climate is a building mass with low thermal capacity and high heat losses. Thermal capacity building inversely with the proportion of surface area to volume during the era. The higher the value of the ratio between the surface area to volume the lower the thermal capacity of the building and the higher the heat loss. This means that the higher the ratio of surface area to volume the faster the heat dissipation occurs.

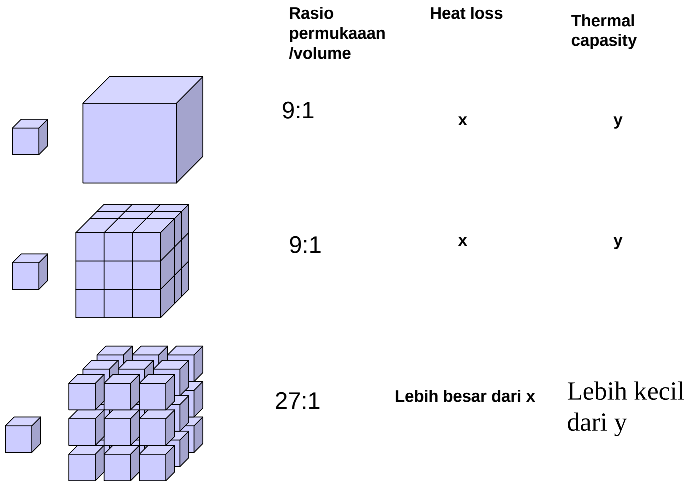

Figure 13. Shape of the mass, the ratio of the surface, thermal capacity and heat loss (Source: developed from Evans, 1980)

Single compact mass has a lower ratio between surface area and volume than a single non compact mass. Therefore dome shape in a very compact dome houses Ngelepen has low ability to release heat. This means that the occupant will get more heat stress. Thus, the dome houses are less favorable views of the form criteria.

Ratio of surface area and volume of a single mass can actually be improved in various ways. An example is the concept of *substract* by giving overdrafts on certain parts or the concept of open space *potio* by completing the middle.

Figure 14. Design of building the dome, a very compact single mass (Source: Eeghout, 2008)

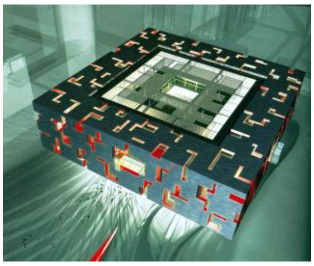

Figure 15. Design museum in Guangdong in Guangzhou. Compact single period combined with the concept that surface area increases *substract* (Source: Design LTD Rocco, 2006)

Figure 16. Houses with posio primitive Indian tribes in the middle (Source: Oliver, 2003)

1. Dome roof form

The shape and orientation to the sun is an effective combination to reduce solar heat intensity of pressure on the building. Dome shape is the form that knows no orientation or called non orientation. Dome will provide a strong possibility of the formation of perpendicular angle of solar radiation on the surface continuously throughout the day and throughout the season. Different things happen in the form of a sloping roof. Sloping roof forms would be relatively perpendicular to the solar radiation at certain hours only. Sloping shape allows us to avoid a particular orientation by placing a narrow field on the orientation of the sun that is not desired.

These conditions make the dome is not favorable to the roof form. It is because the intensity of solar radiation on the surface will depend on the angle of radiation falling on the field. The higher the point of falling or fallen more perpendicular angle, the intensity will be higher. This means that the environmental thermal load of the building will be higher. Eventually this condition will reduce the achievement of thermal performance of building space.

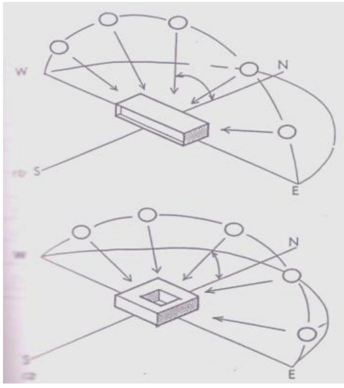

Figure 17. Orientation of buildings should be directed in such a way that minimize espousing to sun dry season (Source: Evans, 1980)

Gambar18. The non-orientation causes the dome can not minimize espousing to the sun during the dry season (Source image: Eeghout, 2008)

2. Building Envelope

Characteristics of the building skin are primarily determined by the materials and construction of roof and walls. In principle, the building skin in warm humid tropical climate areas should be sought so that the skin surface in the building must be colder than the outside either day or night (Evans, 1980). Thus, the best material for the warm humid tropics is a material with the characteristics of the property value that is able to maintain the surface temperature in the room was always lower than either day or night outside. Material with the characteristics of a short time lag is more profitable than the material with a long time lag.

Figure 19. Casting molds and preparation of concrete floors balloon (Source: DFTW, 2008)

Figure 20. Casting concrete monolith. (Source: DFTW, 2008)

Figure 21. When finished casting (Source: DFTW, 2008)

Ngelepen dome houses made of concrete (more clearly seen on the picture above). Development carried out specifically with techniques *ecoshell* monolithic dome, so that the entire skin of the building is a concrete monolith. The time lag value of solid concrete with a thickness of 10 cm is 2.5 -3 hours. This value is almost the same with bricks, ie between 2.3 hours to 3.2 hours (Evans, 1980). If Evans can be analogous comparison in the comparison between the properties of time lag of concrete dome houses with bricks from the surrounding environment, it can be assumed that the material concrete dome house will not pose a significant doubt in reaching a common thermal performance expected by the locals.

The problem is that the shape of the concrete monolith provides little opportunity for making opening to ventilation. Opening to ventilation with proper placement will provide the wind input to the process of convection cooling in indoor. Space cooling by convection is very effective for the creation of thermal comfort in warm humid tropical climate.

3. Opening and shadowing

The accuracy of the design elements are seen from the opening that includes the dimensions, orientation, position and the elements. External elements that are closely linked to control of follow-up thermal interruption of solar radiation are horizontal and vertical shading.

Ngelepen openings on the dome houses are not equipped with either horizontal or vertical shading. Windows and doors not equipped with a verandah. There is no terrace that can help provide shadowing on the buildings and spaces within. As a result of radiation into the room (see Figure 22). This condition is certainly not beneficial to the quality of indoor ventilation. This conjecture is strengthened with the renovation has been done by the occupants of the building. Like add a porch at the front door and windows (see Figure 23).

Figure 22. Solar radiation in the absence of direct entry porch as shading. In addition to the entry of radiation will cause the heat of the scorching sun, this condition will also allow the rain water come into the room when the rain came.
(Source of picture: Liz, 2008)

Gambar 23. Figure 23: Addition by occupant.
(Source of picture: Liz, 2008)

CONCLUSION

Based on this study can be summarized in the previous section there is a presumption that the Ngelepen dome houses can not meet the quality criteria of thermal comfort for the tropical climate of warm humid regions. This conclusion is of course an empirical truth must be tested again. In detail some of the things that caused the Ngelepen dome houses not meet with the thermal comfort criteria for humid tropical climate is as follows:

1. A compact dome shape will have an impact on high value of thermal capacity and low value of heat loss. .
2. The non orientation dome shape of Ngelepen Dome will reduce its ability to minimizing solar radiation, especially in the dry season.
3. From the aspect of material property, the use of concrete materials in the dome houses Ngelepen is not a problem in achieving thermal performance.However, monolithic system will provide a lot of trouble to create opening. Opening in warm humid tropical residential houses will

be very profitable for the convection cooling space.

4. The limited opening dome houses Ngelepen become more no longer profitable because it is not equipped with sun shading. Incoming solar radiation in space will reduce the thermal performance of residential space, especially in the dry season. Besides the absence of eaves are also opportunities for the occurrence of water rain interruption in the room in rainy season.

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COMMUNITY'S PERCEPTIONS ON THEIR OWN ENVIRONMENT TOWARD DISASTER MITIGATION AND PREVENTION; A CASE STUDY OF MENTENG ATAS – JAKARTA, INDONESIA

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ABSTRACT

Menteng Atas is a sub district (Kelurahan) in Southern Jakarta – Indonesia, under the district (Kecamatan) of Setiabudi. As a common crowded settlement in urban area, this location is facing multi problems related to physical environment. Built environment with very high density and not well-arranged of fronts and position, also does not meet standards of healthy construction and environment are the main problems of Menteng Atas that brings to disasters such as flooding and fire. This paper explores how members of Menteng Atas community perceive their everyday surroundings within the context of an environment that has rapidly changed, primarily due to urban development, and what they wants for the future of their environment. The study started from the inside of the local community. Symbolic communication varies from one situation to the next were found by studying the accounts, explanations, and social action that are meaningful to a group of people. This paper is trying to present and identify perception of host community on their environment especially related to disasters prevention, and end up with some recommendations to achieve sustainable housing and settlement in this area

Keywords: *built environment, perception, local community, disaster prevention*

INTRODUCTION

Urban slum area with its dense population and buildings and insufficient and below standard facilities and infrastructures are very vulnerable to flood and fire disasters. Domination of illegal settlers occupying the slum area becomes a driving factor of disaster. As the illegal settlers usually have low environmental concern. Fast growing and evolving Jakarta city development needs sufficient facilities and infrastructure.

Process of housing as a commodity has eliminated natural process between human and their settlement. Community improvement or development becomes a main concern in a housing and settlement area arrangement process. While housing and settlement management process conducted by its community members are used as an instrument for the community development. By considering this instinctive relations and placing housing and settlement development as a strategic instrument to build community, then the housing area arrangement should put the residents and families from local residents in the center of long term and comprehensive solution development process. According to Moh. Jehansyah Siregar (2007), housing and settlement physical environment's improvement and development are initial step in community development process. It is believed that improvement and development process driven by the community may become an effective instrument to bring in change in to community structure, farther change from merely physical change limit and guarantee to be settled. This matter is confirmed by Healey et al. (1997), which is a main shift in planning, in public sector (government) as a main actor to active collaboration among elements in society. Economic consideration becomes a dominant element, where this drives the shift from role of Government as allocation and regulation maker to be more proactive (in term of stimulating development).

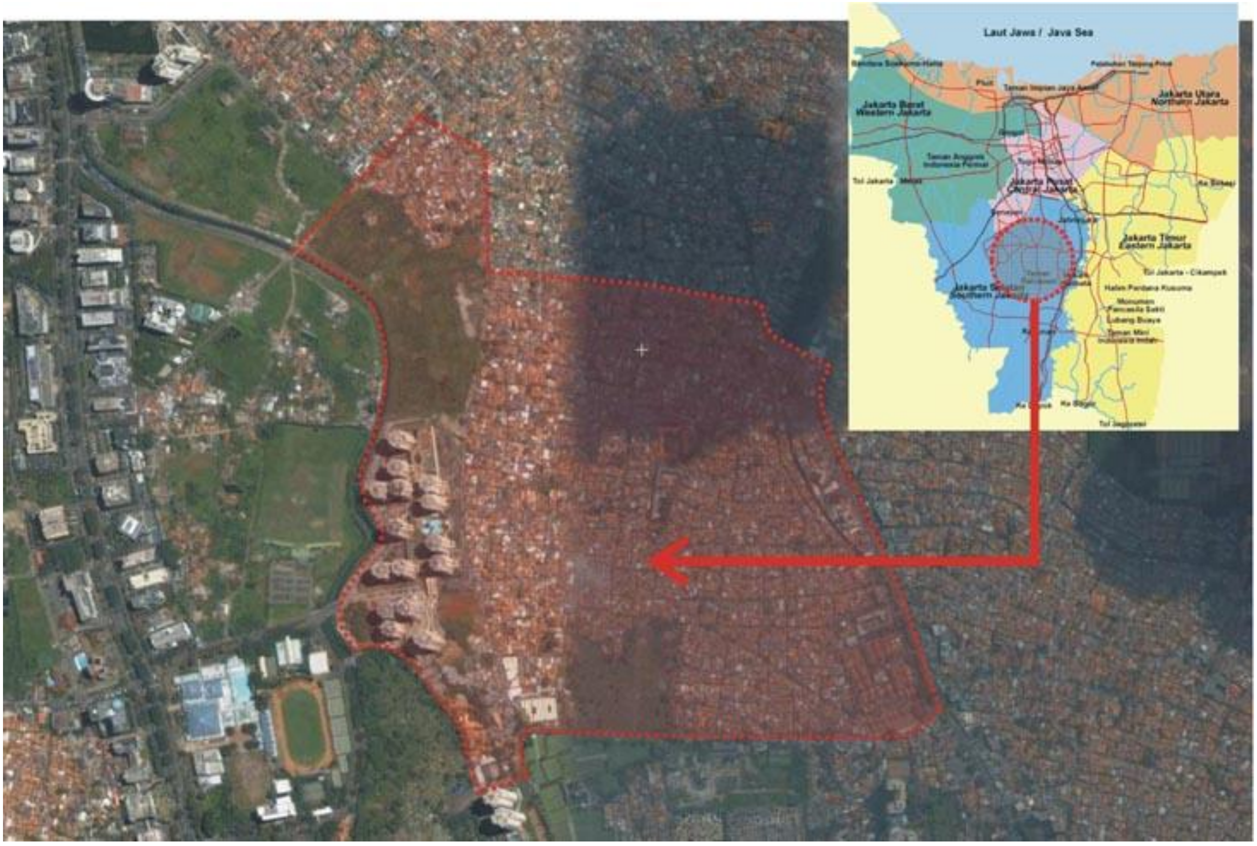

Figure 1 Location of Menteng Atas

Kelurahan (Sub-District) Menteng Atas*,* South Jakarta is not spared from the rapid growth and development of slum settlement that formed by urban community. This paper is discussing perception of host community on their own environment especially related to disasters prevention. Data, analysis, and discussions on this paper are part of study on housing improvement program on slum area in Menteng Atas was conducted in 2009.

METHOD

The study was conducted by qualitative method with semi grounded research technique. As mentioned by Rudito and Famiola (2008), imbalances action as uncommon patterns of society will appear by observing social problems.

Moreover, the description of social living can be clearly and functionally identified from the existing system that applying before (INRR, 2008; Rudito and Femiola, 2008). According to Stark and Roberts (2002), an unstructured observation is a field research method, by informal observation, often impromptu, and usually is recorded in a narrative fashion. Information as primary data shall be searched and collected through opinion expressions, and discussion. The opinion expression (brainstorming) aims at reviewing social ideas and aspiration for environmental betterment and planning.

The field observation is implemented in self-help manner into the location with unstructured interview - a short interview with several local inhabitants and social figures in the study location. Through such activities and other support-data, one gets an illustration of the local citizens and their environment. Visual observation is not related only to physical condition but also that of the target community. In man environment approach, it is clearly identified that any physical formation serves a reflection of social values that affects the local inhabitants. Discussion with the local inhabitants is held in non-formal and easy setting for their perception about their environment. The discussion is organized at every community units (RW). This activity is attended by *RW* administrators, representatives from any *RT* (neighborhood units), *anggota Dewan Kelurahan* (members of district representatives), and the head of informal society associations that identified as a potential group inside the society.

MENTENG ATAS: OVERVIEW AND ANALYSIS

Kelurahan (Subdistrict) Menteng Atas located in Kecamatan Setiabudi District South Jakarta with area of 90.45 hectares divided into 146 RT (Neighborhood Units) and 11 RW (Community Units). Menteng Atas bordered with Kelurahan Pasar Manggis in the North, Kelurahan Manggarai Selatan in the East, Kelurahan Menteng Dalam in the South, and Kelurahan Karet in the West. Most of its area is resident settlement, with detail 85% is used for housing housing and yards, 10% for Charitable Lands and Graveyard and 5% for Industry and Convection. Its populaiton density rate is 371,464 per Hectare. Composition of productive age (20-55 years old) dominates by more than 50% of total population with comparision number of males and females is blanced. Majority work in trading sector and construction and the remaining works in service sector. Most residents embrace Islam religion (90%). Most status of the land in study location is state-owned and other status. From demography's point of view Menteng Atas has population number potential dominated by productive age group, but in other side number of unemployed residents or those with non permanent job also remains high. The seasonal settlers are also high as indicated by growing boarding houses. Informal sector, taking advantage of lands under its control or even limited public space for a wide variety of business types. 80% residents have been living in this location for more than 20 years. Acquisition on the land is by inheriting the land generation by generation for such term. Some illegal housings also emerge in some locations. One of them on the Budhist/Christian graveyard directly bordered with settlement at RW 13. Menteng Atas has community's characteristic namely easy to persuade to cooperate with programs involving them, in addition strong resilience is characterized with high enough social and cultural activities.

From field observation, at the study location can be found urbanism symptom that referred by Louis Wirth (1968) as having a characteristic of transiensi or tendency that urban residents do not know all people in their settlement environemnt as the settlement is growing to become human crowd, crowded so then they do not know each other. In such condition every urban residents then moves or conduct activities among other urban residents without feeling embarassment, as according to them the activities are their own business and do not involve other urban residents' emotion or feeling or in broader meaning the urban public. The absence of social control due to this transiency condition results in public spaces where their utilization control are held by public experiences reduction due to utlization by certain parties arbitrarily for their personal interest or groups collectively with characteristic ignoring legal norms both normative and appplicable social law.

In Menteng Atas there are two characteristic groups of building conditions, namely building characteristic in first-tier which is easy to access and close to main road and building characteristic located at the center of location and rather difficult to access from main road.

Table 1 Building characteristic in Menteng Atas

RW	Permanent Buildings	Non/Semi Permanent Buildings	High Density	Low Density
02	√		√	
04	√		√	
05	√		√	
06	√		√	
07	√		√	√
08	√		√	√
09	√		√	
12	√		√	
13	√	√	√	
14	√		√	
15	√		√	√

Building physical conditions directly related to collective road and in general its environment located in good, sufficient and standardized building feasibility. Dominated by permanent buildings. Well-organized with low building density. The existing allotments are for building, public facilities, government buildings, and well-ordered housing complex (not kampong) with sufficient facilities. This condition only covers small part of Menteng Atas area. In contrast to the first condition, buildings located in center of location are dominated by buildings with characteristic of very densed settlement linked with path which mostly do not meet the health standard. The high building density and their building's fronts and regularity are not patterned well. Most existing buildings are 2-floor buildings, particularly new buildings. The existing settlements are not equipped with sufficient environmental facilities and infrastructures..

Only around 20% from entire location which can be reached by four-wheeled vehicles. In study location only small part served by local/environment road class with ROW (right-of-way, a strip of land for a transportation facility) 3-5 meters and the remaining only linked by narrow alleys. Such existing condition is very worrying, particularly related to emergency conditions such as fire, flood or other disaster. Such access condition certainly would hinder firefighting vehicles and ambulance to reach the location. The most vital of Kelurahan Menteng Atas that there is no any firefighting post at the location. With the existing building density, need for fire handling facilities becomes an absolute requirement, in it would be better if at study location minimum is established a good access which can be used anytime for emergency condition or fire. For that, it needs area of minimum 300 m^2.

Related to flood disaster in urban areas, there are two that mostly related namely drainage system and garbage management. At Menteng Atas main drainage system is divided into two main locations, namely East side at parts in alignment with Jl. Dr. Sahardjo and Jl. Minangkabau, and in West side namely Kali Cideng. The secondary drainage network encircles area of Kelurahan Menteng Atas and in East side of the area. In the study location, not all RW has well-planned garbage disposal. One of them is at RW 13, which currently made Buddhist/Christian graveyard area as garbage disposal. While part of other residents' household garbage are collected and disposed to other area.

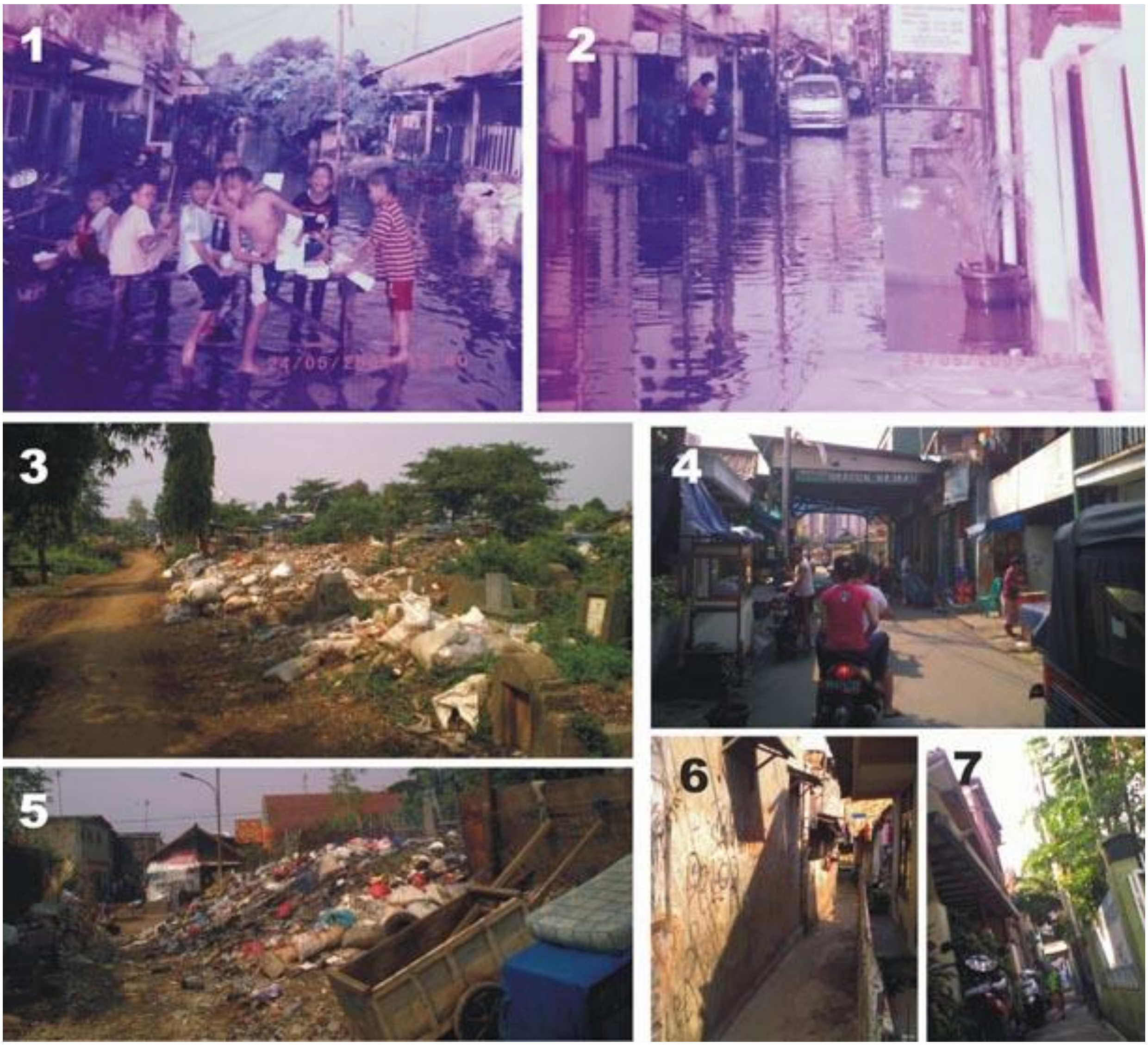

Figure 2 Menteng Atas during rainy season (1 and 2), illegal settlement (3 and 5), building density in Menteng Atas (4, 6, and 7)

Table 2 Garbage handling system and facilities at kelurahan menteng atas

RW	TPS	Location	Meet Requirement	**Remarks**
02	None	-	-	Promptly transported by officials
04	Available	Interactive Park RT.005	Less	Transported by officials every 2-3 days
05	None	-	-	Less carts number
06	Available	Pasar Minangkabau	Less	Less carts number
07	None	-	-	Promptly transported by officials
08	None	-	-	Promptly transported by officials
09	None	-	-	Less carts number
12	Available	Empty land RT.010	No	Transported by officials every 2-3 days
13	Available	Kuburan Bud-Bud-ha/Kristen	No	Un transported
14	None	-	-	Less carts number
15	Available	MCK RT. 003 & Lapangan RT. 005	No	Transported by officials every 2-3 days or more

Analysis is also conducted at each neighborhood unit (RW) toward 3 fundamental principles on zone planning namely physical quality of zone, characteristics and social structure, and opportunity of economic development. Rating scale 1 (very bad) to 5 (very good) is used. Conclusions drawn are:

- Physical Conditions of Zone on average are in sufficient conditions, only at RW 13 having special condition below average.
- Communal social conditions in study location is characterized by non formal social institution but degradate due to urban community growth characterized by transiency/unanomity amog urban residents particularly at RW 13.

Economic opportunity of residents in study area is good enough both considering the location directly bordered with urban commercial area.

Table 3 Result of Physical Environment, Social and Economic Analysis

Location	Physical	Social	Economic
RW 02	3	5	4
RW 04	3	4	4
RW 05	3	4	4
RW 06	3	5	5
RW 07	3	4	4
RW 08	3	5	4
RW 09	4	5	4
RW 12	4	5	4
RW 13	1	3	2
RW 14	3	5	4
RW 15	3	5	4

MENTENG ATAS AND RESIDENTS PERCEPTION

From above description and analysis, can be concluded that Kelurahan Menteng Atas with its various environmental issues is very vulnerable toward flood and fire disasters. Next step, this study tries to see perception of local residents concerning the phenomena. Downs and Stea (1973) said that perception is an all-encompassing term for the sum total of perceptions, memories, attitudes, preferences, and other psychological factors that contribute to the formation of what might better be called environmental cognition. Appleyard (1973) argued that perception is much more responsive to the configuration of the physical environment. Tolman (1951) identified a 'placing need' as a fundamental motivation in perception. Understanding environmental cognition requires a prior understanding of environmental perception. Rapoport (1990) said that environmental quality (physical elements) relate to social meaning. He said that physical elements are related with: vision, space, type of order (order versus disorder), perceived density, level of maintenance, topography, and location. While, social elements are including people, activities, used, and related with objects (signs, advertisements, foods, décor, feces, plants and gardens, possessions, etc.).

In order to know perception of residents, some open questions are raised concerning their response toward environmental issues and potential where they live, either related to physical environmental, social culture or economic. The previous analysis results concluded that Menteng Atas has fire and blood disaster high level was not presented to them in order to guarantee their answers were not biased or artificial.

From formulation of answers obtained, it can be concluded that the residents have not owned self-awareness toward disaster dangers which anytime may affect their area. They respond more to micro issues such as damaged path and need repair, water waterway is damaged and holed, and road light many are defunct/damaged and need points addition. They do not see access to their environment as narrow and winding among the building density as a problem that would obstruct them in case of fire. In answers obtained, obviously they do not see their residence as a part of community with larger scale (macro and multisectoral point of view). This is based on existence of housing and settlement which are inseparable and closely related to economic, industrialization and development activities. According to Jo Santoso (2006), tendency of low income community to prefer their houses close to workplace or place to have opportunity for making housing and environment's physical quality is not important for them. Further Jo Santoso said the important thing for them is to day and not evicted.

Likewise toward the existing local institutional, they have not considered it as the potential they have. Existence of residential community and its activities at Menteng Atas is able to develop independently and run well. Among them are majlis ta'lim, womanhood such as *arisan*, PKK and Posyandu, sports activities, and the existence of cooperatives institutions in some neighborhood units. They considered all only as limited to routine activities which naturally exist in housing environment. From their answers on question what need they require related to the activities, they mention renovation and supporting facilities enhancement as needs they require. While trainings or other capacity building efforts are not priority in their answers. Arif and Bambang (2008) have opinion that to build community's trust is the essence to create participation and activity sustainability. Institutional potential of Menteng Atas community indeed can be utilized as a driver to community development including in it flood and fire disaster anticipating and handling.

RECOMMENDATIONS

Transportation Infrastructure

Area of Menteng Atas needs primary local and secondary local road planning covering entire area of Menteng Atas. This primary local road is serving local transportation with short trip and low average speed. Minimum plan speed is 20 km/hours with ROW (right-of-way) minimum 7 m, so it can be reached by firefighting vehicles and ambulance, and garbage transport vehicles. Construction of these environment/primary local roads are designed such so entire area included in firefighting fire vehicles. This road may not be passed by public transportation, but it can be used for two-, three-, four-wheeled vehicles and pedestrians. While secondary local roads used in this area cover 2 types, namely secondary roads type I and type II. Secondary local roads type I is paths allotted for pedestrians and two-wheeled vehicles (taxi motor or bicycle) with ROW of 4.5 m. But in particular condition, this road may be passed by ambulance car, firefighting trucks, and garbage trucks. Secondary local roads type II is paths which only used by bicycles or other two-wheeled vehicles and pedestrians with ROW 2.5 m.

Flood Control and Drainage System

Drainage planning which its finishing covers broader scale. Flood control plan is directed to normalization of existing macro waterway (particularly Dr. Sahardjo waterway located in arrangement location besides Cideng River in West side of location) with eviction of illegal buildings on rivers and develop vegetation permanently. In addition to macro waterway, secondary waterways go through areas of RW. 07, 08, 09, 13, 14, and 15 also need to receive attention and supervision. Elevation of flood-prone areas and development of linking waterway are integrated with improvement and construction of collector and local roads. Tight security should be taken in macro waterways and link located in illegal buildings and garbage. The planning is also related with embankments along primary and secondary waterways which are damaged in some points. Waterway embankment damage also is one of main cause of inundation/flood in rainy season.

Housing and Settlement Planning

For permanent buildings especially with buiding age above 20 years, then the proposal is to renovate or repair with main target is adjustment with settlement building feasibility standard, relaed to classification of rooms, lighting, air circulation, and fire hazard prevention. If it is possible also conducting adjustment toward applicable urban regulations such as *KDB: Koefisien Dasar Banguan* (building coverage), *KLB: Koefisien Lantai Bangunan* (floor area ratio), distance among buildings, etc. While semi permanent and non permanent buildings which are illegal buildings at location of Buddhist/Christian graveyard it is proposed to be rejunevated and adjusted with its original allotment. Plan of public facility land utilization by optimizing existing land as efficient as possible, by increasing quality and quantity of its building utilization. State land control should be priorized in its utilizaiton. In addition, public facilities are integrated with environmental rejunivication and improvement.

Garbage Disposal and Environmental Sanitation System Plan

Concept of garbage management proposed is by using garbage depot system placed at the center of settlement area (in each Community Unit). Garbage collection service from residents' houses using garbage cart, for further disposed to garbage depot. Garbage collected at garbage depot further disposed to Temporary Garbage Disposal Spot (TPS). Given the garbage management in Jakarta City which still relies on conventional system namely gather-transport-dispose system, resulting in not all garbage transported to TPA. One of things which can be carried out to ease burden in garbage handling in Jakarta is by reducing garbage volume both from source and at the garbage processing spot. Garbage recycle concept or usually referred to as 3R (*Reduce, Reuse, and Recycle*) is one of solutions to be considered, so economic value contained in the garbage can be capitalized on. Garbage processing following 3R concept may be conducted in integrated manner.

Fire Handling System Planning

In general there are two well-known fire handling systems, namely active protection system and passive protection system. In principle, fire handling prefers passive protection effort first, then conducting active protection efforts to handle fire. Both system, at their operating they handle fire simultaneously. But in their implementation it is natural if it would be difficult to facilitate all needs simultaneously and optimally. Let alone the communities themselves have various social classes and their own resistance level toward new things in their environment, which may hinder fire hazard prevention. Particularly concerning fire handling system, passive handling system is minimum handling system which its procurement is mandatory.

Path for fire protection at the housing environment should be planned such so water source is available in form of environment hydrant, fire well or water reservoir and so on which facilitating fire fighter institution to use them, so each house and building can be reached with water gush of fire fighting units from environment roads. Every building environment should be equipped with public communication facility which can be used any time to facilitate fire information report.

In order to conduct protection against spread of fire and facility firefighting operation, at the building environment there should be available environment roads with hardening so they can be passed by firefighting trucks. At each part of settlement building where the highest settlement floor height is measured from average ground does not exceeds 10 m, then it is not require hardening layer expect it needs operational area of 4 m width along the building side where the access opening located, provided that the operational space can be reached in distance 45 m from firefighting truck access route.

In order to conduct protection against spread of fire, access route should be provided and determine distance between buildings, where for buildings less 8 floors requires distance between buildings of 3 meters (Kepmeneg PU. 10/2000). Each part of route for firefighting trucks at the building area should be in freeway of distance 50 m from city hydrant. If city hydrant is not available, then hydrant should be provided at yard. In situation requiring more than one yard hydrants, then the hydrants should be placed along firefighting trucks access route such, so each part of the route is in radius 50 m from hydrant. Water supply for yard hydrant should be at least 38 liters/second at pressure 3,5 bars, and is able to flow water minimum 30 minutes.

Social Cultural Handling

In urban development context economically and physically, then it is relatively very few experience which can be exhibited where community may play role as initiator of commercial efforts which can finance itself continously. Contributions obtained from high income residents/commercial are used up for environment's physical improvement than efforts to manage it as a capital for a larger activity.

Wheas as in fact there many reasons to argue about the necessity of community to have a role in commercial activity for self-reliance. This is apparent in the need to handle various things which without joint handling would result in high social costs such as: bad housing quality (health disturbances, low productivity, less employment and so forth), lack of education and health facilities, less job opportunities and income and so on.

By organizing self in cooperative way, the low income residents have a strong bargaining position to deal with expansion to its area. In this context the development of cooperative movement in community circle has goal with strategic dimension. This is realization of equal and just development concept which at the same time maintaining stability.

Dense settlement particularly in Jakarta never escapes from physical issues of area in form of flood and fire. If both are compared in dense settlement then the fire is most potential to be a disaster. Disaster urgency is in the threat of life victim in human and massive material loss. The hazard every time could become a serious threat for urban densely populated area. Then emerging question is how the physical vulnerability of area occurred in the settlement area.

Technical guidance covers efforts to minimize fire risks due to electronic equipments, caused by family activities to other negligence coming from human error operating in it. There is a tendency that slum settlement environment presents middle to low economic condition having implication to the low education level so it results in low concern level on safety in settlement. This tendency receives serious attention in technical guidance activities as it is related to develop communities' positive behavior in order to prevent fire. Besides to alert on fire hazards the residents are also asked in order that technically they are able to handle standard equipments which must be operated in case of fire.

CONCLUSIONS

As told by Rapoport (1990), environmental quality relate to social meaning. Disaster mitigation and prevention in the urban slum settlements are not only related to physical environment. Social cultural handling is also an important factor that must be considered and implemented together with physical aspects. As mentioned by Kaplan & Kaplan (1995), the study of human physical environment perception is useful to develop physical environment and can be used to recommend guidelines of development, as well as in the case of disaster mitigation and prevention in Menteng Atas, Jakarta Indonesia.

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KATABATIC WINDS: AN EXTREME NATURAL DISASTER IN ANTARCTICA

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ABSTRACT

One extreme natural disaster occurred in Antarctica in meteorology perspective is a Katabatic wind event. Their activity has dramatically affected the polar climate and environmental threats. The occurrence of katabatic winds and its relation to climate variables observed from ground surface meteorology and GPS measurements toward mitigation of their effects for improving numerical weather prediction is main objective of this paper. Data gathered during the September 04 is analyzed, and the occurrence of a katabatic event is compared with the wind images obtained from the NOAA Polar Orbiter satellite. A 3-year of ground-based GPS meteorology observations to show the climate pattern in Antarctica is also presented. Results showed that the katabatic activity and their characteristics depends on density of air and temperature in the source region. Katabatic winds are less frequent during the Antarctic summer (enhanced during the winter), indicating that the onset of a katabatic event is synoptically triggered or activated by large scale weather features such as a high pressure system over high elevations.

Keywords: *Katabatic winds, Climate, Antarctica, GPS*

INTRODUCTION

One extreme natural disaster occurred in Antarctica is a Katabatic wind events. This wind is extraordinary compared to tornadoes, hurricanes, and other storms. These winds occur around every significant mountain range in the world, from Antarctica to Greenland. Katabatic flows over high-latitude long glaciers experience the Coriolis force and can blow with hurricane speeds. The buildup of high density cold air over the ice sheets and the elevation of the ice sheets brings into play enormous gravitational energy, propelling the winds well over hurricane force up to 304 km/h (e.g. Barry, 1992). This wind originates from the cooling by intense radiation of air at top a plateau, a mountain, glacier, or even a hill (e.g. Turner and Pendlebury, 2004). Since the density of air increases with lower temperature, the air will flow downwards, warming adiabatically as it descends. The temperature of the wind can become hot by the time it reaches sea level. In the case of Antarctica, the wind is extremely cold. These winds can cause sudden changes in the weather itself and in the area when the winds spill out. In Greenland these winds are called Piteraq and are most intense whenever a low pressure area approaches the coast. On the eastern slope of the Rocky Mountain Front Range in Colorado, katabatic winds are called Chinook winds if they are warm, and Bora winds if they are cold. Santa Ana and Foehn winds are similar strong downslope winds occurred in Southern California and the Alps in the Europe, respectively. In the case of the Santa Ana, the wind can become hot by the time it reaches sea level, and this wind is totally different with katabatic winds in the case of Antarctica.

Antarctica is the only continent that has never had an indigenous population of humans because it has always been such an extreme environment. The inaccessibility of the place and the lack of reliable food and means for constructing shelter has kept humans away for thousands of years. But, the new technologies developed over the last 200 years made it possible for people to reach these icy shores to explore and study the Antarctic for the first time in human history. Presently, Antarctica is not only fascinating itself, but serves as an excellent laboratory for studying the effects of space travel, developing new technologies for exploring other planets and finding extraterrestrial life. The advantage of doing research in Antarctica is because of the unique situation in terms of weather and climate, which has been under-exploited relative to the Arctic. Antarctica due to its pristine, majestic and unique environment offers a privileged position for the study of atmospheric climate and provides a key to explain the causes of change and prediction of the global climate system. Their higher latitude polar region is directly affected by the entry of the solar particles and energy. Despite large regional differences of a unique location of Antarctica, severe katabatic wind events as one climate variable, plays an important role in performing the local climate, particularly in winter climate. Strong katabatic winds are frequent at some sites and infrequent in other, creating large variation in mean annual temperature owing to the warming effect of the winds (Nylen et al. 2004). Because of the interior of Antarctica is a basically a desert, the coldest air in the layer near the surface leads to high pressure and outflow of air away from the cold region toward the warmer surroundings. The winds really kick in because of the sloping terrain along the edges of the continent and can accelerate to those extreme speeds as mentioned above. The timing of katabatic wind events also varies with the local climate and landscape. High winds combined with low temperatures make Antarctica an inhospitable place for humans. On the other hand, the katabatic activity has dramatically affected the polar climate and most significantly threats the environmental.

Because the katabatic winds playing crucial role in the climate system, this work attempt to mitigate of their effects for improving numerical weather prediction. A significant impact of katabatic winds on the quality and accuracy of GPS signals during the propagation from space to a receiver on the ground is studied. Therefore, for first stage, detecting the occurrence and the characterization of a katabatic event using both ground-based GPS technique and meteorological observations are main objective of this paper. The temporal variations of both measurements during a katabatic event in the Ross Island region, Antarctica on September 2004 is analyzed. The occurrence of a katabatic event is then compared with the wind images obtained from the NOAA Polar Orbiter satellite. A 3-year of ground-based GPS meteorology observations in Antarctica is also presented to show the Antarctic climate pattern.

DATA AND METHODOLOGY

The measurement system employed for this work consists of a GPS receiving system and a ground meteorological system. The GPS receiver at Scott Base station (SBA) located in the Ross Island region, Antarctica was installed in November 2002 under the Malaysian Antarctic Research Programme (MARP) and was maintained by the Antarctica New Zealand (ANZ). The ground meteorological system was managed by the National Institute of Water and Atmospheric Research Ltd., New Zealand (NIWA) and ANZ. GPS data were stored into a PC with sampling rate of 1s. The surface meteorological measurements consist of surface pressure (in mb), temperature (in °C), relative humidity (in percent), wind speed (in m/s) and wind direction (in deg), which are all logged at 10 min intervals. Both measurements are employed to determine the precipitable water vapour (PWV) and such used to study the dynamics of katabatic winds. Details of the measurement system at SBA can be found in Suparta et al. (2008). Figure 1 shows the location of Scott Base station and another five permanent GPS stations which are located along the Antarctic continent.

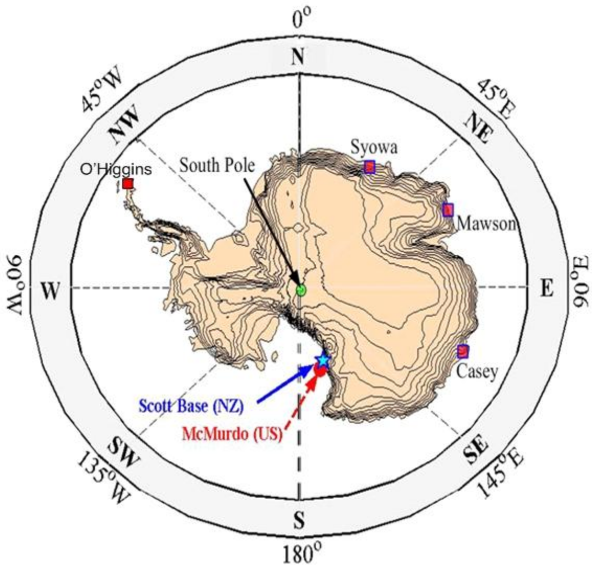

Figure 1 Map of Antarctica for the climate observation in the analysis

The PWV total, as a climate variable, is determined from both GPS signals and the surface meteorological measurements. Surface meteorological measurements are used to correct the errors caused by atmospheric delays of GPS transmissions. There are five steps to derive the PWV from GPS observations. First, the Zenith Tropospheric Delay (ZTD) is calculated based on the Modified Hopfield model. The ZTD is estimated by constraining the positions of widely-spaced GPS receivers and measuring the apparent error in position every 10 minutes. When all systems related errors are accounted, the residual error is presumed to come only from the neutral atmosphere. In addition to the precise of ZTD estimation, the residual tropospheric delay was cancelled by implementing a single differencing technique in the pre-processing with baseline length below 10 km. Second, the Zenith Hydrostatic Delay (ZHD) is calculated using the surface pressure measurement and its precise geographic site position. Third, the total signal delays measured by the GPS receiver from all satellites in view is mapped to the satellite elevation angle using a hydrostatic appropriate mapping function, yields the ZTD. Fourth, the Zenith Wet Delay (ZWD) is obtained by subtracting the ZHD from ZTD. Finally, PWV is derived from ZWD signals and a conversion factor that proportional to the weighted mean surface temperature. Detail of GPS derived PWV for this work can be found in Suparta et al. (2008). In this study, the Tropospheric Water Vapour Program (*TroWav*) written in Matlab developed by author was used to produce the PWV data. At SBA, the high resolution of GPS PWV product for this analysis was available in 10-min intervals and with a bias 1~2 mm.

To observe a comprehensive katabatic wind in Ross Island region, the data collected during the September 2004 at SBA were processed. A 3-year of climate variables consists of surface pressure, temperature, relative humidity, wind speed and PWV at Scott Base (SBA), Casey (CAS1), Mawson (MAW1), McMurdo (MCM4), Syowa (SYOG) and O'Higgins (OHI3) were also processed on a monthly basis to get clear the climate pattern in Antarctica.

RESULTS AND DISCUSSION

Climate Pattern in Antarctica

Figure 2 shows the temporal variations of surface pressure, temperature, relative humidity, wind speed and PWV at six stations in Antarctica for 3-year observation period from 2003 to 2005. The annual pattern of pressure at each station exhibits a similar character with a semi-diurnal pattern or a sinusoidal pattern; two peaks (Dec/Jan and Jun) and valleys (Mar/Apr and Sep), respectively. Mean pressure values at all stations was varying from approximately 982 to 998 mb (987 mb, on average). The value and variation of surface pressure depend on the weight of atmospheric mass on top of particular measurement point. The increase of latitude will decrease the pressure value. The second panel of Figure 2 presents the air temperature. Air temperature in Austral summer (Dec Jan Feb) and Austral winter (Jun Jul Aug) were seen warm and cold, respectively. In summer, the monthly mean temperature usually remains below 0°C and approximately -20°C in winter. The maximum ever reached was 7°C. The lowest temperature ever recorded at Scott Base is -57°C. On the whole, temperature pattern in Antarctica was shown a seasonal pattern, with DJF and JJA are warmest and coldest months, respectively. The third panel of Figure 2 presents the relative humidity. At all stations, their variations exhibit an irregular pattern with mean value varying from 65% to 75% (70% on average). Roughly, relative humidity pattern follows the air temperature pattern. The low value of relative humidity was seen recorded at MAW1, which possibly affected by the Southern Ocean, while the high value was seen at OHI3. This station is located nearly the Antarctic Peninsula with highly pressure depressions. The fourth panel of Figure2 presents the wind speed variations. The high speeds of wind clearly seen during the Austral winter, and in one case, they can reach to 40 m/s. The wind was observed blows in all directions with daily mean maximum can reach 20 m/s, which kept the polar cap in coldest conditions. The annual pattern of wind speed was shown reversal compared to the air temperature and relative humidity variations. The last panel of Figure 2 presents the PWV variability. PWV is the amount of water vapor content in the atmosphere. Their variation was closely following the temperature pattern. At all stations, mean PWV value ranging from approximately 3 to 10 mm, or ~5 mm on average. As shown in the figure, PWV values at SBA and MCM4 are the lowest compared to other stations, which both stations are located in the vicinity of the Ross Island with high elevation.

As shown in Figure 2, the temperature and PWV variations were close to each other patterns, which show a large seasonal variation; largest in Austral summer (wet summer) and lowest in Austral winter (dry winter). The high amount of PWV during summer means that there more quantities water vapor can be held in the atmosphere. The low and high amount of PWV depends on the intensity of solar radiation reached to the Earth's surface. Figure 3 shows the clear seasonal solar radiation cycle at Scott

Base, averaged over the year of 2003-2005. The temporal variations of solar radiation received at the ground surface measured by pyramometer composed of direct, diffused (skylight) and net global components. The direct solar radiation is the amount of solar radiation reaching the Earth's surface emitted from the solid angle of the Sun's mainly on unscattered and unreflected solar insolation. The high amount of solar radiation received on the surface (the surface-absorbed solar flux) during the summer is associated with low cloud cover, and low irradiance values measured during winter is being associated with cloudy periods. The low value of diffuse solar radiation of about 20% compared to the global solar radiation, because it was scattered by molecules or suspensoids in the atmosphere before reaching the Earth's surface.

From Figure 3, the Sun at SBA is sets at the end of April and seen rises again at the end of August. Based on the annual pattern of solar radiation cycle, there were two significant seasons in Antarctica: summer season (summer polar days) covers months from October to February, and winter season (winter polar night) covers months from April to August. For two of these four months in winter season, there is complete darkness, though there is 24 hours a day of sunlight during mid-summer. The September and the March months are considered as a 'Polar morning' and a 'Polar sunset' respectively, which both commonly excluded in the seasonal analysis.

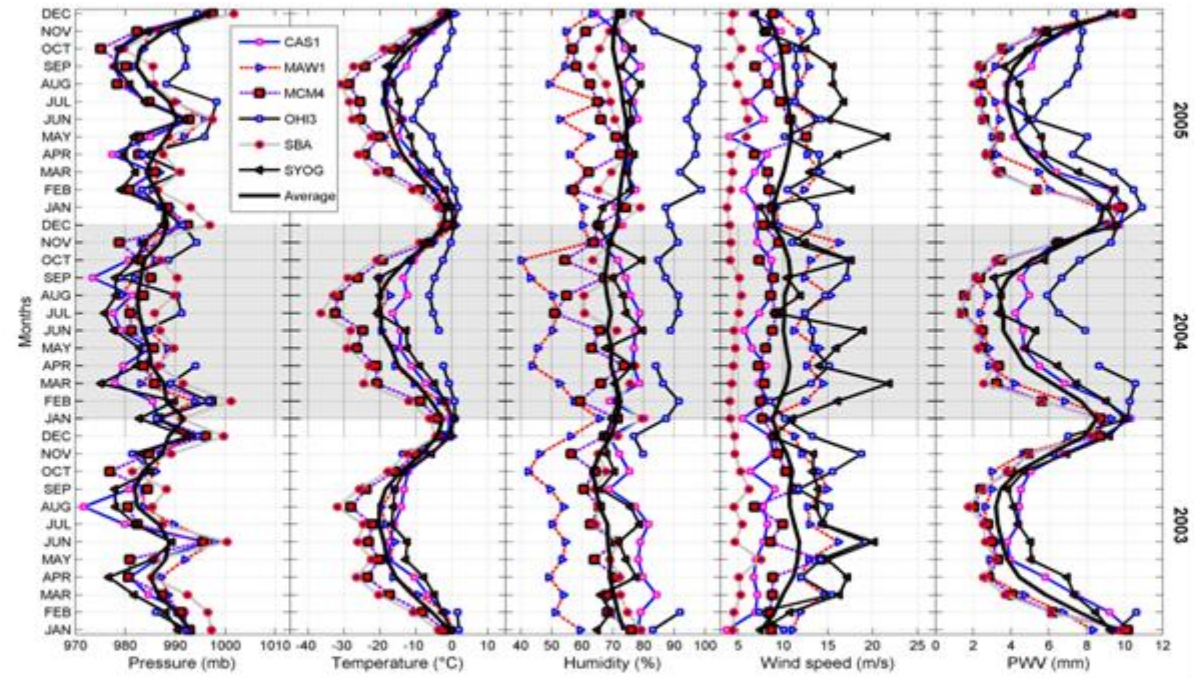

Figure 2 Climate patterns observed for the period from 2003 to 2005 at six stations in Antarctica. The highlighted background over 2004 represents the main study of this paper.

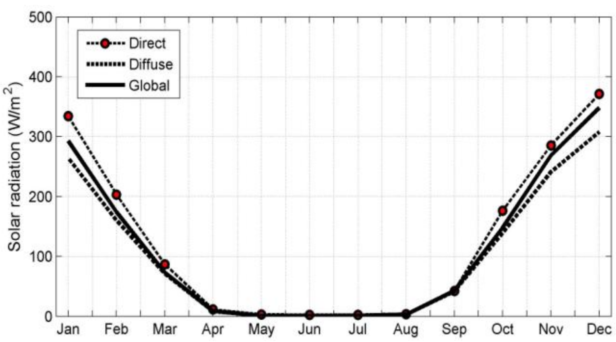

Figure 3 Annual solar radiation patterns observed at Scott Base, Antarctica averaged over the year of 2003 - 2005

Katabatic Winds Detection for September 2004

A katabatic wind can be defined as a wind that carries high density air from a higher elevation down a slope under the force of gravity, attaining hurricane gusts in valleys, along the shore and event out the sea. These winds also heat up by compression and lose humidity. Their speed and direction are controlled by the shape of ice cap. Based on the severe wind depiction from Parish (personal communication 2006) and Glickman (2000), katabatic winds are strong wind with a minimum speed of 4 m/s during which, the pressure and humidity level rises while the temperature level fall. This wind originates in the cold upland areas from the Transantarctic Mountains and cascade toward lower elevations to McMurdo Sound under the influence of gravity. Figure 4 shows the illustration of generation of the katabatic winds in Antarctica.

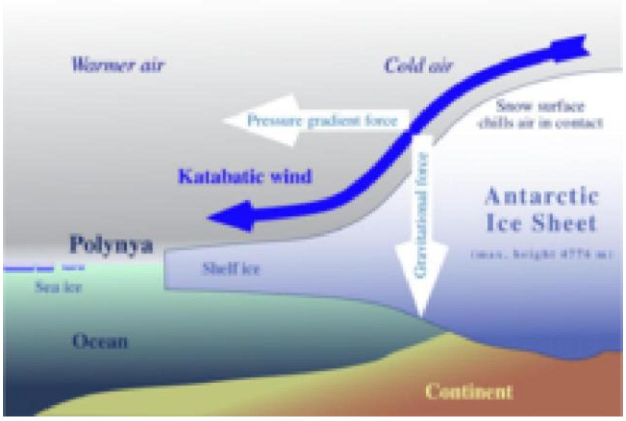

Figure 4 An illustration of the generation of katabatic winds (http://en.wikipedia.org/wiki/Katabatic_wind)

To identify the katabatic wind event from a definition above, data gathered during the September 2004 are analyzed. The surface meteorological records and PWV from GPS are plotted in Figure 5. There are six katabatic events, which are identified in the Ross Island region based on the composite wind images obtained from the SSEC/UW-Madison in 2004 (http://amrc.ssec.wisc.edu). However, only two of them had occurred at nearly SBA and MCM4 stations, i.e. on 9 and 27 September at 10:11 UT and 12:05 UT, respectively.

Looking katabatic event on 9 September 2004, as indicated by grey background, it can be explained as follows. Cold air is more dense than warm air. On the high plateau, temperature was very, very cold, and this air wants to reach the lower part of the continent. It will sink down the side of the continent, such as into the ocean, or in the case are it will affect Scott Base, in the valleys of the Transantarctic mountains. When this cold air, moves to lower elevation under gravity force, it is speed up, making winds that very, very fast. This wind can cause suddenly changes in the weather in the area when the wind spill out. When the katabatic winds come down the mountain and mix with the surface inversion (an inversion is an area where the temperature increase with height instead of the usual case where the temperature decreases with height), they actually become warmer than surrounding air.

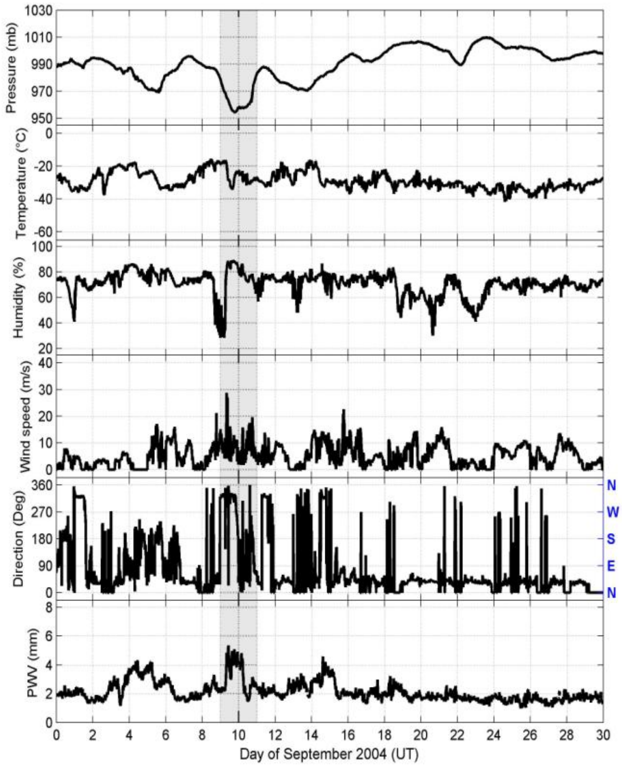

Figure 5 Meteorological variables measured at Scott Base, Antarctica for the period from 1 to 30 September 2004. The grey background signature the katabatic event in Ross Island.

During this condition, the relative humidity starts drops to 28% followed by pressure drop to 954 mb and temperature was decreased to a -32°C. At the onset of the katabatic event, relative humidity reach to maxima value of 89%, temperature increasing to -22°C and pressure seen slightly increase to 958 mb. At this onset, the wind was blowing from the North and reached to a maximum speed at 28.2 m/s. At almost similar time, the moisture was more active and water vapor molecules (PWV) starts to increase to a maximum value at 5.4 mm. Sudden increasing of PWV content during the event, indicating that GPS signals are obvious delaying their propagation by the katabatic events. The occurrence katabatic events on 9 September 2004 can be validated with a composite wind image as shown in Figure 6. In Figure 6, SBA in the image seems located at nearly the Ross Ice Shelf, or about 1 km from the katabatic source. Most of the Ross Ice Shelf is located within the Ross Dependency claimed by New Zealand. Noted that the katabatic event on 27 September 2004 taken by the NOAA Polar Orbiter satellite, was not of a katabatic wind type. As can be seen in Figure 5, at the onset of event, pressure and relative humidity decreased together as the temperature increased. The wind was zero before it increased to 14 m/s. In addition, the wind is not coming from the North or Transantarctic mountains, it could be due to the storm activity originating from the sea.

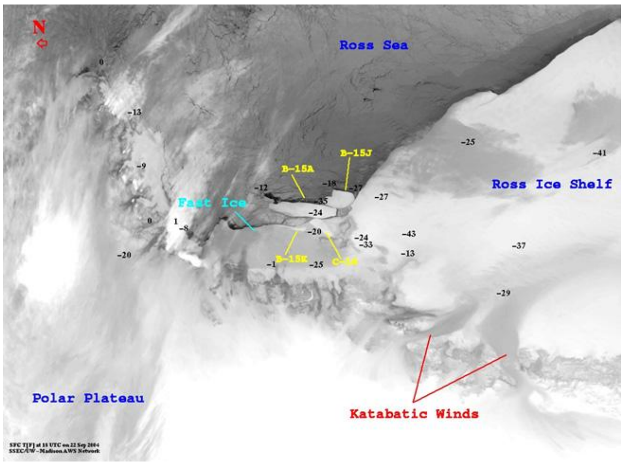

Figure 5 Wind composite image obtained from theNOAA Polar Orbiter satellite at the SSEC/UW-Madison

CONCLUDING REMARKS

The katabatic wind events have been observed by using a ground-based GPS receiver and the surface meteorological measurements. Their activity and characteristics depend on density of air and temperature in the source region. In the case of Antarctica, the emission of longwave radiation to space cools the surface and the boundary layer, leading to a horizontal pressure gradient along a line orthogonal to the coast. The pressure gradient forces the downslope flow. The strength and persistence of the katabatic winds waere noted damaging many of the coastal research stations in Antarctica. In addition to the important constitutes a katabatic wind, they are less frequent during the Antarctic summer (enhanced during the winter), suggesting the onset of a katabatic event is synoptically triggered or activated by large scale weather features such as a high pressure system over high elevations. One would be noticed that not all stronger winds in Antarctica are categorized as the katabatics.

Another point to conclude this work is that the katabatic event had impacts on GPS signals through significant effect on PWV, is then probably take into account for modeling of local horizontal gradient of the total tropospheric delay as well as climate modeling toward improving GPS accuracy. Further investigations are needed to quantify accurately the katabatic effects or dependencies, for advance our understanding of atmospheric weather systems and weather prediction.

ACKNOWLEDGEMENT

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LOCAL WISDOM AS A TOOL IN CONTROLLING GREENHOUSE GAS EMISSION FROM LAND AND FOREST FIRE IN SOUTH KALIMANTAN

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ABSTRACT

Land and forest fires have been occurring in Indonesia with different frequency and intensity. Indonesian government has done several efforts to prevent, control and manage the land and forest fire, but the efforts have yet not stopped the forest fires probably due to the luck of understanding on local wisdom related to land and forest fire managements. A descriptive study was carried out in Paramasan sub-district, and Gambut and Sungai Tabuk sub-district, Banjar District (South Kalimantan) to elucidate the local wisdom of South Kalimantan people related to land and forest fire management. The results showed that local wisdoms related to land and forest fire in South Kalimantan include (a) the use of tajak (large sickle) for weed cutting and clearing, (b) control burning of cut forest and or crop residues, and (3) sanction to re-plant and other following the fire. These are potentials of the local wisdoms to be scaled-up. The relation of the local wisdom with REDD and CDM schemes will be discussed.

Keywords*: Local wisdom, land and forest fire, greenhouse gas emission*

INTRODUCTION

Land and forest fires have been occurring in Indonesia with different frequency and intensity. The land and forest fires have lead to air pollution and subsequent health problems, loss of property and biodiversity, reduction in educational quality, and political conflict among fire-affected countries. Land and forest fires have also suspected as precursor of greenhouse gas emissions and successive global warming (Wetland International, 2008).

Land and forest fires can be caused by (1) land clearing activity for forest or estate crop plantation, (2) peat burning to release nutrients for food crops, (3) weed regeneration for animal feeding, and (4) natural fire due to certain wood crushing, thunder, volcanoes etc (Usup et al., 2000; Widen, 2007). The fire became severe in peatlands because the fire releases toxic substances and is long-lasting and difficult to be exhausted (Okazaki et al., 2000; Limin et al., 2008). International concern on greenhouse gas emissions has put land and forest fire on a hot issue and critical for international partnership hence need to be minimized.

To minimize the accident, several national, regional and international meetings and negotiations have been held, namely 10th ASEAN Ministerial Meeting on the Environment (Indonesia?), 5th ASEAN Plus Three Environment Ministers Meeting (the Philippines) and Ministerial Meeting on Haze Pollution (Brunei). Including the international aids resulted from the negotiations, Indonesian government has done several effort to prevent, control and manage the land and forest fire. The management comprises of prevention, controlling and rehabilitation efforts. However, the efforts have not stopped the forest fires. This probably due to the luck of understanding on local wisdom related to land and forest fire managements.

In South Kalimantan during year 2002 to 2006, 74.1% of land and forest fires occurred out side forest area (versus only 25.9% fires inside forest area), indicating the influence of human on fire incidences (Table 1). Moreover, Limin (2008) has asserted that the forest and land fires in Central Kalimantan almost always start at land and or forest easy accessed by people. Therefore, the objective of this paper is to elucidate the local wisdom of South Kalimantan people related to land and forest fire management

Table 1 Number of hot spots and their distribution di South Kalimantan as recorded by NOAA satellite during year 2002-2006

No	Year	Number of Hot Spot			Remark
		Total	Inside forest area	Outside forest area	
1	2002	1.142	343	799	
2	2003	1.910	399	1.511	
3	2004	2.372	554	1.818	
4	2005	686	203	483	
5	2006	5.813	1.585	4.228	1.028 spots in Banjar
2002-2006		11923	3.084 (25.9%)	8,839 (74.1%)	

Source : Dinas Kehutanan Provinsi Kalimantan Selatan, 2007

METHODOLOGY

The study was carried out in Paramasan sub-district (upland), and Gambut and Sungai Tabuk sub-district, Banjar District, South Kalimantan (Figure 1). The district is the biggest district in South Kalimantan and has experienced the most severe fire in South Kalimantan in Year 2006 with 1.028 hot spots (among 5.813 hot spot in South Kalimantan).
The methodology used was a descriptive study in order to describe the individual characteristics of society members, their views, responses and specific social phenomenon related to land and forest fire. Primary data was obtained through participatory discussion and deep interview at Paramasan sub-district (upland) and Gambut sub-district (low land). Purposive sampling technique was employed. Firstly, five teen respondents were interviewed at each location which comprised of tribal leader, village head and village members. Secondly, five respondents were then deeply interview to obtain more information.

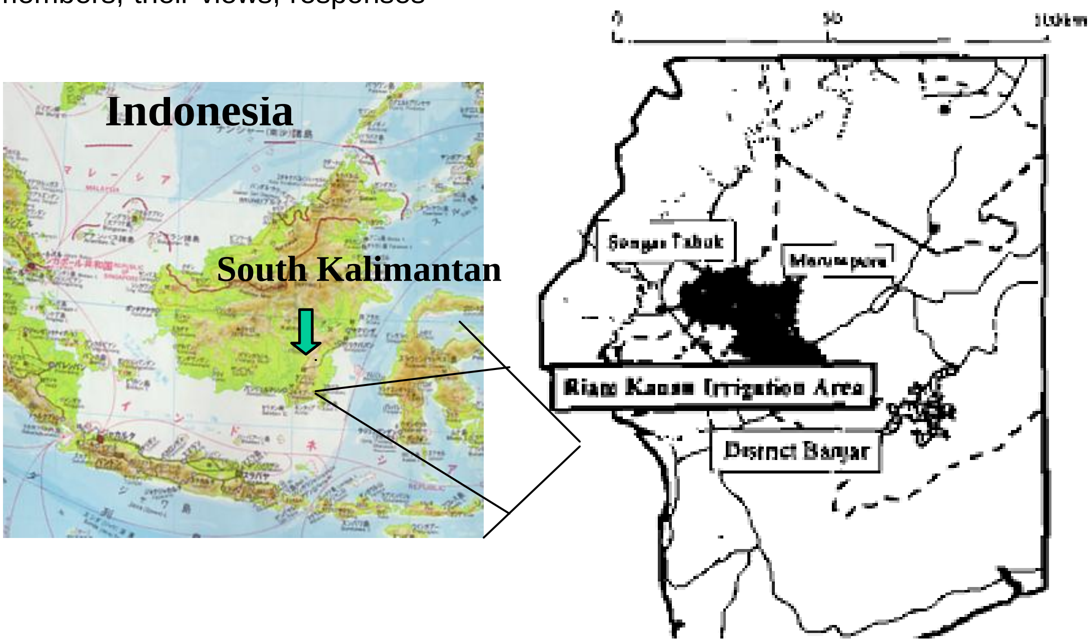

Figure 1 Map of study area

A focus group discussion was carried out at each location to elucidate the actor and modus of land and forest fire incidents. A deep discussion was then carried out to elucidate the background, motivation, and felling of the actors. The information obtained were analyzed qualitatively, including data reduction, data representation, and data summarizing. The data validation was also carried out according the steps: (1) observation extension, (2) respondent re-interview, (3) triangulation, (4) negative case analysis, (5) reference confirmation, and (6) member check (Wahyu, 2007).

Secondary data were also collected from Village Office, Statistical Biro of District Government and related Bodies. The secondary data included demography, economical resources, social and cultural facilities etc.

RESULTS

Site Location

Banjar district stretches from 114° 30' 20"East to 1150 33' 37" East and from 2° 49' 55" South to 3° 43' 38" South. The area covers 4.667,04 Km^2 which is 12.2% of total provincial area. The land is mainly upland, though quite significant area under low land with peat soil as dominant soil type. Detailed descriptions of the study area are listed in Table 2 below.

Table 2 Sub-districts in Banjar district and their area in year 2006

No	Sub-district	Area (Km^2)	Percentage
1	Aluh-Aluh	112,21	2,40
2	Beruntung Baru	73,52	1,58
3	**Gambut**	**117,32**	**2,51**
4	Kertak Hanyar	74,68	1,60
5	**Sungai Tabuk**	**149,00**	**3,19**
6	Martapura	53,37	1,14
7	Martapura Timur	22,53	0,48
8	Martapura Barat	148,26	3,18
9	Astambul	146,53	3,14
10	Karang Intan	315,52	6,76
11	Aranio	1.007,43	21,59
12	Sungai Pinang	458,65	9,82
13	**Paramasan**	**560,85**	**12,01**
14	Pengaron	260,68	5,59
15	Sambung Makmur	82,15	1,76
16	Mataraman	234,69	5,03
17	Simpang Empat	712,43	15,27
	Kabupaten Banjar	4.667,04	100,0 0

Source : Anonymous, 2006

Paramasan sub-district is located in the step of Meratus mountain, hence is fully considered as upland area. Total inhabitant of this district is 3,189 head with 1,621 man and 1,562 woman. Annual precipitation at the area (10 years average) was 2,181.2 mm with 3-6 months considered as dry month (precipitation <100 mm/month). The infrastructures, such as electricity, road etc are limited here. Most of the respondents are Dayak, mostly as farmers, some are temporal miner and governmental employee.

Sungai Tabuk and Gambut districts are situated in low land part of South Kalimantan dominated by alluvial and peat soils. The population were more danced as compare to Paramasan, those are 48,227 head in Sungai Tabuk and 31.071 head in Gambut districts, respectively. The people in Sungai Tabuk and Gambut districts are Banjarese. Most of the respondents in this area were farmers. The infrastructures here are fairly good with full electricity and the road access can reach the people house.

Prevention

Preventive wisdom related to land and forest fire was found in Sungai Tabuk and Gambut sub-districts. This was by the use of *tajak* (large sickle) for land preparation, and followed by in situ biological decomposition/degradation of the cut weed. This technique became possible probably because the lands in the two sub-districts have been used continuously, hence no tree or hard wood in the field. Leaving the weed decomposed naturally in the field following the weed cutting is enough to reduce the volume of the organic matter to a certain volume that will not disturb the successive steps in crop cultivation (mainly paddy). The land and forest fire occurred in these areas, if any, are believed to be wild fire or fire caused by cigarette boot thrown by passages. The two sub-districts have quite good road access, including the Trans Kalimantan road which stretches through the areas.

Land preparation using fire is common for people in Paramasan as part of shifting cultivation practice in agriculture. This tradition has been heritage from generation to generation by their Dayak predecessors. The preventive wisdom is practiced during the selection of the site to be cleared. The people are advised to return to the same field with about four-year-interval. This system prevents big fire that might be happened if they open native forest. This wisdom also leads to the utilization of degraded lands.

Controlling

Shifting cultivation in Paramasan starts by the felling of trees, usually around May. The brunches of the trees were then cut from the tree trunk and chopped to smaller size. The fire is set when the tree brunches become dry about three months after the felling. The tree felling is commonly done by farmer and family, while burning process will involve the neighboring farmers and some time the tribal head voluntarily.

Establishment of *sekat bakar* (fire transect) is a must in burning procedure prior to burning process by Paramasan people. *Sekat bakar* is made by establishing fuel-free zone surrounding the felled forest. This is done by freeing a ring road surrounded and area to be burn from thee trunk, brunch and leaf, scrub and or weed. Water tanks are also spread along the transect in order to exhaust fire brought by wind to outside of the transect (Figure 2).

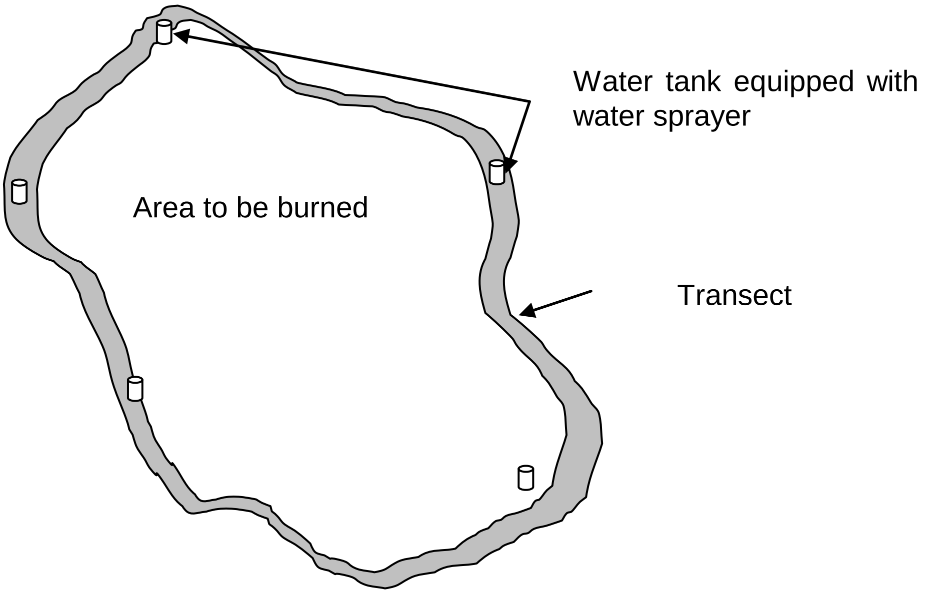

Figure 2 Schema of *sekat bakar*

Farmers in Sungai Tabuk and Gambut sub-district only burn the plant biomass from previous harvest. The burn the straw of rice, corn or other crop residue in order to release nutrients contained in the residues in the form of ash. The crop residue is dump near the farmer house prior to burning to easy to control. The farmer then transported the ash to and spread at their crop fields.

Rehabilitation

In Paramasan, suctions will be given to people who caused other people house, plant, or other properties get burned. The people will be punished, thought the punishments are not in the form of money but in the form of obligation to replace the damaged plant or properties. The suctions are not really punishment, but more likely educational and to avoid conflict among the people in the Dayak society in Paramasan.

DISCUSSION

The results suggested that local wisdoms do exist in South Kalimantan which ought to contribute to the management of land and forest fire in the future. This particularly relevant to the commitment of President Susilo Bambang Yudoyono during the UNFCC in Copenhagen (December, 2009) to reduce greenhouse gas emissions.

Hooijer et al. (2006) has estimated the greenhouse gas emissions during land and forest fire in Indonesia ranged from 1.42 to 4.32 (averaged to 3.0) Gton CO_2 per year in between 1997-2007 (Figure 3). Though this high greenhouse gas emissions has contributed by accidental peatlands fire in Central Kalimantan, the land and forest fires truly need to be minimized in the future.

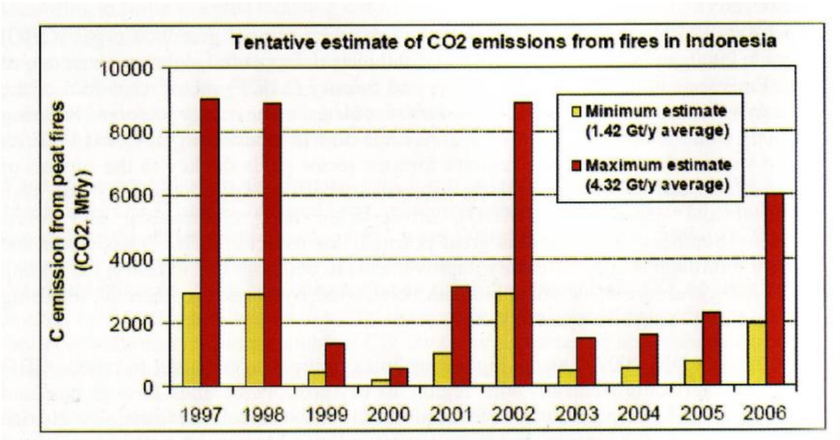

Figure 3 Estimated annual and averaged annual CO_2 emissions from fire in Indonesia (Hooijer et al., 2006)

The presence of reduced emission from deforestation and peatlands degradation (REDD), clean development mechanism (CDM) and or Bio-right schemes may be an economical incentives for people to manage the land and forest fire in South Kalimantan. More practical studies are then needed if the local wisdom to be practiced at large scale to minimize land and forest fire, including the cost and benefit raised from the application of the practices (Muramatsu et al., 2007).

The information about land and forest fires presented above is more about fire caused farmers, and less about fire caused by plantation which usually control wide area of land. It is therefore important to search the burning practice in plantations which have growing in number in South Kalimantan.

CONCLUSSIONS AND RECOMMENDATION

It could be concluded and recommendedthat:

1. Local wisdoms relating to land and forest fire in South Kalimantan include (a) the use of tajak (large sickle) for weed cutting and clearing, (b) control burning of cut forest and or crop residues, and (3) sanction to re-plant and other following the fire.
2. The are potentials of these local wisdoms to be scaled-up, particularly in relation to REDD and CDM schemes.
3. Further and detailed studies are needed to estimate the cost and benefit rised from scaling-up of these practices.

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INTEGRATING GEO-HAZARD INTO LAND CAPABILITY ASSESSMENT FOR SPATIAL PLANNING
A Case Study in Tawangmangu Sub District, Karanganyar Regency, Central Java, Indonesia

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ABSTRACT

Land capability assessment is usually applied in the spatial planning processes to separate the protected and productive areas. Land capability assessment is basically based on the evaluation of some limitation physical factors for several purposes. The physical limitation factors are usually mainly based on erosion hazard factors. While, in Tawangmangu Sub-District is not only suffered by erosion but also landslide. There are at least 35 landslides were found during the field work. Therefore, this paper is going to introduce the application of landslide hazard information in the land capability assessment for spatial planning based on the Act number 26 2007 about spatial planning.The methods applied in the research were land capability assessment based on the field survey using landscape approach. Landform units were applied as mapping unit. The landform units were mapped based on the remote sensing imageries interpretation as well as topographic map interpretation. Some techniques of land capability assessment were compared and evaluated in order to provide the evidence that the proposed land capability assessment technique using landslide hazard information provide more reasonable results.The study area was mostly categorized as moderate susceptible to landslide (43%) while 42% of total area is classified as high and very high susceptible area. General land capability class for study area was class IV, VI, VII, and VIII whereas the detailed class consisted of class III, IV, V, VI, VII, and VIII. General land capability class classified 58% of study area as protected area, 31% as buffer area and 11% as productive area whilst detailed class allocated 55% of study area as protected area, 37% as buffer area, and 8% as productive area.

Keywords: *Land Capability, Landslide, Land Use Function, Spatial Planning*

INTRODUCTION

Hazard is a potentially damaging physical event, phenomenon or human activity. The hazard may reveal casualties, injured people, property damage, and disruption of social and economic sector so that its probability must be recognized in order to minimize the future impact.

Hazard probability can be reduced by managing the current human activity and planning the future activities in a certain area. Act number 26, 2007 (Anonymous, 2007) about spatial planning has been established to control human activity by considering the hazard. Based on this rule, hazard prone area must be restricted for development purpose whereas productive zone has to be allocated in safer area. The allocation of protected and productive zone itself is related to the land use function analysis conducted in preliminary stage of spatial planning process. Hazard information therefore can be involved through division of land use function.

Land use function in spatial planning is divided into protected, buffer, and productive zone. The function indirectly represents the capability of the land for a development purpose. Land capability appraisal for land use function division is currently based on Legal Document of Ministry of Agriculture number 837/Kpts/UM/11/1980 (Anonymous, 1980) and number 683/Kpts/UM/8/1981 (Anonymous, 1981). The land capability assessment is based on scoring method of three parameters (slope, soil type, and average daily rainfall intensity) and only contemplates erosion hazard related to soil type. This analysis is not clearly enough in assessing the land capability because other hazards as constraint factors possibly exist as well. Thereby, this research was intended to develop more comprehensive land capability assessment by including the prominent hazard in a given area.

STUDY AREA

Tawangmangu Sub District is located in south western flank of Lawu Volcano. This area is influenced by volcanic activities from Lawu Volcano, Mount Jobolarangan, and Mount Sidoramping occurred in Pleistocene and Holocene period. The area is typified by steep slope, deep soil, clay and loam texture, and low to high permeability. Geologically, this location is laid upon brittle rock due to the high amount of sand fragment. The study area is also intensively used as agricultural land and settlement area either in flat and/or steep areas. The combination of those situations and the influence of high rainfall intensity drive landslides. During the field work, it has been found 35 recent landslides which mostly caused damaged houses, roads, and agricultural lands. Those landslide events are categorized as rotational slide and mostly dominated by soil materials (see Figure 1). The rotational slide does not have relation with soil erosion. The number of landslide events in this area implicitly shows landslide as a major hazard particularly influencing land capability and intensity of land utilization in Tawangmangu Sub District.

Figure 1. Several landslide events in Tawangmangu sub district (source: field survey, 2009)

METHOD

The research was focused on the integration process between hazard information and land capability assessment to be applied in spatial planning process. Since the landslide acts as a main hazard in study area, the evaluation of land capability must consider this hazard as one of the inhibiting factors. Furthermore, landslide is investigated based on its susceptibility because land capability appraisal is proposed for not only to manage the current land use activities but also the future doings as well. Regarding to the research aim, the method was generally divided into three stages, i.e. landslide susceptibility analysis, land capability assessment, and land use function division. The method comparison between proposed method and local government's method was also done in the stage of land capability assessment and land use function division (see Figure 2).

Required data for this research was taken from topographic map, geological map, soil type map, satellite images (Ikonos 2006 and Landsat ETM 2001), SRTM (Shuttle Radar Topographic Mission), literature review, and field survey. The literature review was done to collect information about erodibility index, land capability analysis in spatial planning of Tawangmangu Sub District and Karanganyar regency whereas field survey was conducted to obtain several primary data related to soil properties (depth, texture, permeability), land characteristics (rock fragment and soil drainage), and the location of landslide events.

The field survey to compile data of soil properties and land characteristics was carried out based on landscape approach. Landform was chosen as an analysis unit since it gives a framework that can be worked out in soil survey and land evaluation as well (Desaunettes, 1977). Landform itself can be defined as the product of many geomorphological processes. The processes act on various rocks and other parent materials for varying time periods (Desaunettes, 1973 in Desaunettes, 1977). The study area in this research was divided into 13 landforms obtained from interpretation of 3d view. The 3d view was generated by combining Landsat ETM and DEM (Digital Elevation Model) of SRTM supported by contour and geological map. The landforms in study area are volcanic cone of Lawu Volcano (*vcl*), lower slope of Mount Sidoramping (*lss*), higher part of Sidoramping lava flow hills (*hhs*), middle part of Si-

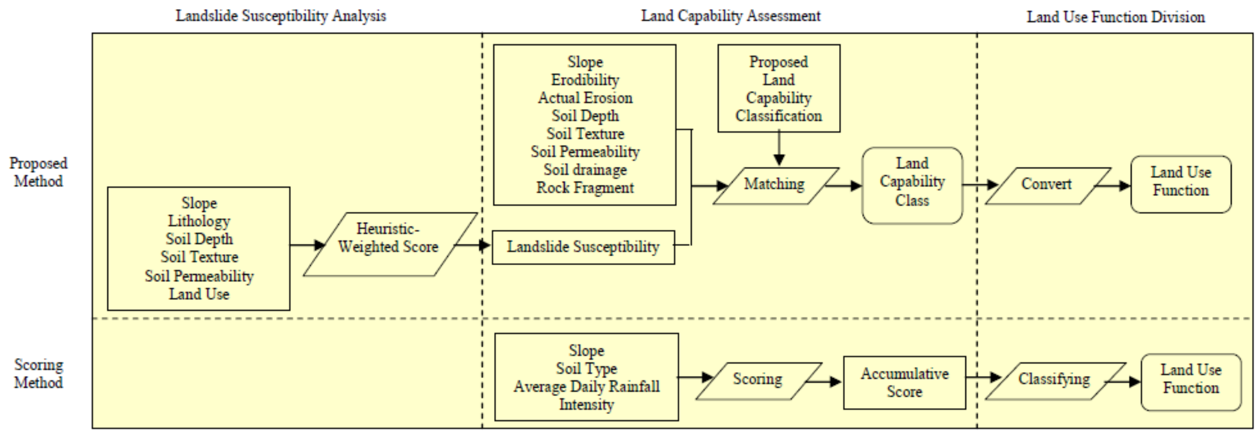


Figure 2. Research flowchart

doramping lava flow hills (*mhs*), lower part of volcanic rock formation (*lhv*), undulating terrain in lava flow (*utl*), small valley in Sidoramping lava (*svs*), river valley (*rvl*), eroded volcanic cone (*evc*), front slope of Lawu Volcano (*fsl*), Lawu lahar plain (*llp*), andecite hills (*adh*), and limestone hills (*lsh*). The landforms were then used as analysis unit in land capability assessment and land use function division.

Landslide Susceptibility Analysis

Landslide susceptibility can be defined as spatial probability of landslide occurrence in a certain area. The higher landslide susceptibility level stands for the higher probability of landslide event. The susceptibility can be examined through several approaches, i.e. statistic, deterministic, and heuristic.

Landslide susceptibility in this research was analyzed by using Heuristic approach with weighted-score method. The weighted and score depicts the influence of each parameter and its class in landslide mechanism. The weighted and score was based on expert judgment which was automatically generated utilizing rank method and pair wise method respectively (see Table 1). Both methods are available in ILWIS (Integrated Land and Water Information System) software.

Landslide susceptibility analysis harnesses six parameters, i.e. slope, lithology, soil depth, soil texture, soil permeability, and land use. Rainfall intensity was not used since the study area is relatively small and the intensity is quite similar. It means that in the large areas the rainfall intensity must be considered in the landslide susceptibility analysis. The susceptibility level was grouped into five classes according to the accumulative weighted score. The total score range of each class is very low

Table 1. Weighted and Score of Parameter's Class for Landslide Susceptibility Analy-

Parameter's class	Score
Slope (weighted factor = 40.8)	
Flat and undulating (0 – 8%)	0.103
Moderately sloping (8 – 15%)	0.213
Hilly and moderately steep (15 – 45%)	0.449
Steep (>45%)	1.000
Lithology (weighted factor = 24.2)	
Andecite, Wonosari formation	0.087
Jobolarangan lava, Sidoramping lava, Candradimuka lava	0.202
Lawu lahar , Jobolarangan breccia	0.489
Lawu volcanic rock	1.000
Soil depth (weighted factor = 10.3)	
Very shallow (<25 cm)	0.200
Shallow (25 – 50 cm)	0.000
Moderate (50 – 90 cm)	0.000
Deep (>90 cm)	1.000
Soil texture (weighted factor = 6.1)	
Sandy loam, loamy sand, and sand	0.098
Loam, silty loam, and silt	0.208
Sandy clay loam, clay loam, and silty clay loam	0.464
Sandy clay, silty clay, and clay	1.000
Soil permeability (weighted factor = 2.8)	
Moderately fast, fast (> 6.25 cm per hour)	0.103
Moderate (2.0 – 6.25 cm per hour)	0.238
Moderately slow (0.5 - 2.0 cm per hour)	0.502
Slow (<0.5 cm per hour)	1.000
Land use (weighted factor = 15.8)	
Limestone area, paddy field, pine plantation	0.105
Shrub and bush, mixed garden, forest	0.236
Mixed paddy field with vegetable garden	0.507
Settlement, vegetable garden, sparse vegetation in forest region	1.000

Source: Data Analysis, 2009

(less than 28), low (28-45), moderate (46-63), high (64-81), and very high (more than 81).

Land Capability Assessment

Land capability assessment was done by establishing proposed method modified from US-DA approach (United States Department of Agriculture) (Klingebiel and Montgomery, 1966 and Arsyad, 1989). The modification was made by omitting two parameters (flood and salinity) and by including landslide susceptibility factor. Flood is an absent hazard in the study area while salinity is only valid for dry season or coastal area. Furthermore, landslide susceptibility class was distributed in each land capability class (see Table 2) regarding to the following assumptions:

1. Very low landslide susceptibility is set up in class I and II. These classes were allocated as settlement area and productive zone so that very low susceptibility of landslide is recommended for those classes.
2. Low susceptibility of landside is allocated for class III and IV since these classes are still assigned as productive area.
3. Moderate, high, and very high susceptibility are added in class VI, VII, and VIII respectively.
4. Landslide susceptibility is not included in class V because this class represents inundation zone.

Proposed method was also arranged the proposed sub class division. In this case, landslide susceptibility is included in sub class "e" together with slope, erodibility, and actual erosion.

Land capability was assessed in general and detailed way. The detailed way was done by overlaying the general land capability class with slope and landslide susceptibility map and by then matching with proposed land capability classification. The detailed land capability class was developed to propose more elaborated land use function division and to determine more specific land use practice in study area.

Land capability analysis with scoring method was also conducted. This is intended to compare the result from the current method used by local government and proposed method. The scoring method was performed by overlying three required parameters and by summing the score from each parameter class (see Table 3,4,5). As done in proposed method, land capability based on scoring method was analyzed in general and detailed way as well. The detailed way was carried out by considering slope distribution and by accumulating the score.

Land Use Function Division

Land use function was recognized by applying the obtained land capability class. The scheme of correlation between land capability and intensity of land use (Klingebiel and Montgomery, 1966) was employed (see Table 6). It is assumed that class I – IV is classified in arable land while class V – VIII is included in non arable land. The arable land is proposed as productive area whereas non-arable land is supposed as buffer and protected area. The non-arable land of class V - VII is classified as buffer area and it is potential for natural preservation/wildlife conservation, forestry, and limited-intensive grazing. Class VIII is included

Table 2. Proposed land capability classification

Inhibiting Factor	Land Capability Class							
	I	II	III	IV	V	VI	VII	VIII
Slope	A	B	C	D	A	E	F	G
Erodibility	KE1, KE2	KE3	KE4, KE5	KE6	*	*	*	*
Actual erosion	e0	e1	e2	e3	**	e4	e5	*
Soil depth	k0	k1	k2	k2	*	k3	*	*
Soil texture	t1/t2/t3	t1/t2/ t3	t1/t2/t3/t4	t1/t2/t3/t4	*	t1/t2/t3/t4	t1/t2/ t3/t4	t5
Soil permeability	p2/p3	p2/p3	p2/p3/p4	p2/p3/p4	p1	*	*	p5
Soil drainage	d1	d2	d3	d4	d5	**	**	d0
Rock fragment	b0	b0	b1	b2	b3	*	*	b4
Landslide susceptibility	LS1	LS1	LS2	LS2	**	LS3	LS4	LS5

** It doesn't have particular characteristics, ** Inapplicable*
Source: Klingebiel and Montgomery (1966), Arsyad (1989), and Modified (2009)

Table 3. Slope classification

Class	Slope	Score
Flat	0 – 8%	20
Slightly slope	8 – 15%	40
Moderately steep	15 – 25%	60
Steep	25 – 45%	80
Very steep	> 45%	100

Source: Anonymous, 1980 and Anonymous, 1981

Table 4. Soil type classification

Soil Type	Score
Aluvial,Glei, Planosol,Hidromerf, Laterik ground water (not sensitive with erosion)	15
Latosol (less sensitive with erosion)	30
Brown forest soil, non calcic brown mediteran (moderately sensitive with erosion)	45
Andosol, Laterit, Grumusol, Podsol, Podsolic (sensitive with erosion)	60
Regosol, Lithosol, Organosol, Renzina (very sensitive with erosion)	75

Source: Anonymous, 1980 and Anonymous, 1981

Table 5. Average daily rainfall intensity classification

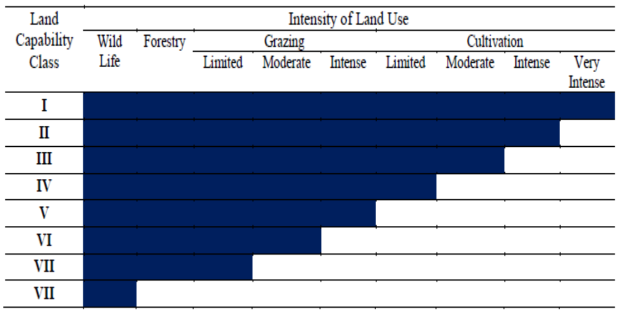
Class	Average Daily Rainfall Intensity (mm/day)	Score
Very low	0 – 13.6	10
Low	13.6 – 20.7	20
Moderate	20.7 – 27.7	30
High	27.7 – 34.8	40
Very high	> 34.8	50

Source: Anonymous, 1980 and Anonymous, 1981

as protected area since it is only apportioned as natural preservation/wildlife conservation. Since land capability class was generated in general and detailed way, land use function division follows that rule as well.

Land use function based on scoring method uses accumulative score and classifies the score to determine land use function. The area with score of ≥ 175 is classified as protected area. The area with score of 125-174 and the score less than 125 are categorized as buffer area and productive area respectively.

Table 6. The correlation between land capability and land use intensity



Source: Klingebiel and Montgomery, 1966

RESULT AND DISCUSSION

Landslide Susceptibility

The study area is mostly classified as moderate and high susceptible to landslide. The analysis shows that 43% of study area is categorized as moderate susceptible zone while 37% represents high susceptible zone. Based on this result as well, it is only 15% classified as very low and low susceptible zone. The rest areas are categorized as very high susceptible zone.

Very low susceptible zone is only situated in *svs* whereas low susceptible areas are majorly located in *llp*, *adh*, *svs*, and *lss*. Very low and low susceptible zones are typified by relatively flat area, fast permeability, and loam texture. On the other hand, moderate susceptible zone mostly exists in *vcl*, *hhs*, *mhs*, and *utl*. The characteristics of moderate susceptible zone are generally slope of more than 30%, slow permeability, clay loam texture, and broad existence of settlement and mixed paddy field with vegetable garden. In addition, high susceptible areas are generally positioned in *vcl*, *mhs*, *lhv*, and *fsl* while very high susceptible zone is only located in *lhv* and *rvl*. Those areas are characterized by steep slope, slow and moderately slow permeability, clay and clay loam texture, and also intensive development of settlement area and vegetable garden (see Figure 3).

The susceptibility analysis in this research indirectly asserts that most of settlement areas in Tawangmangu Sub District are laid upon moderate up to very high susceptible to landslide. More than half of settlement areas (51%) are located in moderate susceptible zone whilst 35% of settlement area exists in high and very high susceptible zone. This circumstance exposes that almost all people in study area live under landslide threat. As a proof, a big landslide event occurred on December 26th, 2007 and caused 34 casualties. This event happened in Ngledoksari Sub Village situated in the hill slopes. The other evidence can be found in Tengklik Village where 35 houses were destructed by landslide.

The other research that has been conducted in this area was also stated that almost all areas in Tawangmangu Sub District were classified as moderate and high susceptible to landslide (BAKOSURTANAL, 2008). Regarding to established landform in this research, high susceptible zones were particularly situated in *vcl*, *hhs*, *mhs*, and *lhv*. According to this situation, local government cooperation with local community should develop more comprehensive landslide mitigation strategies to minimize the future risk.

Land Capability

Land capability based on proposed method was evaluated by involving nine inhibiting factors (see Table 7). Each of constraint factors shows particular distribution. The characteris-

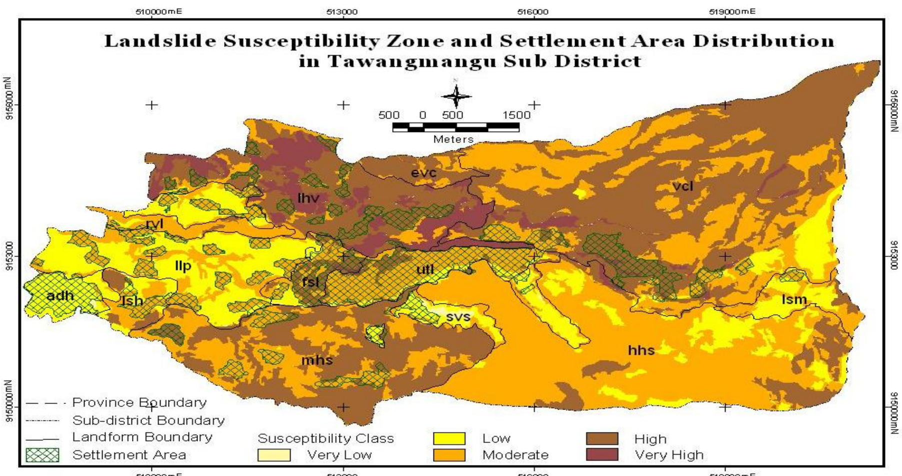


Figure 3. Landslide susceptibility zone and settlement area distribution in Tawangmangu Sub District

tics of inhibiting factors related to landform in study area are described below:

1. Slope

   The generalized slope demonstrates that most landforms have slope of 15-30% (D). The other landforms have slope of 8-15% (C), 45-65% (F), and more than 65% (G). Northern and southern parts of study area (*vcl*, *evc*, *hhs*, and *mhs*) majorly have slope class F and G whilst the rest areas have slope class C and D.

2. Erodibility

   The range of erodibility index in study area is 0.14 – 0.29 (Asdak, 2007 and Hartono, 2008). It means that study area only encompasses two erodibility classes, i.e. low (KE2) and moderate (KE3). Northern parts of study area generally have low erodibility whereas the southern parts (*hhs*, *mhs*, and *lsh*) have moderate erodibility index.

3. Actual erosion

   Erosion in study area is classified into three classes, i.e. minor erosion (e1), moderate erosion (e2), and moderately severe erosion (e3). Regarding to landform division, minor erosion exists in *lhv*, *llp*, *fsl*, *utl*, and *lsh* whereas moderate erosion can be found in *adh*, *rvl*, *mhs*, *svs*, and *lss*. In addition, moderately severe erosion occurs in *vcl* and *hhs*.

4. Soil depth

   In terms of soil depth, almost all of study areas have deep soil. It is only in *adh* and *lsh* which have very shallow soil (less than 25 cm).

5. Soil texture

   The soil texture in Tawangmangu Sub District consists of clay, clay loam, loam, and sandy loam. Based on this condition, the texture can be classified into four classes, i.e. clay (fine textured/t1), clay loam (moderately fine textured/t2), loam (medium textured/t3), and sandy loam (moderately coarse textured/t4). Clay texture is found in *mhs* and *lhv* whilst clay loam texture can be identified in *adh*, *lsh*, *llp*, and *rvl*. Moreover, soil with loam texture exists in *fsl*, *svs*, *evc*, *hhs*, *vcl*, and *lss*. In addition, sandy loam texture is only generally detected in *utl*.

6. Soil permeability

   Soil permeability level of study area can be categorized into four classes, i.e. slow (p1), moderately slow (p2), moderately fast (p4), and fast (p5). In relation with soil texture, the areas with clay and clay loam texture are commonly classified as slow and moderately slow permeability zone. On the other hand, the areas with loam and sandy loam texture are generally categorized as moderately fast and fast permeability zone.

7. Soil drainage

   Study area mostly has well drained condition (d1). Poorly drained condition (d4) only occurs in *rvl*, *llp*, and *adh* while excessively drained condition (d0) happens in *lsh*. Sloping situation in this area reduces the inundation activity which influences soil drainage condition.

8. Rock fragment

   The existence of rock fragment is generally not much. Almost areas are categorized as no rock fragment (b0). Nevertheless, some locations are classified as moderate (b1) up to very much (b3) class, i.e. *lhv*, *svs*, *fsl*, *adh*, and *lsh*.

9. Landslide susceptibility

   The generalized landslide susceptibility for each landform depicts that the study area consists of three landslide susceptibility classes, i.e. low (LS2), moderate (LS3), and high (LS4). The areas with low susceptible class are *lsm*, *svs*, *llp*, and *adh*. Besides, the landforms with moderate susceptible class are *utl*, *hhs*, *rvl*, and *lsh*. The rest areas are classified as high susceptible zone.

Land capability in study area generally consists of four classes, i.e. class IV, VI, VII, and VIII (see Figure 4). Since some prominent constraints (soil depth, permeability, slope, landslide susceptibility, and soil drainage) exist in each landform, the general class then comprises class IVe, VIe, VIs, VIIe, VIIIe, VIIIs, and VIIIw. Based on the general land capability class overlaid with slope and landslide susceptibility map, several detailed land capability class can be revealed. The elaborated land capability class for study area encompasses class III, IV, V, VI, VII, and VIII (see Figure 5).

The assessment of land capability based on scoring method gives a particular accumulated score. The general way shows that the score range is 90 – 195 while the detailed way reveals score range 70 -195. The result illustrates that the detailed way demonstrates broader score range than general way.

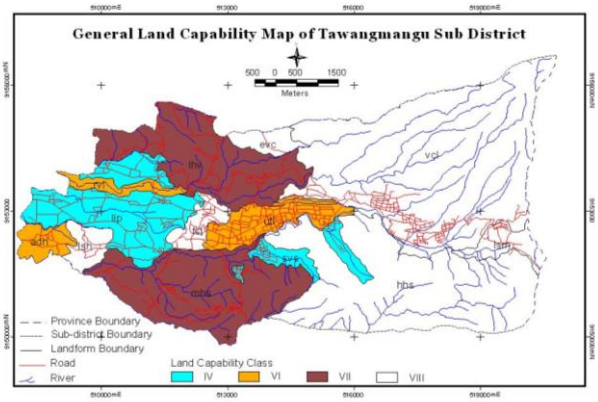


Figure 4. General land capability class

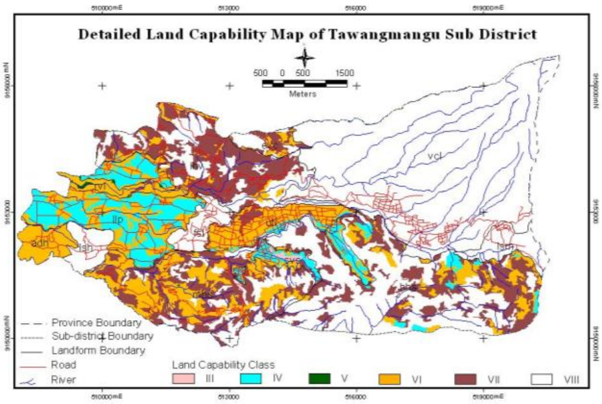


Figure 5. Detailed land capability class

Table 7. General and Detailed Land Capability Class

Landform	Inhibiting Factors*									Land Capability Class	
	1	2	3	4	5	6	7	8	9	General	Detailed
vcl	G	KE2	e3	k0	t3	p5	d1	b0	LS4	VIIIe	VIII
lsm	D	KE2	e2	k0	t3	p5	d1	b0	LS2	VIIIs	VIII
utl	D	KE2	e1	k0	t4	p4	d1	b0	LS3	VIe	IV, VI, VII, VIII
hhs	G	KE3	e3	k0	t3	p4	d1	b0	LS3	VIIIe	IV, VI, VII, VIII
mhs	F	KE3	e2	k0	t1	p1	d1	b0	LS4	VIIe	VI, VII, VIII
lhv	D	KE2	e1	k0	t1	p2	d1	b1	LS4	VIIe	VI, VII, VIII
svs	D	KE2	e2	k0	t3	p4	d1	b1	LS2	IVe	III, IV, VI, VII, VIII
rvl	D	KE2	e2	k0	t2	p1	d4	b0	LS3	VIe	V, VI, VII, VIII
evc	G	KE2	e2	k0	t3	p4	d1	b0	LS4	VIIIe	VI, VII, VIII
fsl	D	KE2	e1	k0	t3	p5	d1	b1	LS4	VIIIe	VIII
llp	C	KE2	e1	k0	t2	p2	d4	b0	LS2	IVe	IV, VI, VII
adh	D	KE2	e2	k3	t2	p2	d4	b2	LS2	VIs	VI
lsh	D	KE3	e1	k3	t2	p2	d0	b3	LS3	VIIIw	VIII

Note (*)
1=slope,
2=erodibility,
3=actual erosion,
4=soil depth,
5= texture,
6=permeability,
7=soil drainage,
8=rock fragment,
9=landslide susceptibility.

Land Use Function

Land use function is a term in spatial planning concerned to general zoning of the land. It is employed as a basis in determining proper land use practice. Since land use function is correlated to land capability assessment, the land use function in this research was determined by harnessing the obtained land capability class from proposed method and accumulative score from scoring method.

Proposed method generally classifies 58% of total area as protected area pervading *vcl*, *lsm*, *hhs*, *evc*, *fsl*, and *lsh*. Those areas are mostly typified by steep slope and moderate-high susceptible to landslide. Furthermore, buffer area encompasses 31% of total area, particularly in *utl*, *mhs*, *lhv*, *rvl*, and *adh* while productive area implicates *svs* and *llp*. On the other side, the general land use function can be elaborated into other functions. As an example, *utl* which is previously categorized as buffer area can be specified into protected, buffer, and productive area (see Table 8 and Figure 6). In detailed way, protected areas are commonly characterized by very steep slope and high susceptible to landslide. Buffer areas are typified by moderate-high landslide susceptible and/or mod-

Table 8 General and detailed land use function based on both methods

Landform	General Land Use Function		Detailed Land Use Function					
	Scoring Method	Proposed Method	Scoring Method			Proposed Method		
			Pt	Bf	Pd	Pt	Bf	Pd
vcl	Protected	Protected	■	■	■	■		
lsm	Buffer	Protected	■	■	■	■		
utl	Productive	Buffer		■	■	■	■	■
hhs	Protected	Protected	■	■		■	■	■
mhs	Buffer	Buffer		■	■	■	■	
lhv	Buffer	Buffer		■	■	■	■	
svs	Buffer	Productive	■	■	■	■	■	■
rvl	Productive	Buffer		■	■	■	■	
evc	Buffer	Protected		■		■	■	
fsl	Productive	Protected		■	■	■		
llp	Productive	Productive		■	■		■	■
adh	Productive	Buffer		■	■	■	■	
lsh	Buffer	Protected		■	■	■		

Pt: Protected Area, Bf: Buffer Area, Pd: Produc-

erately steep-steep slope while productive areas are characterized by very low-low susceptible to landslide and flat-hilly area.

The accumulative score obtained from scoring method explicitly describes that study area can be divided into three land use functions. In general version, protected area comprises 51% of total area whereas buffer area pervades 31% of total area. The rest areas are allocated as productive zone. Apart from that, the detailed way allocates 38% of total area as protected zone whilst 45% and 17% of total area as buffer and productive zone respectively. Protected areas are associated slope of more than 45% and soil type of andosol and lithosol. Moreover, buffer areas are characterized by various slopes from flat to very steep and latosol and mediteran as the main soil type.

employed in analysis of physical and environment's support capability. Moreover, the current spatial planning document in Tawangmangu Sub District and Karanganyar Regency has not involved hazard information yet (BAPPEDA, 1997 and BAPPEDA, 2007). Therefore, proposed land capability analysis also fulfills the need of involvement of hazard information in spatial planning as stated in Act Number 26, 2007.

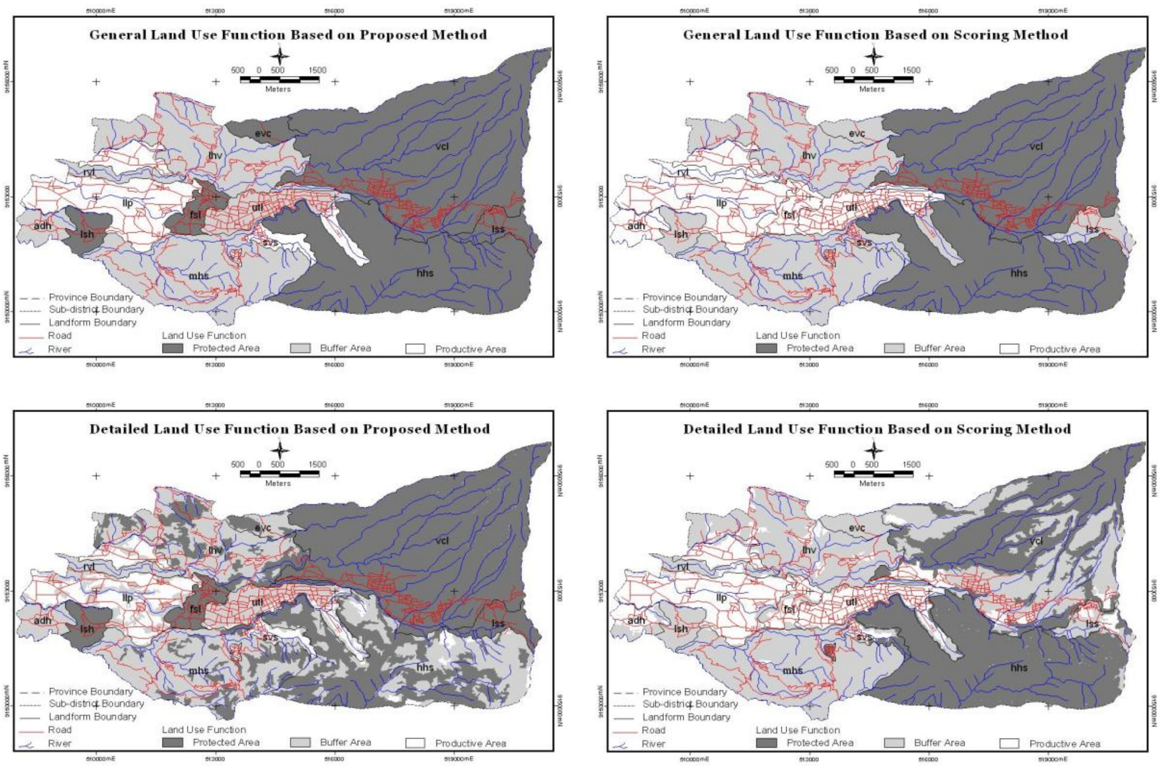


Figure 6 General and detailed land use function based on proposed and scoring method

Both methods give different result. The existing disparities implicitly reveals since scoring method is not clear enough in describing the worst situation obstructing intensive land utilization. However, the scoring method can be improved by identifying the most constraint as illustrated in proposed method. For instance, *svs* is categorized as buffer area (scoring method) and productive area (proposed method). This area is quite suitable to be intensively exploited as productive zone because it is supported by relative flat area and low susceptible to landslide.

Based on the obtained result, it can be identified that the determination of land use function through proposed land capability classification can be used to improve scoring method. It means that, proposed method can be directly applied in spatial planning process. In this case, the proposed method is suitable to be

CONCLUSIONS

The research comes up with two significant findings, as follow:

1. Land capability assessment based on scoring method in the present spatial planning in Indonesia does not give comprehensive description of constraint factors influencing land capability.
2. Proposed land capability classification integrating hazard analysis can be harnessed as an alternative way in conducting thorough land capability analysis. The landslide susceptibility analysis can be also used separately to estimate the prone degree of landslide occurrence in this area. In addition, this method is also able to support decision

making in properly separating land use function which is valuable in the spatial planning.

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Infrastructures

THE SOUTH INDIAN OCEAN TROPICAL CYCLONES INFLUENCE TO THE SOUTH COAST OF JAVA

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ABSTRACT

The occurrence frequency assessment of tropical cyclone in the southern part of Indian Ocean for the period of 1969-2007 has been investigated in this research. The result shows that there is 607 tropical cyclones occurred in this area for that period. Some of those tropical cyclones had raised the sea water level in the Indian Ocean significantly which is known as the storm surge phenomenon. Due to its position, the south coast of Java is one of the risk areas which are affected by the raising of the sea water level caused by the tropical cyclones in the basin of Australia. The occurrence period of the tropical cyclone had been studied also. The maximum number is occurred in the month of January which is related to the position of the sun in the southern part of the earth. In order to recognize the risk area of south Indian Ocean that is passed by the tropical cyclones track, this study implements GIS method to investigate the spatial analysis of the tropical cyclones. The spatial analysis shows the change of the tropical cyclone movements monthly. This analysis divides the investigating area in 1'x1' grids to understand more the character of cyclone generation and development. Understanding the tropical cyclones character periodically and spatially is one of the mitigation approaches that will be very useful as a guidance of public awareness, community preparedness, local level contingency planning, and also social mobilization.

Keywords: *Tropical Cyclone, Storm Surge, South of Java*

INTRODUCTION

Background

Most coastal areas in Indonesia are a great economic potential region, such as tourism, industry, transportation, housing and so forth. On the other hand coastal areas have also a very high disaster potential such as earthquakes, erosion/coastal erosion, tsuna-mis, tidal waves, storm surge, hurricanes (tropical cyclones), sea level rise flooding, sedimentation, pollution, etc. This hazard potential condition gets worse by the vulnerability of coastal area caused by a lack of disaster mitigation efforts. The mapping of disaster prone coastal areas is one of the coastal hazard mitigation efforts and will be the basis for the proposed of area development zoning.

Tropical cyclone is one of the phenomena that can cause disasters in coastal areas. Wind power from a very large tropical cyclone could damage the structure of buildings in coastal areas. The strength of tropical cyclones is also able to raise the height wave at sea until the shore. Waves caused by tropical cyclones are then known as a storm surge. A high storm surge could reach more than 3 meters. Storm surge is very dangerous for marine transportation and residents in coastal areas. Disasters caused by this tropical cyclone can cause a lot of casualties.

Base on the numerical modeling studies that have been done by Ningsih, et al. (2009), the southern coast of Java, which is the coastal regions of Indonesia is a prone area of the storm tide hazard Results of numerical simulation for the hurricane Jacob and George case study in March 2007 showed that although the maximum height of storm tide on the southern coast of Java is not more than 20 cm, but the storm tide was able to muffle the beach up to ± 500 m from the beach

Based on that reason, many researchers are interested to observe the behavior of the tropical cyclones and their relation with other phenomena such as climate change. Many methods can be performed to investigate the behavior of these tropical cyclones. Statistical method is the most common techniques to analyze the frequency, intensity and growth period of tropical cyclones.

Although the source of tropical cyclones are not widely available in Indonesian waters, but the impact of tropical cyclones can also be felt in coastal regions of Indonesia. Southern coastal area of Indonesia, is the area that faces the southern Indian Ocean which has a high enough of tropical cyclone frequency occurrences. Therefore, the research on tropical cyclones and their effects on coastal regions of Indonesia need to be done as part of efforts to mitigate coastal disasters. The aim of this study was to analyze tropical cyclones in the south Indian Ocean both spatial and temporal by using the statistical methods and Geographic Information System.

Scope

This study investigated the characteristics of tropical cyclones in the south of Indian Ocean (Indian Ocean basin and the basin of Australia), both spatial and temporal. Kuleshov (2003) in Kuleshov (2006), made the longitude of 135 ^{o}E as a boundary to divide the southern hemisphere in two regions, namely the South of Indian Ocean (west of longitude 135 ^{0}E) and the Pacific Ocean (east of 135 ^{o}E). Based on that reason, this study restricts the domain of the research on 0-40 ^{o}N and 30–135 ^{o}E. Figure 1 shows the study area of tropical cyclones observed.

The Tropical Cyclone in Indonesia

Gualdi, et al. (2008) divided the world basin into 7 basins area of the tropical cyclone formation, namely: Northern Indian Ocean (NI), Western North Pacific (WNP), Eastern North Pacific (ENP), the North Atlantic (ATL) and three regions in the southern hemisphere i.e Southern Indian Ocean (SI), north of Australia (AUS) and Southern Pacific (SP).

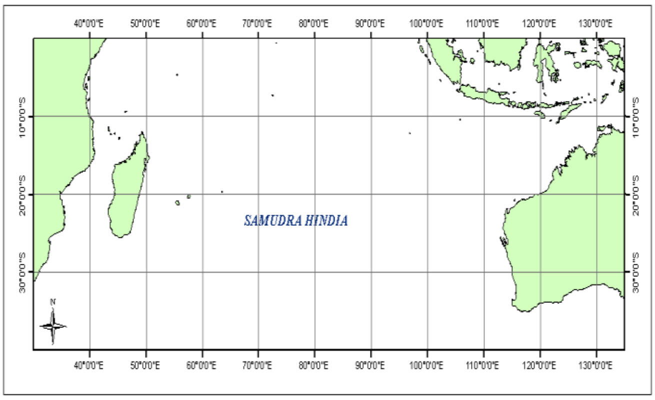

Figure 1 The domain of the research

Based on that distribution, there are 4 basin of tropical cyclones formation area that affects the coastal regions of Indonesia, namely: SI, AUS, NI, and WNP. The two ones are located in the northern hemisphere (NI and WNP), while the others are located in the southern hemisphere. The tropical cyclone activities in the south of Indian Ocean occur in the autumn season and peaks in the summer when the sea reach warm temperatures. Due to its position which is close to the equator, the area of Indonesia is not a tropical cyclone path. But the tail of the cyclone has an impact that can be felt by the Indonesian south coast area.

Storm Surge

Storm surge is an ocean wave generated by a meteorological phenomenon of a very fast wind in the ocean such as tropical cyclone. The size of the storm wave height can reach about 5 feet in areas near the source of the wind or even more than that. Related to the tropical cyclone as a trigger of the storm surge, this phenomenon only occurs at certain times and will only hit certain locations as well. Storm surge is the most dangerous impacts caused by tropical cyclones.

The storm surge can inundate all coastal areas which are close to the source of the waves. Storm surge could achieve the mainland of the coast until 200 meters from the shoreline. When these waves enter the mainland, it can cause flooding in the coast, especially when this wave comes together with a tidal wave which is also called as a storm tide. The slope of the coast determined the total area of inundation. Sloping beach will cause an inundated wide area, while the steep coast will not cause an extensive area. Nevertheless, a large wave breaking would be a problem when a storm surge comes into the steep beach.

DATA AND DATA PROCESSING

Data

This study used tropical cyclone data from the years of 1968-2007 obtained from Bearou of Meteorology Australia (BOM Australia) and the Joint Typhon Warning Centre (JTWC). The data consists of:

1. The occurrence date of tropical cyclones.
2. Tracks of tropical cyclones,
3. Pressure in the cyclone center,
4. Cyclones wind speed.

The data is used to analyze changes in frequency, period, intensity, and spatial analysis of the tropical cyclones.

Data Processing

Analyses in this research consisted of:

1. The frequency analysis, to know the occurrence frequency in 39 perception years and also to know the monthly average and annual frequency of the tropical cyclone occurrences in the south part of Indian Ocean.
2. The period analysis, to know the period of the tropical cyclone growth and its development in the south of Indian Ocean. This analysis will also allow us to know the period when tropical cyclone has the maximum occurrence frequency. On this analysis, we made a diagram of tropical cyclone occurrence times for 39 years based on the happening month of the tropical cyclones
3. The tropical cyclone intensity analysis, to know the tropical cyclone strength. On this analysis we classified a tropical cyclone base on its atmospheric minimum pressure, and refer to Saffir-Simpson scale of tropical cyclone intensity.
4. The spatial analysis, to analyze the path of the tropical cyclone. We used Geographical Information system to present the tropical cyclone trajectory band from time to time.

RESULT AND DISCUSSION

Results and discussions of this research are as follows.

Annual Frequency of Tropical Cyclones in the Southern Indian Ocean

There were 607 tropical cyclones incidents in the southern Indian Ocean over a period of 39 years (1969-2007). The average occurrence of tropical cyclones in the time interval of 1969 to 2007 is about 15 per year. It is mean that the tropical cyclone occurred every month over a year. Figure 2 shows the graph of the annual occurrence frequency of tropical cyclones in the southern Indian Ocean. The graph tends neither to decrease nor increase.

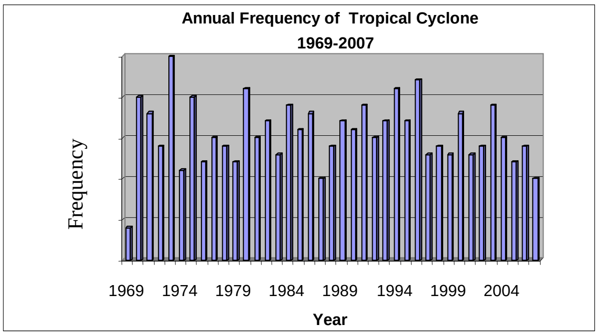

Figure 2 The annual frequency of South Indian Ocean tropical cyclone (1969-2007)

Tropical Cyclone Intensity

Although no incidence increased of tropical cyclones frequency in the Indian Ocean during 39 years period observation, but the Figure 3 shows that the intensity of tropical cyclones in the southern Indian Ocean was increasing progressively. Most of the cyclones in the last observation years are classified as a tropical cyclone. Only some of them are classified as a

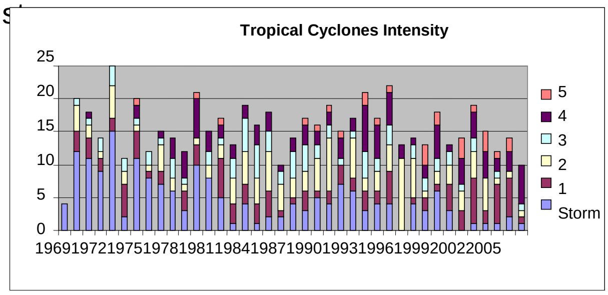

Figure 3 The Intensity of tropical cyclone occurrences in the South of Indian Ocean

South Indian Ocean Tropical Cyclone Generation Period

The Indian Ocean tropical cyclones occur nearly every month over a period of one year. Tropical cyclones start to increase in October, peak in January to February, and decrease from March until June. It is mean that the south Indian Ocean tropical cyclones begin to occur in the spring season and have a peak season in summer and then start to decrease in the fall season. This condition can be explained by the phenomena of the sun position above the earth. In summer, the heating process of the waters in the southern hemisphere will arouse the tropical cyclone. The process of tropical cyclone formation are required a low atmospheric pressure conditions which is correlated with the heat of the waters. The frequency mounting of the tropical cyclones in January and February is caused by the sun position at about 23.5 ^{o}S. On this position, the sun gives a maximum heat to the southern hemisphere of the earth. Figure 4 shows the period in which the tropical cyclones formed in the southern Indian Ocean.

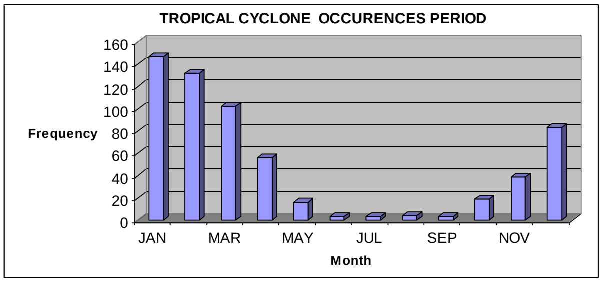

Figure 4 The period of tropical cyclone occurrences in the South of Indian Ocean

Spatial Analysis of the South Indian Ocean Tropical Cyclones

For this tropical cyclone spatial analysis, we divided the domain model into grid size 1 'x 1' to understand more the path characteristics of tropical cyclones in the south of Indian Ocean. The tracks of tropical cyclones from 1969 to 2007 were mapped and related to the months of tropical cyclones occurrence. Figure 5 shows the regions through which tropical cyclones from 1969 until 2007.

The path area of the tropical cyclone is located in the region of 5-40^{o}N and 35- 135 ^{o}E, whitin the 10-20 ^{o}N is the most frequently traveled areas of tropical cyclones. Almost there are not any tropical cyclones surrounding the equator. The corriolis force has kept away the cyclone from that area. The tropical cyclone track area shows that the south coast area and also the south west coast of Indonesia are the most dangerous location of Indonesia due to the development of South Indian Ocean tropical cyclone.

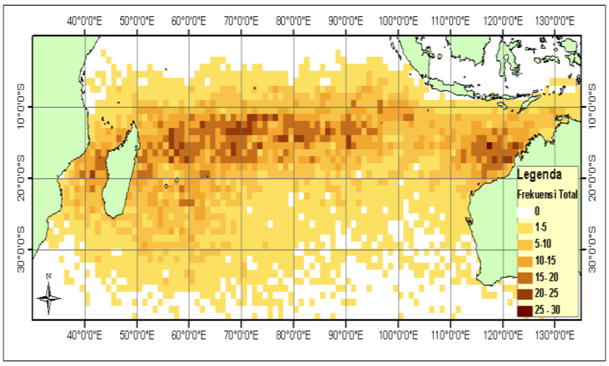

Figure 5 The South Indian Ocean tropical cyclone track area for the year of 1969-2007

Figure 6 is a figure showing the path of tropical cyclones in January of the years 1969 to 2007. January is the month in which has a maximum frequency the tropical cyclone incidences. In general, the tropical cyclones traversed the area of 10-20 ^{o}N in this month. The east African waters and the northwest Australian waters are the Maximum are the maximum frequency of tropical cyclone track for this month. In addition, the tropical cyclone track has also spread to the region 20-40 ^{o}N in the area of the east African waters.

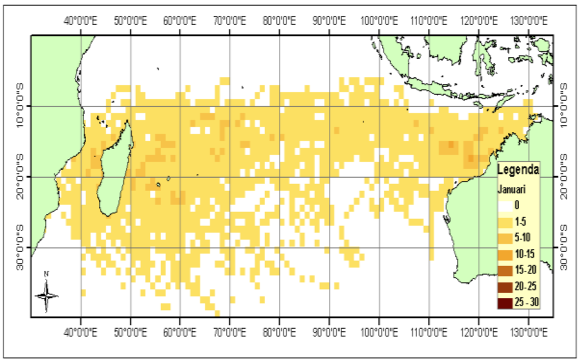

Figure 6 Tropical cyclone track area of January 1969-2007

February is the month that has the second highest frequency after January. Figure 7 is a figure showing the path of tropical cyclones in February from the year 1969-2007. The figure shows a similar pattern with regions of tropical cyclone track in January. The tracks are still concentrated in the area of 10-20 ^{o}N, mainly in the east African waters and the northwest of Australia waters.

The tropical cyclone track began to spread out to the south in March. The frequency of the tropical cyclone occurrences is more distributed in this month. The movement of the tropical cyclones in March can be seen in Figure 8.

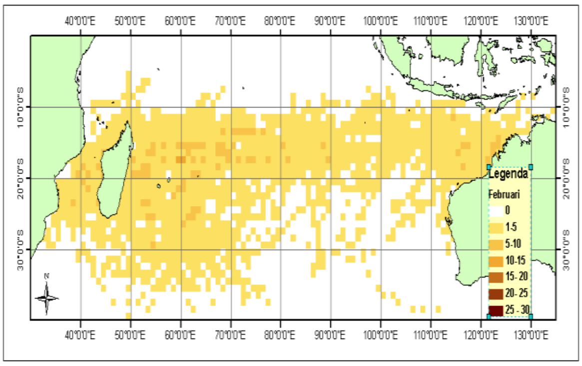

Figure 7 Tropical cyclone track area of February 1969-2007

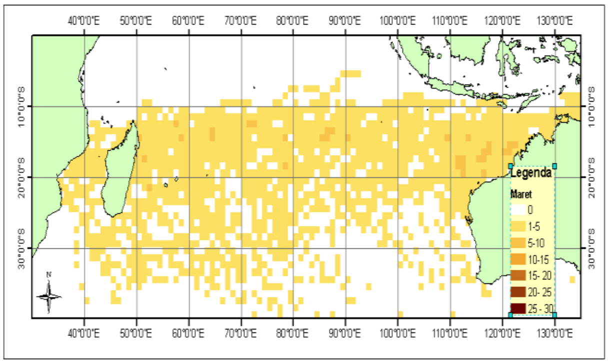

Figure 8 Tropical cyclone track area of March 1969-2007

The tropical cyclones begin to move away from the eastern Africa and northwest Australia seawaters in April. In this month the cyclones are more concentrated in the area of 10-20 °N. Figure 9 depicts the tropical cyclone movements in the months of April.

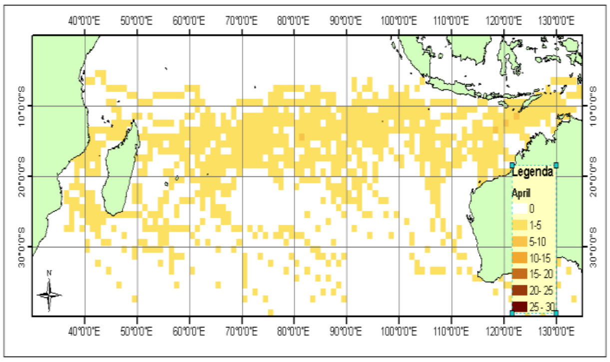

Figure 9 Tropical cyclone track area of April 1969-2007

The frequency of tropical cyclones began to decrease in May. On this month, tropical cyclone line moved toward the equator so that the southwest of Sumatra seawater has to be alert by the threat of tropical cyclone. The map of tropical cyclone track in May can be seen in Figure 10.

Only a few numbers of tropical cyclone occurred on the months of June, July, August and September. The range of frequency is about 1 to 2 occurrences. In these months, there are some of tropical cyclones which close to the equator (5-10 °N). The cyclones moved from the low latitudes to high latitudes. Track of the tropical cyclones movement at that period time can be seen in Figure 11, Figure 12, Figure 13, and Figure 14.

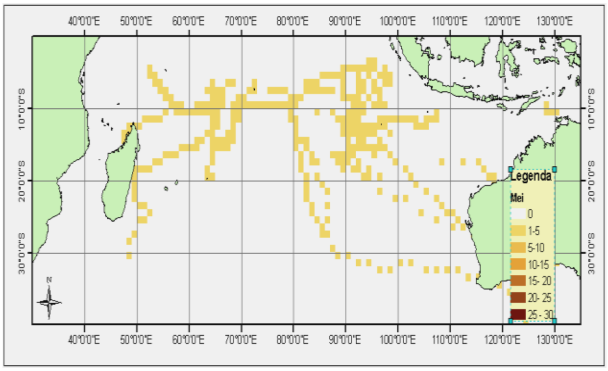

Figure 10 Tropical cyclone track area of May 1969-2007

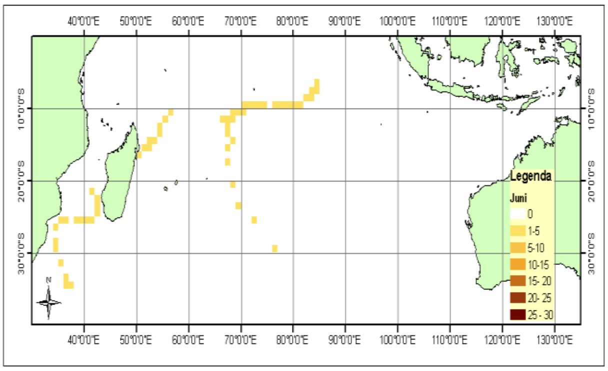

Figure 11 Tropical cyclone track area of June 1969-2007

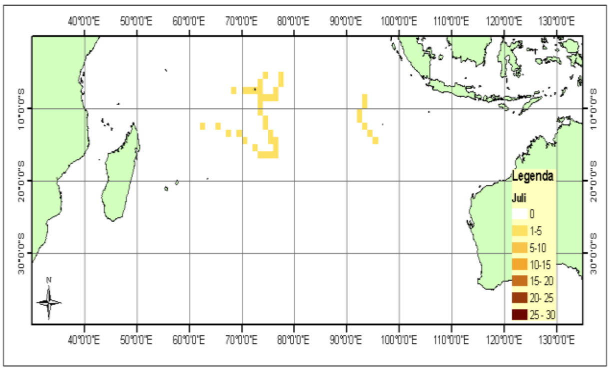

Figure 12 Tropical cyclone track area of July 1969-2007

The tropical cyclones growth were started to rise in October. In this period the tropical cyclones appeared in 5-10 °N. At least 5 times of tropical cyclone occurred in that area. Path of tropical cyclones in October can be seen in Figure 15.

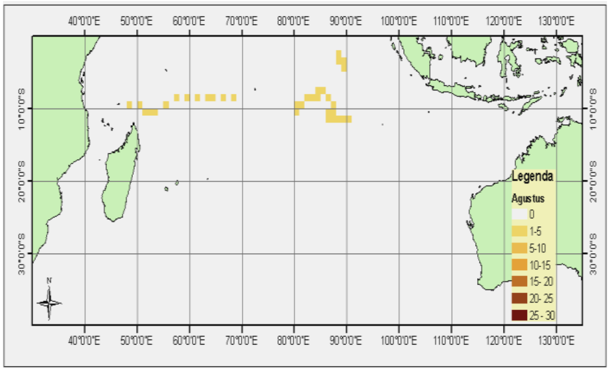

Figure 13 Tropical cyclone track area of Agustus 1969-2007

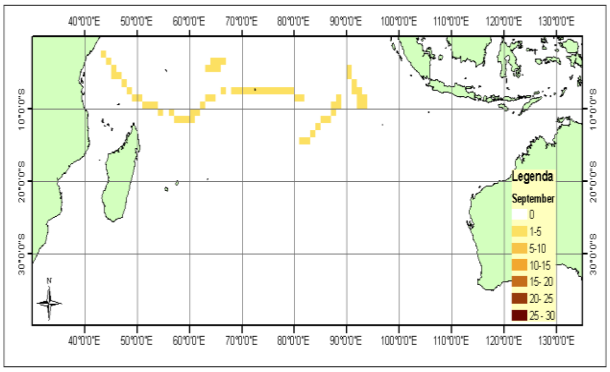

Figure 14 Tropical cyclone track area of September 1969-2007

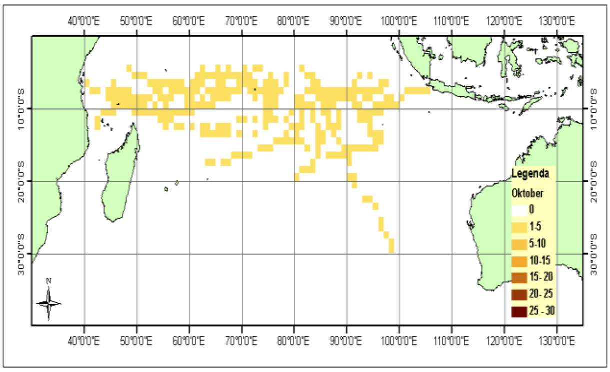

Figure 15 Tropical cyclone track area of October 1969-2007

Line tropical cyclone began moving toward 20 ^{o}N in November. Maximum frequency increased to about 7 compared to the frequency of tropical cyclones occurrence in October. The path of tropical cyclones in November is more concentrated in the central of Indian Ocean. In November the southwest of Sumatra waters threatened by tropical cyclones that grow on 5-10 ^{o}N. Figure 16 shows the path of tropical cyclones in the Indian Ocean in November 1969-2007.

In December, the path got closer to the high latitudes zone. It is caused by the sun position which is located above the high latitudes of the south part of the earth. The frequency of tropical cyclones are also started to increase in this month. The increasing frequency of tropical cyclones occurred in December because at that time the southern hemisphere was entering the period of summer.

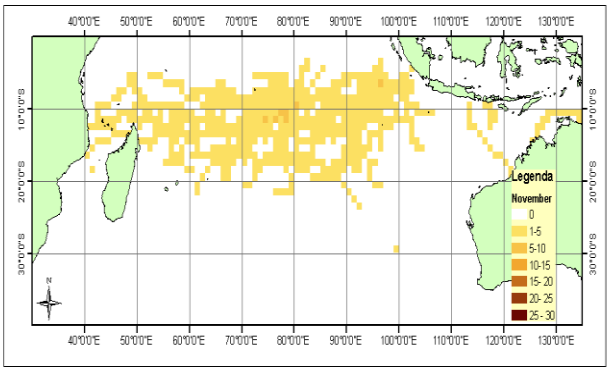

Figure 16 Tropical cyclone track area of November 1969-2007

In summer, sea surface temperature increase, and the atmosphere pressure become low. Southern coastal areas of Java, Bali, Nusa Tenggara and the eastern Indonesian waters are threatened by the phenomenon of tropical cyclones during this period. Southwest coastal Sumatra is still threatened by tropical cyclones, because the cyclone tracks still crossed the area of 10^{o}N and had not moved further to the south.

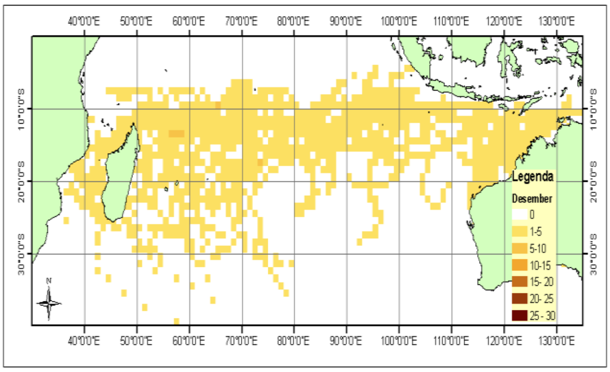

Figure 17 Tropical cyclone track area of December 1969-2007

Some Examples of the Affecting Tropical Cyclones to the Southern Indonesian Waters

Jacob Tropical Cyclone (2-12 March 2007).

The Jacob tropical cyclone moved from the northwest of Australia waters (118.9 ^{o}E; 13.8 ^{o}N). At the beginning, this cyclone moves eastward and then turned toward to the southeast and ended up in the mainland of Australia.

This cyclone has a minimum pressure of about 960 HPA. Based on the Saffir-Simpson tropical cyclones intensity scale, the cyclone is classified as a number 3 of the tropical cyclone category. This tropical cyclone had triggered a storm surge along the seawaters in the south of Indonesia.

Meteorological Climatological and Geophysical Agency of Indonesia (BMKG) reported that sea levels in western part of Bengkulu, southern Lampung, the Sunda Strait, southwest of Banten, Java Sea, Flores Sea, Masalembo to the Indian Ocean, south of Java to East Nusa Tenggara, Timor Sea, Strait of Sumba, Bali Strait, seawaters around Nusa Tenggara, Banda Sea and Arafura Sea reach more than 2.5 meters (taken from www.detik.com March 7, 2007).

This tropical cyclone influence is also perceived up to the region of Malang in East Java Indonesia. The Jacob tropical cyclone has destroyed the roof of some elementary school in the district of Karangploso Malang Regency on the evening of March 8, 2007, as reported by the daily Kompas March 9, 2007. No casualities reported caused by the tropical cyclone. Figure 18 shows the path of the Jacob tropical cyclone.

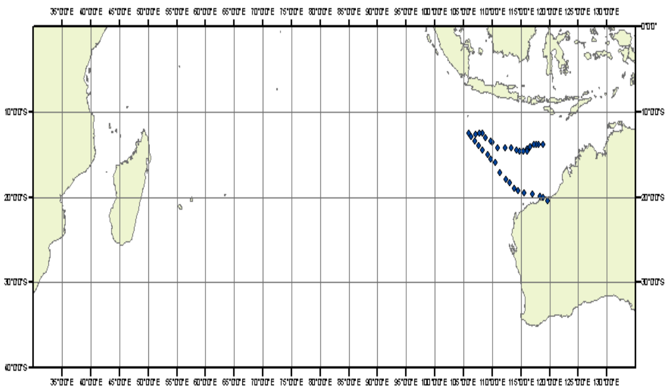

Figure 18 The path of the Jacob tropical cyclone

The Clare Tropical Cyclone (6-10 January 2006)

This tropical cyclone occurred in the month which has a maximum frequency of cyclone occurrence. This cyclone has a medium-strength scale (number 3 cyclone category). The cyclone moved from northern Australian waters, then moved toward the west and ended at the western part of the Australian continent. This cyclone influence felt in the East Java Sea waters as reported by BMG to www.infoanda.com on January 10, 2006. According to BMKG, due to the Clare tropical cyclone, extreme weather was occurred in several districts in East Java such as heavy rain, high winds and rising sea waves. Ocean wave height in the waters of East Java is reported until 3 meters height. Figure 19 shows the path of the Clare tropical cyclone.

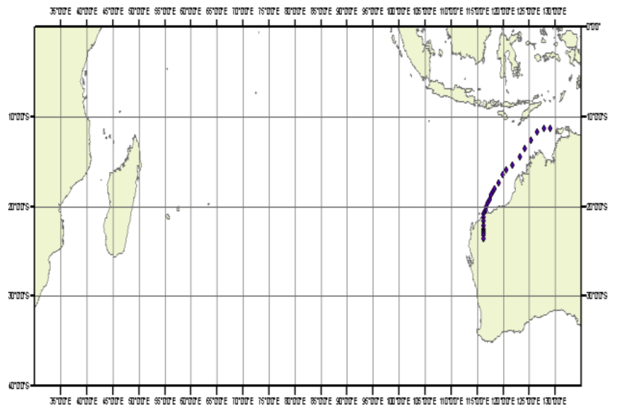

Figure 19 The path of the Clare tropical cyclone

The Vivienne Storm (4-9 February 2005)

Vivienne actually was only a tropical storm category, which is a tropical cyclone with a minimum pressure of greater than 989 HPA. Although it was only a tropical storm but its impact was felt in several areas in Java. The Pasuruan city which is located in East Java is one of the areas reported affected by this storm.

The impact of tropical cyclones had increased the height of waves in the waters of Pasuruan (Suara Merdeka, February 15, 2005). Vivienne storm was originating from the northwest Australian waters. The length of the path of the cyclone was not too long (about 2^o). Short path of the Vivienne tropical storm can be seen in Figure 20.

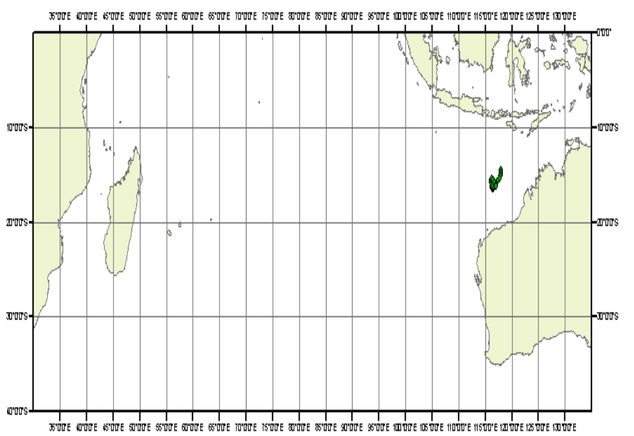

Figure 20   The path of the Vivienne storm

CONCLUSIONS

The tropical cyclone generation and development in the south of Indian Ocean occurs every month along a year. The South Indian Ocean tropical cyclone intensities tend to become stronger during 39 years observation. The influence of the cyclones reaches the south coast of Java as an extreme weather such as heavy rain and high winds. Another impact of the Indian Ocean tropical cyclones that can be felt in the south coast of Java is the rising sea waves or storm surges. As reported by Meteorological Agency of Indonesia, of the surge can reach 3 meters height. Due to the influence of the cyclones, some of buildings are destroyed. The height of the sea water level caused by the surge may also disturb the ships transportation.

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COMPOUND DEVICE OF WAVE ENERGY AND WIND ENERGY SYSTEM TO FACE THE FUTURE ENERGY PROBLEM

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ABSTRACT

West Kalimantan has a long coastline of approximately 982 km. Potential to explore is the energy of waves and wind. Coastal areas and islands in West Kalimantan is very unique that the potential of the topography and bathymetry should be reviewed to be used optimally in order to create a model of energy generation that joined with nature or according to local site characteristics. This study will examine the combined model consists of wind energy and wave energy generator in one device.
This study was conducted in the laboratory by testing the performance of the propeller and gearbox to drive the generator. Combined electronic circuits for wave energy conversion devices and wind energy were also performed. Analysis conducted on the efficiency of the combined instrument.
In general, the results of the design of the physical model is reliable, and can provide guidance to make the design of physical models and laboratory-scale prototype for wave energy and wind energy conversion into electrical energy. The best performance of alternator windmill obtained at 1400 rpm, and will work at minimum 900 rpm. Windmill blade efficiency is 20%, the efficiency of windmill gearboxes is 72%. Meanwhile, the wave converter gearbox efficiency was 82.1%. Efficiency of alternators for wave energy conversion devices is about 88.5%.

Keywords: wind and wave energy; compound device system

INTRODUCTION

According to the Energy Research Center of the Netherlands (ECN) the role of renewable energy in various activities, particularly in mitigating the impact of climate change will increase. Furthermore, renewable energy provides a positive impact to reducing fossil fuel consumption.

Today, renewable energy has become a trend to race of the windmill and wave converter device. The utilization of wind energy is the most developed renewable energy utilized nowadays. Wind energy is also regarded as relatively clean, safe and environmentally friendly.

With a 982 km long coastline, Kalimantan Barat has considerable potency for the use of wind and wave energy. Coastal areas and islands in western Borneo has a sectional shape of topography and bathymetry that can be used optimally for renewable energy, in this case are wind and wave energy.

The small-scale windmill has an important role especially for areas that cannot be reached by electricity such as islands and coastal areas. Wave energy conversion device is also potential to develo with windmill as together.

Energy from wind and wave can be transformed into electrical energy by using a compound converter device. The advantage of using compund converter device is its ability to catch the two energies in one device.

OBJECTIVE

The objective of this research is to design compound device converting both wind and-wave energy. This compund device can be applied in areas that cannot be reached by electricity network such as islands and coastal areas.

DESIGN OF COMPOUND DEVICE

Windmill Design

The device consists of components such as blade, gearbox, alternator, pulley, dynamo, storage battery (Burton et al., 2001).

The alternator has specification of 12 Volt, 20 Ampere and 1400 rpm. The battery's specification is 60 Ampere.

A wind turbine has three rotating blades. The length of each blade is 1 m. The speed of the wind is designed at 5 m/s. The windmill has a tower of 5 m to 10 m.

It was assumed that the efficiency for the rotating blade and rotor is 40%, the gearbox efficiency is 95 % and the generator efficiency is 70%.

Design of Gearbox

One of the most important main components in the wind turbine is the gearbox. The function of the gearbox is to connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm which is the rotational speed required by most generators to produce electricity.

Steps to determine the gearbox ratio is as follows (El-Sharkawi, 2007).

a. Compute wind power of density using equation

$$\rho = 1/2\, \delta\, v^3 = 1/2\, x 1.164\ x\ 5^3 = 72.772\ W/m^2$$

b. Compute the power captured by blades

$$P = A\rho = \pi r^2\ \rho = \pi\, x\, 20^2\ x 72.772 = 228.6\ W$$

c. Compute output power of wind turbin. $P_{out} = \eta_{tot}\, P = (0.4\, x\, 0.95\, x\, 0.7)\, x\, 228.6 = 468.67\, W$

d. Compute gear ratio

$$v_{tip} = TSR.v = 0.7\, x 5 = 3.5\, m/s$$

$$n = 60\frac{v_{tip}}{2\pi r} = 60\frac{3.5}{2\pi 1} = 33.4$$

$$\frac{n_g}{n} = \frac{905}{33.4} = 27$$

This gearbox ratio is enough to increase the speed of rotation up to 1543 rpm with comparation ratio between gearbox 1 and gearbox 2 (pinion) is 2.25.

From this result, we can then design the diameter and gearbox gear number. There is a two-gearbox type. Gearbox 1 has diameter 118 mm with number of gearbox gear is 45. Gearbox 2 (pinion) has diameter of 55.6 mm with number of gearbox gear is 20 (see Figure 1).

The windmill and gearbox are designed using AutoCad Inventor 2008 because of the quickness, simplicity and precision (Tualkia, 2008).

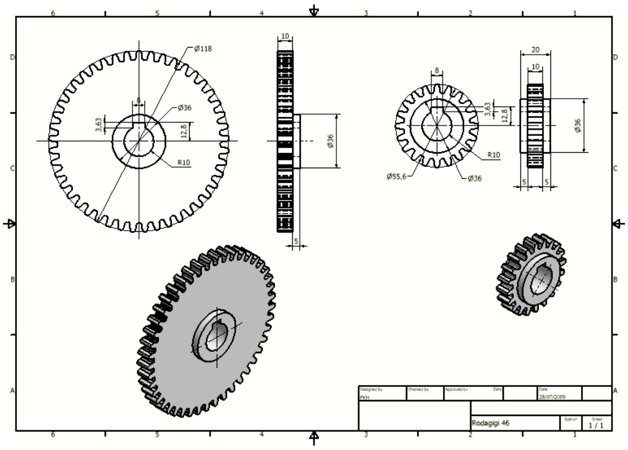

Figure 1. Design of pinion and gearbox tooths

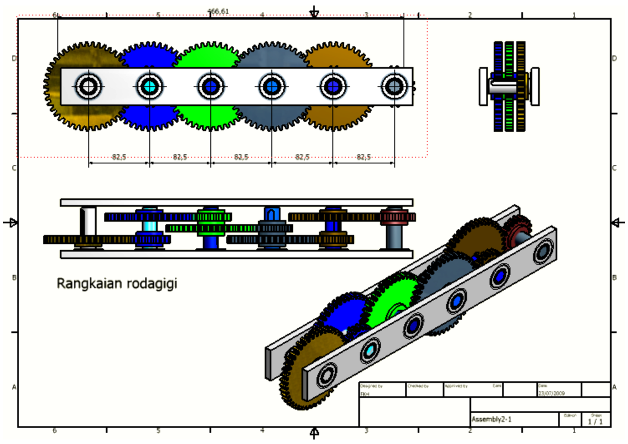

Figure 2. Design of gearbox

From Figure 2, the gearbox for windmill must have five level of acceleration to reach 1400 rpm to be able to generate the alternator. Material for gearbox and shaft for windmill and wave energy converter are made from aluminium because of lightweight characteristic (Sularso and Suga, 1997).

From Figure 3, gearbox and pinion were built at mechanical laboratory. Gearbox and pinion, each consist of 6 pieces.

Figure 3 Gearbox and pinion

Rotating Blade

Rotating blade is important to captur the kinetic energy of the wind. In this windmill, there are only three that were made of iron plate St37 (See Figure 4).

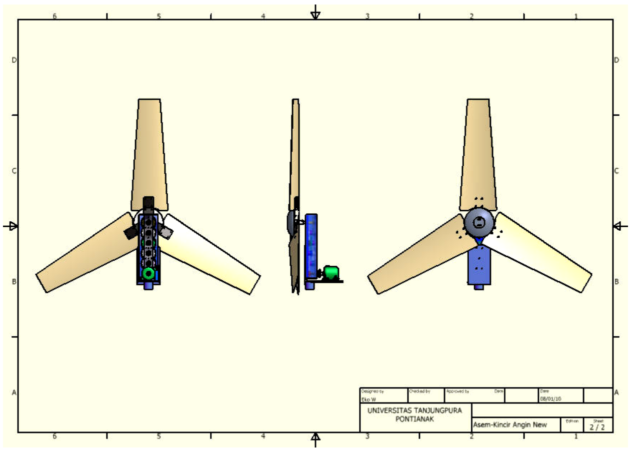

Figure 4 Rotating blade design

Assembling of Windmill

In Figure 5 and Figure 6, assembly of windmill consists of the following components:

a. A tower that keeps the rotating blades at a height of 5m to 10 m. Tower was made from tubular steel. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
b. A Gearbox was installed behind the rotating blade coupled with the shaft of rotating blade and connected to high-speed generator or alternator.
c. Alternator was installed behind the gearbox and connected to the shaft of the gearbox.
d. Rotating blade is installed perpendicular to the wind direction and connected with shaft of gearbox and alternator.

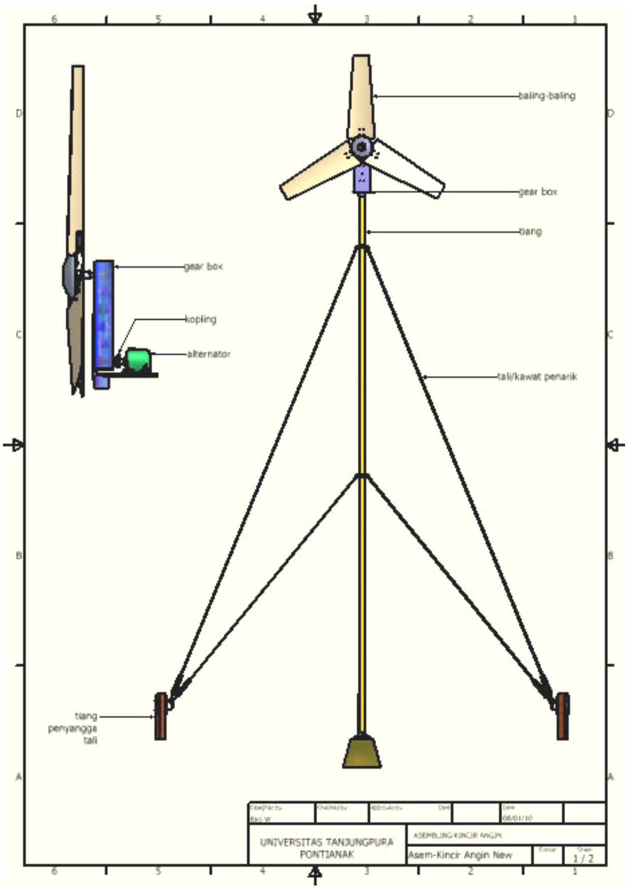

Figure 5 Windmill design

Figure 6 Assembling of wind turbin

MECHANISM OF COMPOUND DEVICE

The Work Mechanism of Windmill

When the wind blows the windmill or rotating blade captured the kinetic energy of the wind. Rotating blade is connected with the shaft that connected with the gearbox that is used to increasing the low-speed rotating blades to the high-speed generator.

A generator connected to the high-speed shaft of gearbox can then convert mechanical energy of the rotating blades into electrical energy. A controller system was required to maintain range of rotating blade from 800 rpm to 1500 rpm.

The Work Mechanism of Wave Energy Converter

The gearbox for wave energy converter must have three levels of accelerations to reach 1400 rpm to be able to generate the alternator. The diameter of gearbox and pinion of wave energy converter were the same as that of gearbox and pinion of windmill. The device consists of board, sprochet, chain, gearbox and alternator (see Figure 7).

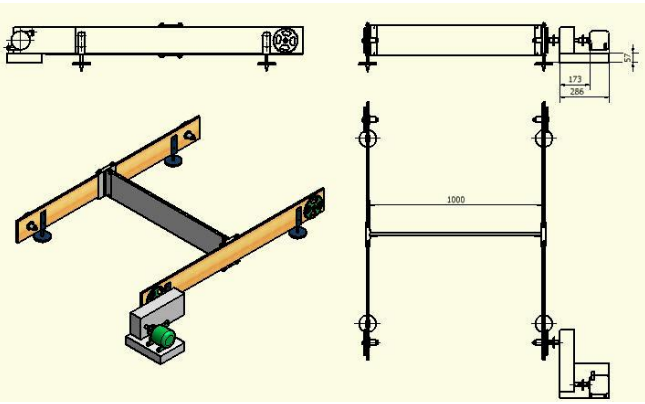

Figure 7 Wave energy converter design

Working principle of wave energy converter is as follows:

a. Wave action push the board and move the chain and sprochet that enables the gearbox to increase low speed to high speed.
b. The gearbox was connected to the shaft of the alternator and if the speed range of gearbox has already reach the speed range of the generator; it will be able to generate electric current.
c. Rotating gearbox for wave energy converter cannot continue over time because of the influence of periodic waves.

Compound Energy Converter

Compound energy converter was designed as a device which wasable to catch two energies from wind and wave simultaneously (See Figure 8).

The device has the controller system starts the machine at rotating speed of about 800 rpm to 1600 rpm and shuts off the machine at about below 800 rpm and above 1600 rpm. Turbines do not operate at rotating blade above about 1600 rpm because they might be damaged by the high winds.

The mechanism of compound energy converter is very simple. If two energies are available, the device of windmill and wave energy converter rotate the gearbox and increase the rotational speed from about 30 to 60 rotations per minute (rpm) to about 800 to 1600 rpm.

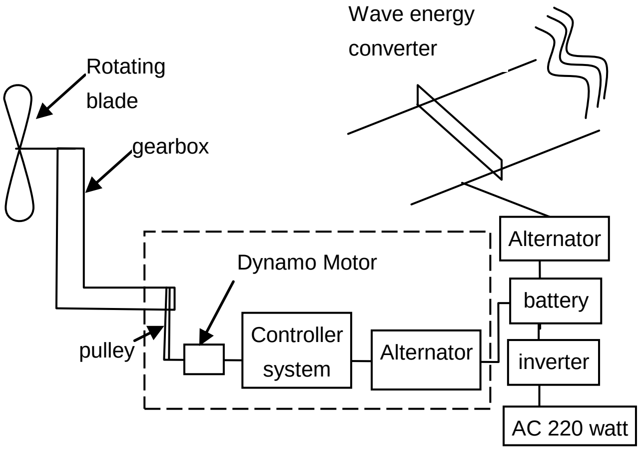

Figure 8 Compound energy converter design

If the rotational speed had already reached the speed range of the generator, the gearbox was able to generate the generator. Reversely, if the rotational speed did not reach the speed range of the speed generator, the gearbox was not able to generate the generator.

If windmil or wave energy converter can generate generator, than it can produce the electricity and can be transmitted and distributed for various purposes. The electricity from alternator can be used to charge the battery and must be changed from DC to AC using inverter before transmitted for other purpose.

MECHANICAL AND ELECTRICAL TEST

Mechanical and electrical test was required to see the performance of the alternator. The purpose was to determine the optimal speed range of the alternator (Arwoko, 1999). The best performance was reached when blade rotated at a speed range of 800 rpm - 1400 rpm.

Table 1. Alternator test with 25 Watt

Rotating shaft Alternator		Voltage DC (volt)		Current (A)	
unload (rpm)	loaded (rpm)	unload	L oaded	unload	loaded
900	800	10	8.7	0	1.2
1000	900	12	10	0	1.4
1150	1000	12.4	11.6	0	1.6
1250	1100	13	12.5	0	2
1300	1200	14.3	13.8	0	2.4

In Table 1, it can be seen that the increase of the alternator rotational speed was proportional to the increase of voltage. The higher the alternator shaft rotation the higher the voltage produced. Similarly, the increase of alternator shaft rotational speed is proportional to the increase of the flow.

Performance of the compound energy converter device was as follows.

a. The performance of alternator at the range of 900 rpm to 1400 rpm.
b. The efficiency of rotating blade and windmill gearbox is 20% and 72% respectively.
c. The efficiency of wave energy converter gearbox and alternator is 82% and 88% respectively.

From test results, the performance of rotating blade can be increased using two ways. Firstly, by increasing the length of rotating blade. It can produce a higher power of rotating shaft due to enlargement of capture area. Secondly, by increasing the width of rotating blade. The higher efficiency of the blade area resulted wil bring to a higher power of rotating shaft of blade.

CONCLUSION

Some conclusions can be taken as follows:

a. The gearbox of wind turbine has 5 stages of speed to increase rotating speed to 57 fold., whereas the gearbox of wave energy converter has 3 stages of speed to increase rotating speed to 57 fold.
b. The best performance of wind turbin is obtained at range of 800 rpm to 1600 rpm.
c. The gearbox efficiency of windmill and wave energy converter are about 72% and 82%, respectively.
d. The alternator efficiency of windmill and wave energy converter are about 72% and 88.5%, respectively.

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STUDY OF IMPLEMENTATION PROGRESS AND APPLICATION OF QUALITY IN REHABILITATION AND RECONSTRUCTION OF PUBLIC INFRASTRUCTURE AFTER THE JOGJAKARTA EARTHQUAKE IN 2006

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ABSTRACT

Since earthquake on May 27, in Jogjakarta Special Province, the government has been being the rehabilitation and reconstruction of public infrastructure. The success of a rehabilitation and reconstruction programs in each of the affected areas differ from one another. Criteria for success of a program of rehabilitation and reconstruction can be viewed from several aspects, such as timeliness of implementation, the success rate of services and application of structure building quality. This paper will present analysis of the success rate of services and application of structure quality in the rehabilitation and reconstruction of public infrastructure by the method of statistical analysis descriptive and comparative descriptive. The results of study shows that the implementation of rehabilitation and reconstruction of public infrastructure was going according to the specified time, the factors affecting this success is the involvement and commitment between countries/donor agencies with the Provincial Government of Jogjakarta and Bantul Regency, and the active participation of the community Bantul. Post-implementation rehabilitation and reconstruction, the public infrastructure service was increase, shown by the success rate of transport infrastructure services 85%, government infrastructur 85%, education infrastructure 92%, health infrastructure 85%. Different results shown by the trading infrastructure which is after implementation rehabilitation and reconstruction carried out a physical condition does not affect the success rate of infrastructure services trade, which is only rate 73%. The results of study on application of quality shows that not all projects of rehabilitation and reconstruction of public infrastructure to apply the quality of materials and structures in accordance with the standards of the Directorate genaral of Bina Marga and the recommendation of experts in earthquake resistant structures.

Keywords: *rehabilitation, reconstruction, public infrastructure, succes rate of service, application of quality*

INTRODUCTION

In the implementation of rehabilitation and reconstruction of public infrastructure in the Jogjakarta Special Province after the earthquake in Jogjakarta, the central government has appointed the Provincial Government of DIY to implement the program by optimizing the local community empowerment. The policy was taken with the consideration that after the earthquake of Jogjakarta Provincial government system is still able to function well. This policy is different from the policy of post-tsunami recovery program in Aceh Province and Nias Island, which is implementing the program of rehabilitation and reconstruction of public infrastructure delegated only to the Rehabilitation and Reconstruction Agency (BRR). The policy was taken because after the tsunami disaster, the system of Province government cannot function properly, and almost all people become victims of the earthquake.

One example of the same program policies with the policy of the recovery program in Aceh province is the policy on rehabilitation and reconstruction in Gujarat India in 2001. Similarities between both are the two agencies appointed by the government to carry out rehabilitation and reconstruction programs. Implementation of rehabilitation and reconstruction delegated to Gujarat State Disaster Management Authority (GSDMA). Implementation of rehabilitation and recons-truction was planned for three years from 2001 to 2004, but the recovery program was completed only in two years. Based on perfor-mance evaluation by the Technical Asistance of GSDMA concluded that the performance was very satisfied (Technical Assistance Completion Report 2003).

Implementation program of rehabilitation and reconstruction of public infrastructure in Aceh Province is planned for five years, namely from 2005 until 2009. Based on the results of realization of the absorption of funds, the performance of the BRR was too slow.

It can be seen in the year 2005, for implementation of rehabilitation and reconstruction in Aceh and Nias, the central government provides a budget of Rp 3.966 trillion. But until the end of 2005, which absorbed only Rp 414.662 billion and approximately USD 2.082 trillion should be launched in 2006. For fiscal year 2006, it is allocated a huge budget, namely Rp 10.522 trillion. But until the end of the year, which successfully absorbed only Rp 5.684 trillion.

Budget absorption BRR NAD-Nias until the end of August 2007 was still low. Total funds absorbed by the new Rp 2.824 trillion or 25,30% of the ceiling provided this year around Rp 11.165 trillion. This indicates the performance of BRR NAD-Nias at the beginning of fiscal year 2007 has not been able to better than two years earlier (Serambi Indonesia, 2007).

From the results of the performance of the rehabilitation and reconstruction program of public infrastructure in Gujarat and in the Province of NAD, it can be said that the GSDMA performance is better than BRR performance.

Study of Implementation progress and application of quality in rehabilitation and reconstruction of public infrastructure after the Jogjakarta earthquake in 2006 can be know the level of successful implementation of programs implemented by the Provincial Government of DIY optimize community empowerment.

PUBLIC FACILITY AND INFRASTRUCTURE

Public infrastructures refers to physical systems that provide transportation, drainage, buildings and other public facilities needed to meet basic human needs in the social sphere and economic (Grigg in Kodoatie 2005). Infrastructure system is a major supporter of the functions of social systems and economic systems in the daily life of society.

According to Grigg in Kodoatie, the system can be defined as infrastructure facilities or basic structures, equipment, installations and systems needed for the functioning of social and economic system of society. The technical definition also provides specifications system and the infrastructure related with physical assets which is designed in systems that provide essential public services. The definition of public infrastructure according to the dictionary terms of spatial and regional development is a government-owned buildings or community needs and community use with a specific function to support the needs of society (Kimpraswil, 2002). Example is the health infrastructure, the infrastructure of worship, educational facilities, governance infra-structure, trade infrastructure and transport-tation infrastructure.

METHODOLOGY

Method of analysis to get the success level of service is a descriptive statistical method. All data described in common form of central tendency and variability, both for every single statement, dimensions or variables. It includes a central Tedensi average, median, and mode. Size range includes the variability (range), the smallest value, largest value and standard deviation. In addition, the number of respondents who researched on every single statement and variables also need to be reported. For each item statements and variables, frequency or percentage of each response are also reported. For example, a number of respondents who strongly agree, agree, neutral, disagree and strongly disagree about the success of the service.

Quality is very important for a completion of project. This means that the product or the results of project activities must meet the specifications and criteria required. The definition of quality is the product characteristics, in the form of goods or services, and the characteristics of a series of activities according to the desires of the owneer of the project, customer or consumer (Wibowo 2005). According to Garven in Tjiptono and Diana (2001), one of the dimensions of quality that can be used as a framework for strategic planning and analysis is conformity to the specification (conformance to specification), ie the extent to which the design and operating characteristics meet the standards set previously.

According to Wibowo (2005), the application of quality in the project includes construction of three things which are:

a. Quality engineering is a procedure used to ensure appropriate engineering design criteria or recommendations from experts or associations.

b. Quality Assurance is all that is required for the use of standards and procedures to ensure that the products, services or facilities established to reach beyond the needs of elderly or function.

c. The quality control is part of quality assurance that provides guidance and a way to control the quality of materials, structure, component or system to meet the needs or the needs that have been determined.

In the implementation of rehabilitation and reconstruction of public infrastructure implementation of quality management is necessary, so that the resulting buildings are earthquake-resistant buildings. Some guidelines for the implementation of construction is used as the reference standard quality of implementation of rehabilitation and reconstruction of public infrastructure. Construction quality control can be seen in the document containing the quality control characteristics of a specific product. Control documents including drawings, specifications of building materials and construction methods.

Data required in this research were the primary data and the secondary data. The data were obtained in several ways and used to analyses these following activities:

a. To find a comparison between plans and implementations of reconstruction and rehabilitation of public infrastructure required data include: (1) data regarding the factors that influence the progress of implementation of rehabilitation and reconstruction of public infrastructure, obtained by in-depth interviews; (2) data about the progress of implementation of rehabilitation and reconstruction of public infrastructure, documentation gathered by the survey directly or browsing the Internet. Data sources are document of plan and progress rehabilitation and reconstruction program from Residence and Infrastructure Of Regional Agency (Kimpraswil) of Jogjakarta Special Province, Agency of Regional Develoment Planning Agency (BAPPEDA) of Jogjakarta Special Province, Goverment of Bantul Regency, National Development Planning Agency (BAPPENAS) and an expert resource person several government agencies.

b. To determine the success rate of public infrastructure on public services, data collected by distributing questionnaires to the community. The data is analyzed by using descriptive statistical methods. Data sources are from the community respondents consisting of several community leaders, village officials, and the general public in the sub-district of Bantul, Kasihan and Piyungan.

c. To determine the quality of buildings on the application of rehabilitation and reconstruction of public infrastructure required data: (1) Data concerning the application of the physical quality in the programs of rehabilitation and reconstruction of public infrastructure that is collected by questionnaire and in-depth interviews to the consultant planner and supervisor techniques, (2) Data on the standart physical quality of the building plans collected by direct survey of construction quality standards documentation issued by the Directorate General of Bina Marga and recommendations of experts in earthquake resistant construc-tion. Respondents were from the consultant planners or engineering field supervisor. Source of data is a technical manual, guidelines and recommendations regarding construction experts in earthquake resistant buildings.

RESULTS AND DISCUSSION

Progress Rehabilitation and Reconstruction Implementation of Public Infrastructure

Based on the description of the progress of the program, a recapitulation of the progress of implementation of plans and programs of rehabilitation and reconstruction of public infrastructure in Bantul is presented in form of graphs and tables, as shown in Table 1.1 and Figure 1.1. Table 1.1 and Figure 1.1 show that implementation of rehabilitation and reconstruction in the Bantul regency was going according to plan implementation time. Based on in-depth interviews with resource persons from government institutions, it is known to some of the factors leading to the achievement of the program of infrastructure rehabilitation and reconstruction in Bantul, according to specified time. A primary cause of the achievement of rehabilitation and reconstruction of public infrastructure in the Bantul Regency is a good coordination between the state / donor agencies with local government and community participation in recovery support activities. Whereas, secondary causes are availability of government budget for post-disaster recovery activities of the earthquake, both from the State Budget, Budgets Budgets I and II; assistance from donor countries, state enterprises, the National Companies and local and international NGOs; and project resources, such as labor, materials and construction equipment.

Table 1 Recapitulation of the implementation plan and progress rehabilitation and reconstruction of public infrastructure in Bantul regency

No	Public Infrastructure	Percentage of Plan and Progress of Program Implementation on The Rehabilitation and Reconstruction of Public Infrastructure					
		2006		2007		2008	
		July-Nov 2006		Feb-June	July-Nov	Feb-June	July-Nov
1	Transportation infrastructure						
	Plan Implementation Program		47%		85	100%	
	Progess Implementation Program		47%		69	100%	
2	Goverment infrastructure						
	Plan Implementation Program		34%		70%	85%	
	Progess Implementation Program		25%		63%	82%	
3	Education infrastructure						
	Plan Implementation Program		54%		100%		
	Progess Implementation Program		72%		100%		
4	Health infrastructure						
	Plan Implementation Program		100%				
	Progess Implementation Program		100%				
5	Trade infrastructure						
	Plan Implementation Program		55%		91%	95%	100%
	Progess Implementation Program		32%		73%	86%	

Source: Goverment of Bantul Regency dan BAPPENAS, 2007

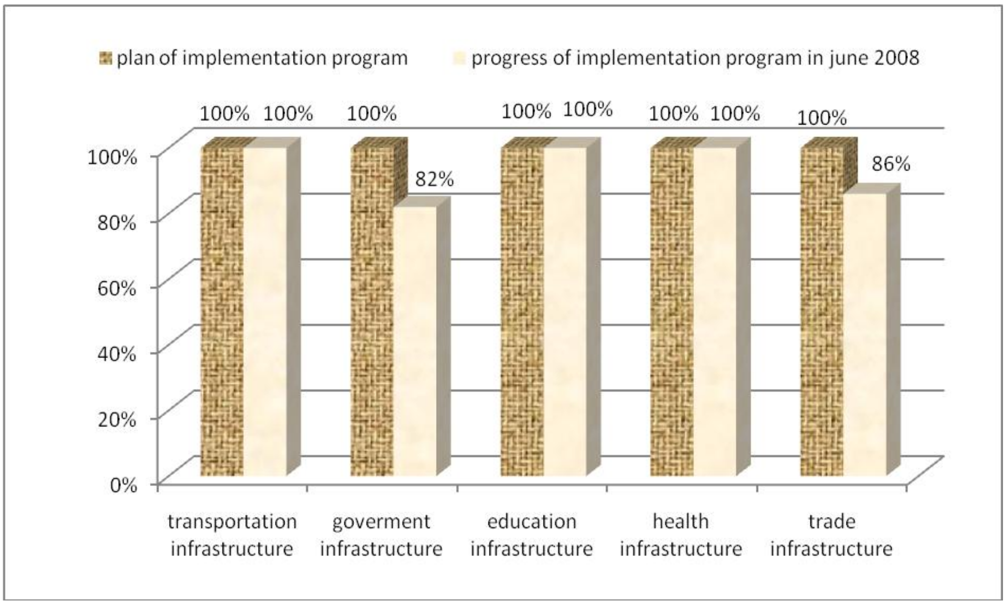

Figure 1 Implementation plan and progress rehabilitation and reconstruction of public infrastructure in Bantul regency (source: analysis)

EVALUATION OF THE SUCCESS RATE OF PUBLIC INFRASTRUCTURE SERVICES POST EARTHQUAKE

The study shows that the success rate of transportation infrastructure, government infrastructure, educational infrastructure, infrastructure and health services post implementation of rehabilitation and reconstruction are high. However, different result shown by the trade infrastructure which has smallest success rate of services, compared with the rate of success on the infrastructure services.

Based on the study of the success rate of public infrastructure services post implementation of rehabilitation and reconstruction, a recapitulation of the study in Bantul Regency presented in form of graphs and tables, as shown in Table 2 and Figure 2.

Table 2 Recapitulation the success rate of public infrastructure services post earthquake

Infrastructure	Before Earthquake / Post Implementation	Percentage of physical condition of public infrastructure	Percentage of success rate of public infrastructure services
Transportation Infrastructure	Before Earthquake	86%	82%
	Post-Implementation of Rehabilitation and Recontruction	86%	85%
Goverment Infrastructure	Before Earthquake	83%	79%
	Post-Implementation of Rehabilitation and Recontruction	85%	83%
Educational Infrastructure	Before Earthquake	89%	85%
	Post-Implementation of Rehabilitation and Recontruction	92%	91%
Health Infrastructure	Before Earthquake	83%	82%
	Post-Implementation of Rehabilitation and Recontruction	87%	85%
Trade Infrastructure	Before Earthquake	71%	69%
	Post-Implementation of Rehabilitation and Recontruction	84%	73%

Source: analysis

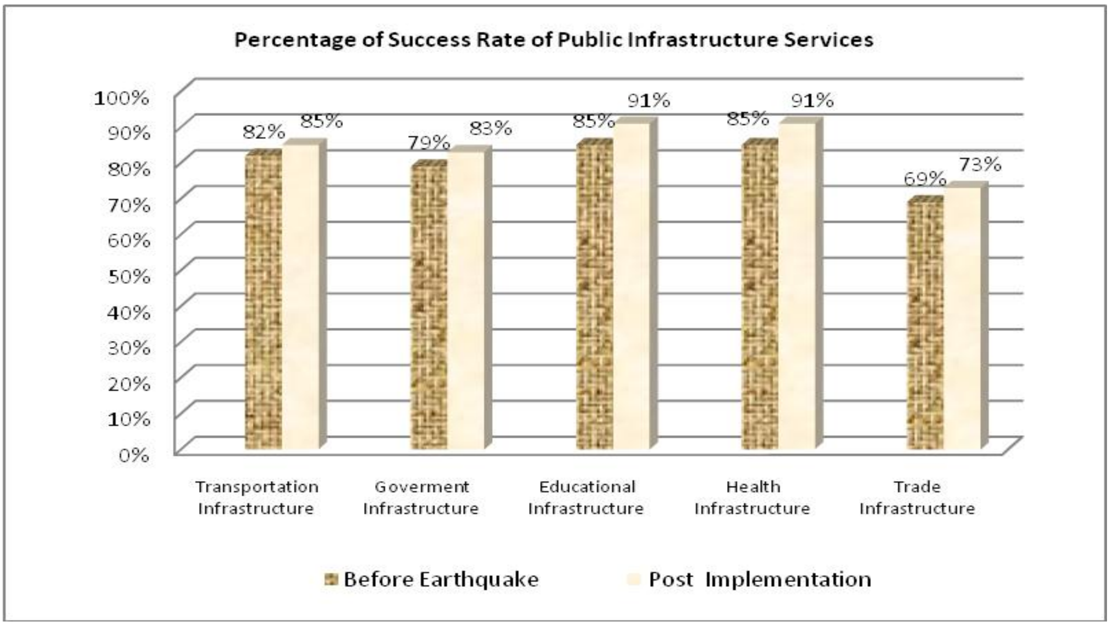

Figure 2 The success rate of public infrastructure services post implementation of rehabilitation and reconstruction (source: Analysis)

Table 2 shows that post implementation rehabilitation and reconstruction percentage of physical condition of public infrastructures are increase compared before earthquake. Similarly, post-implementation rehabilitation and reconstruction, the success rate of public services is also increased. It is suspect that upgrading of the physical condition of public infrastructure may be causing the increase of public infrastructure services.

However, different result shown by the trade infrastructure which post rehabilitation and reconstruction of the physical condition of the building trade infrastructure (traditional market) does not affect the trade infrastructure services. Based on the depth interviews with expert resource persons from the Ministry of Industry, Trade and Cooperatives of Bantul Regency, the low success rate of trade infrastructure services seems to be cause by reduction of purchasing power and economic revitalization programs have not worked well.

EVALUATION OF QUALITY APPLICATION IN REHABILITATION AND RECONSTRUCTION PROGRAM FOR PUBLIC INFRASTRUCTURE POST EARTHQUAKE

The results of studies on the quality application of rehabilitation and reconstruction projects after the earthquake for building public infrastructure in Bantul Regency can be seen in Table 3. Table 3 shown that not all project of rehabilitation and reconstruction of public infrastructure applied the quality of materials and structures in accordance with the standards of the Bina Marga and the recommendation of experts in earthquake resistant structures. This is caused not all the projects implement of construction quality assurance (Quality Issurance) and poor quality control (quality control) on the implementation of construction work.

CONCLUSION

a. Progress of implementation rehabilitation and reconstruction of public infrastructure was going according to plan implementation time, which cause by a good coordination between the state / donor agencies with local government and community participation in recovery support activities.

b. The success rate of transportation infrastructure, government infrastructure, educational infrastructure, and health infrastructure services post implementation of rehabilitation and reconstruction are high. Whereas the success rate of most infrastructure services trade is small compared to other infrastructure

c. Not all project of rehabilitation and reconstruction of public infrastructure to apply the quality of materials and structures in accordance with the standards of the Bina Marga and the recommendation of experts in earthquake resistant structures.

Table 3 Quality application in the rehabilitation and reconstruction program for public infrastructure Post-Jogjakarta earthquake

No	Material Parameters	Study In the application of Materials Quality for Rehabilitation and Reconstruction Project				
		Transportation infrastructure	Goverment Infrastructure	Educational Infrastructure	Health Infra-structure	Trade Infra-structure
1	Coarse Aggregate Or Gravel	100%	100%	100%	100%	100%
2	Fine Aggregate Or Sand	100%	100%	100%	100%	100%
3	Aggregate For The Mixture	100%				
4	Asphalt	100%				
5	Portland Cement		100%	100%	100%	100%
6	Redbrick		60%	100%	100%	40%
7	Wood		80%	100%	100%	40%
8	Reinforcement		60%	60%	100%	60%
9	Water		100%	100%	100%	100%
10	Roof-Tile		100%	100%	100%	100%

Table 3 Quality application in the rehabilitation and reconstruction program for public infrastructure Post-Jogjakarta earthquake (continued)

No	Structure Parameters	Study In The Application Of Structure For Rehabilitation And Reconstruction Project				
		Transportation infrastructure	Goverment Infrastructure	Educational Infrastructure	Health Infrastructure	Trade Infrastructure
1	Thick Of Top Foundation	60%				
2	Thick Of Under Foundation	20%				
3	Thick Surface Layer	100%				
4	Type Of Test In The Project Location	20%				
5	Foundation		100%	100%	100%	100%
6	Sloof		40%	60%	100%	60%
7	Column		40%	60%	100%	60%
8	Beam		40%	100%	100%	60%
9	Roof		100%	100%	100%	100%
10	Brick-Wall		100%	100%	100%	100%
11	Concrete		100%	100%	100%	100%
	Average of Quality Implementation	75%	81%	92%	100%	79%

(Source: Author's Analysis)

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SIMULATION OF VULNERABLE AREAS TO THE IMPACT OF STORM TIDE ALONG SOUTHERN COASTS OF JAVA, BALI, AND WEST NUSA TENGGARA

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ABSTRACT

Storm surges generated by tropical cyclone in the Indian Ocean have often attacked southern coasts of Java, Bali, and West Nusa Tenggara (NTB) and might cause serious disasters, such as: houses and infrastructures around the coastal areas being totally flooded, hundreds of families being displaced, tourism activities being unavailable, and damage of fishing ships. In this study, A two-dimensional (2D) hydrodynamic model of Mike 21 has been applied to simulate wave height, run-up, and inundation along the southern coasts of Java, Bali, and NTB, generated by tides and the Cyclone Jacob during 2 – 12 March 2007 and by the Cyclone George during 3 – 9 March 2007 in northwestern coastal waters of Australia.The storm tide event was simulated by imposing tidal elevations at the open boundaries, winds, air pressure, and storm tracks. Tidal elevation data derived from TMD (tide model driver), while wind and air pressure data were obtained from NCEP (National Centers for Environmental Prediction). The weekly TOPEX Poseidon Sea Level Anomaly (SLA) was used to validate the model results of surge height.Highest surges along the southern coasts of Java, Bali, and NTB existed at Nusa Kambangan (Jawa; 19.0 cm), Tuban (Bali; 14.7 cm), Gumbang Bay (Lombok; 12.2 cm), and Labulawah Cape (Sumbawa; 12.5 cm). Maximum distances of storm tide flooding (R_{max}) and their associated run-up heights (H) occured at Penanjung Bay (Java; R_{max} = 835.2 m, H = 0.73 m), Tuban (Bali; R_{max} = 623 m, H = 1.02 m), Ringgit Cape (Lombok; R_{max} = 1112.3 m, H = 1.03 m), and Cempi Bay (Sumbawa; R_{max} = 4136.5 m, H = 1.0 m).The simulation carried out in this study is important for prediction of current fields and surge height distributions, especially for the areas susceptible to the impact of storm tide flooding such as the southern part of Java, Bali, and NTB coastal waters. It is hoped that the results of this present study could be significantly valuable for designing both proper management plans and investment policies in the coastal water areas.

Keywords: *storm surges, storm-tide, inundation, run-up, hydrodynamic model*

INTRODUCTION

Storm tides are the sum of the astronomical tides (the daily changes in water level due to gravitational interactions between the earth, moon and sun), the storm surges (the transient changes due to the effects of a storm), and long-term changes (sea level rise, seasonal and decadal changes), frequently causing losses of lives and substantial economic damages. Since coastal zones are at risk of storm tides, it is necessary to study crucial coastal zones affected by storm tide flooding, especially along southern coasts of Java, Bali, and NTB. Moreover, accurate estimation of maximum storm surge (MSS) and inundated (flooded) areas caused by storm tides are necessary, primarily from the view of flood protection.

Severe storm surges generated by tropical cyclone in the Indian Ocean have often hit the southern coasts of Java, Bali, and NTB. For example, during 16 – 19 May 2007 they were hit as a consequence of a massive storm with wind speeds greater than 35 m/s at the Cape of Good Hope (South Africa) on 9 May 2007 and in March 2008 they were battered by cyclone Nicholas.

As far as we know, storm tide investigation along the southern coasts of Java, Bali, and NTB are still limited, especially on the study of coastal zones vulnerable to the impact of storm tide flooding. Therefore, we are interested in studying influences of storm surges combined with the astronomical tide along the coasts of Java, Bali, and NTB. In this study, we only considered storm tides as the sum of the astronomical tides and storm surges. Hence, we neglected the influences of the long-term changes.

Estimations of surge height, water run-up height, and inundation areas due to the impact of tides and storm surges were carried out in this study by considering the Cyclone Jacob during 2 – 12 March 2007 and Cyclone George during 3 – 9 March 2007 in the northwestern part of Australian coastal waters as a generating force of storm surges and by using a barotropic hydrodynamic model (2D version of Mike 21 developed by DHI Water & Environment 2005).

NUMERICAL SIMULATION WITH STORM TIDE MODEL

The applied model is based on the finite volume method, which allows for a substantial flexible discretization of the model domain. An unstructured grid comprising of triangle or quadrilateral element was used in the horizontal plane (DHI Water & Environment 2005). The computational area was set from 2° 24' 16.5" – 24° 42' 33.8" S and 100° 33' 44.7" – 125° 38' 15.7" E, which covers coastal areas of southern parts of Java to NTB, and the Indian Ocean (as shown in Figure 1), and the grid sizes vary from ~ 50 km in the deep ocean to fine resolution of about 150 m in the coastal area. Since the present study focuses on the southern coasts of Java to NTB, the higher resolution of grid sizes in those areas is performed of about 50 m in order to include inundation processes in the model simulation.

The storm tide event, which was generated by tides, the Cyclone Jacob during 2 – 12 March 2007 (Figure 2a) with wind speed range about 10.28 – 35.98 m/s and Cyclone George during 3 – 9 March 2007 (Figure 2b) with wind speed range about 10.28 – 56.54 m/s, was simulated by imposing tidal elevations at open boundaries, winds, and air pressures.

The storm tide event, which was generated by tides, the Cyclone Jacob during 2 – 12 March 2007 (Figure 2a) with wind speed range about 10.28 – 35.98 m/s and Cyclone George during 3 – 9 March 2007 (Figure 2b) with wind speed range about 10.28 – 56.54 m/s, was simulated by imposing tidal elevations at open boundaries, winds, and air pressures.

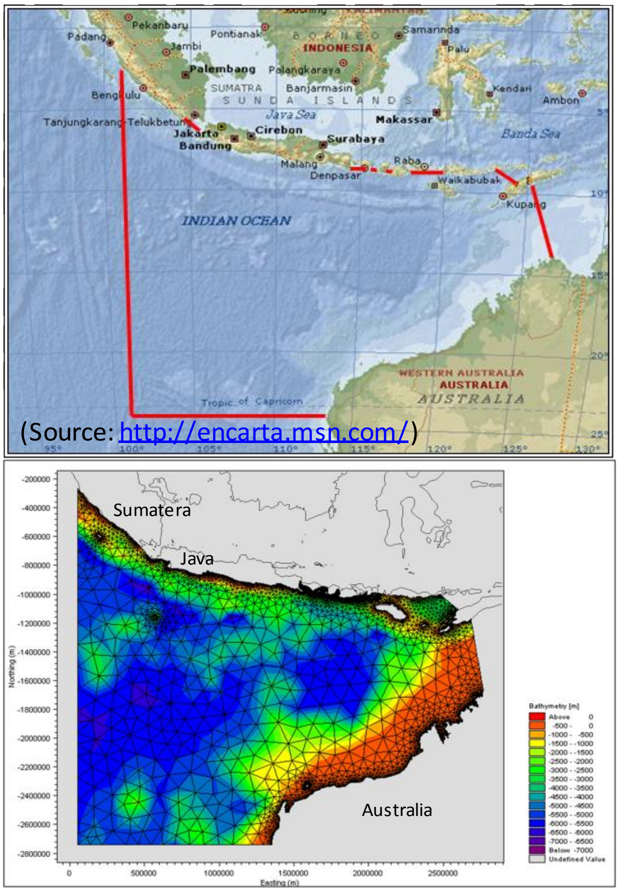

Figure 1 Computational domain, bathymetry (in m), and model meshes of the southern coastal waters of Java, Bali, and NTB, and the Indian Ocean

The tidal elevation data was derived from the tide model driver (TMD) of Padman and Erofeeva (2005). The TMD is a Matlab package for accessing the harmonic constituents, and for making predictions of tide height and currents. The tide model driver has 1/4° x 1/4° resolution and eight tidal constituents (M_2, S_2, N_2, K_2, K_1, O_1, P_1, and Q_1) and was used for predicting the tidal elevations at the open boundaries. We used 6-hourly wind and air pressure data with 2.5° x 2.5° resolution obtained from NCEP (National Centers for Environmental Prediction).

The applied model was run for 22 days (28 February – 21 March 2007), which covered the occurrence of both cyclones. Zero normal flow was applied to solid boundaries, while along open boundaries tidal elevation varying both in time and space were specified to accommodate tidal forcing and a radiation boundary condition was used for currents. When wind forcing was included, the tilt facility of the applied model has been used to improve the boundary conditions.

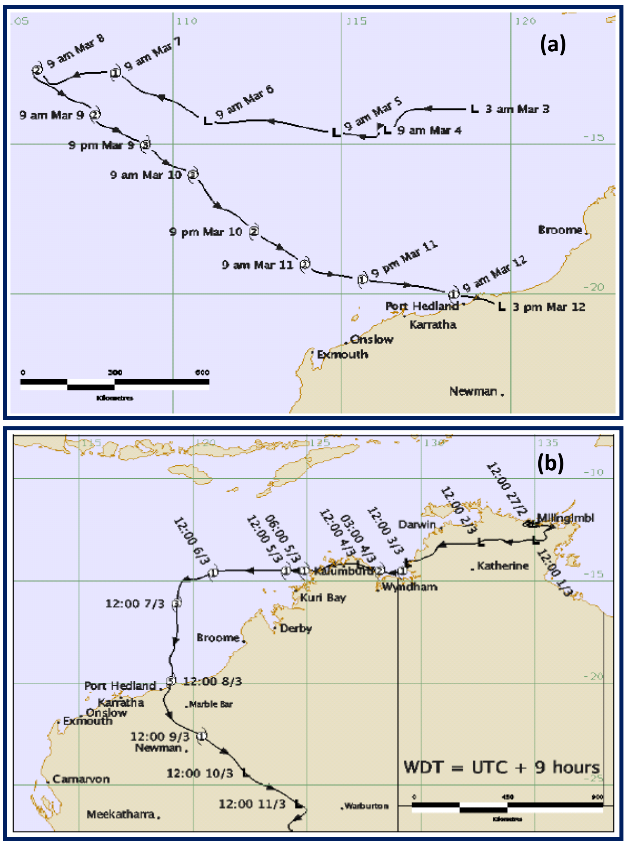

Figure 2 Depression tracks of: (a). the Cyclone Jacob during 2-12 March 2007 and (b). the Cyclone George during 3-9 March 2007

Source: http://www.bom.gov.au/announcements/sevwx/wa

Tilting provides a correction of water level at each point along the boundary based on the steady state Navier Stokes equations. A detailed description of this tilt facility can be found in DHI Water & Environment (2005). Further, flooding and drying (FAD) capabilities of the model were enabled to simulate water run-up and the inundation processes of storm tides caused by tides and both cyclones.

Bathymetry was generated using the 1 minute resolution GEBCO data (IOC, IHO and BODC, 2003). Topography was resolved using the 90 m resolution Digital Elevation Model (DEM) of the Shuttle Radar Topographic Mission (SRTM), (SRT, 2007). The parameterization of bottom friction is based on Manning's approach, with the ranges of friction coefficient *n* from 0.01 for smooth concrete to 0.06 for poor natural channels (Arcement and Schneider 1984). Since no other information of bottom friction is available along the computational domain, we used a constant manning number of 0.03125 $m^{-1/3}s$ as suggested by DHI Water & Environment (2005). Horizontal diffusion is needed for numerical stability. It is a Smagorinsky type with the Smagorinsky's constant = 0.28.

SIMULATION RESULTS AND DISCUSSIONS

Model Verification

Following Tkalich et al. (2009), we compared the simulated storm surges, obtained by removing the tidal part from the storm tide simulation, with weekly data of TOPEX Poseidon Sea Level Anomaly (SLA), (http://apdrc.soest.hawaii.edu). A sea-level anomaly is the difference between the total sea-level and the average sea-level for this time of year (Chambers 1988).

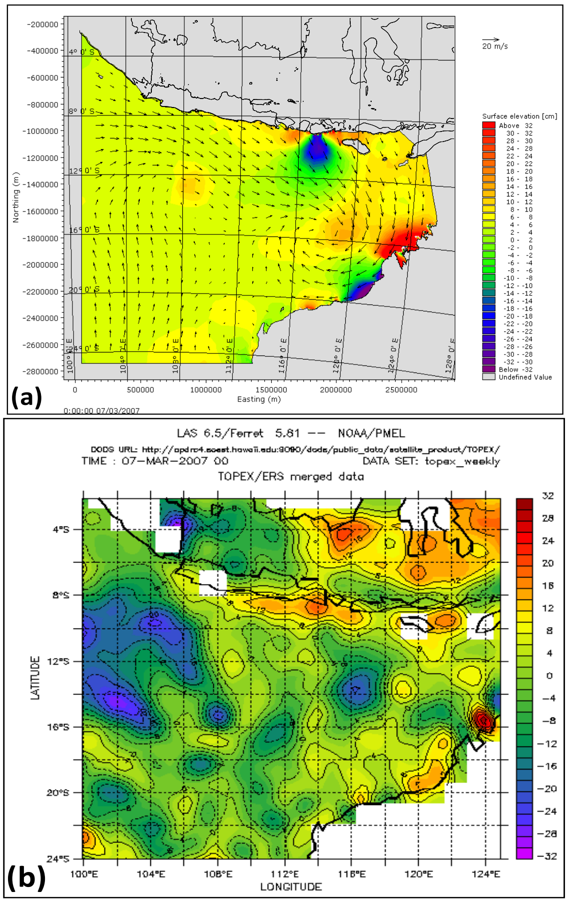

Figure 3 Validation of the computed storm surge height at 00:00 UTC on March 7, 2007. (a) Simulated results (in cm). Arrows indicate speed and direction of winds (m/s); (b). The TOPEX Poseidon SLA (in cm) (Source: www.apdrc.soest.hawaii.edu)

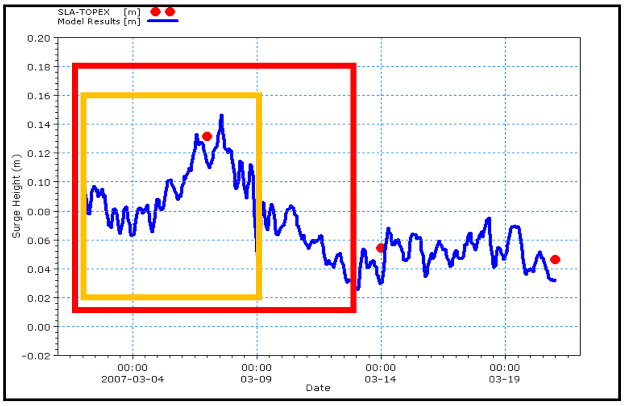

Figure 4 Validation of the computed storm surge height at 00:00 UTC on 7, 14, and 21 March 2007. Blue line (the simulation results); red dots (the TOPEX Poseidon SLA); red square (period of the cyclone Jacob); yellow square (period of the cyclone George), at Tuban (marked by 24 in Figure 6a)

Figure 3 shows validation of the simulated storm surge height with the TOPEX Poseidon SLA at the whole computational domain, whereas an example of the surge height validation at a station, such as at Tuban (marked by 24 in Figure 6a) can be seen in Figure 4. In general, storm surge heights obtained from the simulation show a good agreement with those of the TOPEX Poseidon SLA. It can be seen from Figure 6b that the storm surge generated by the cyclones Jacob and George attacked the southern coasts of Java, Bali, and NTB, and caused an increase in sea level up to about 19 cm. Sea level differences between the computed results and those of the TOPEX Poseidon SLA at 33 locations (marked by Points 1 – 33 in Figure 6a) are shown in Figure 5. Generally, the simulated surge heights are smaller than those of the TOPEX Poseidon SLA of about 0.03 – 5.20 cm.

Surge Heights and Inundation Areas

Figure 6a shows that there were 33 areas most affected by the storm surge generated by the Cyclones Jacob and George, namely: *a). along the southern coast of West Java:* (1). Tereleng Cape; (2). Panto Cape; (3). Layar Cape; (4). Pelabuhan Ratu-A; (5). Pelabuhan Ratu-B; (6). Cileuh Bay; (7). Ujung Genteng; (8). Cilauteureum Cape; (9). Gedeh Cape; (10). Parigi Cape; and (11). Penanjung Bay; *(b). along the southern coast of Central Java:*: (12). Citandui Bay; (13). Nusa Kambangan; and (14). Karang Bata Cape; *(c). along the southern coast of East Java:* (15). Pacitan Bay; (16). Dukuh Bay; (17). Tapen Bay; (18). Lengkosono Bay; (19). Pelindu Cape; (20). Bandialit Bay; and (21). Grajakan Bay; *(d). along the southern coast of Bali:* (22). Gilimanuk; (23). Candi Kesuma; and (24). Tuban; *(e). along the southern coast of Lombok:* (25). Kloto Cape; (26). Blongas Bay; (27). Gumbang Bay; and (28). Ringgit Cape; and *(f). along the southern coast of Sumbawa:* (29). Labulawah Cape; (30). Cempi–A Bay; (31). Cempi–B Bay; (32). Waworada–A Bay; and (33). Waworada–B Bay. Meanwhile, storm surge heights at those locations are shown in Figure 6b.

It can be seen from the Figure 6 that Nusa Kambangan (marked 13 in Figure 6a, as a part of Cilacap Regency) experienced the highest surge among the other stations, about 0.19 m, at 17:00 UTC on 7 March 2007. Meanwhile, Figure 7 shows the maximum storm surge height (MSSH) at the 33 locations (marked by Points 1 – 33 in Figure 6a), which are most prone to the impact of the storm surge generated by the Cyclones Jacob and George.

Figure 8 shows an example of the calculated heights of astronomic tide, storm tide, and storm surge at the Citandui Bay (marked 12 in Figure 6a). Based on the simulated results in this present study, it is found that the derived storm surge heights are of order of few centimeters (< 20 cm), so it seems that the Cyclones Jacob and George in March 2007 did not generate high storm surges along the coasts of Java, Bali, and NTB. Unlike the occurrence of high waves along the southern coasts of Java to NTB in May 2007, which was reported extensively in both electronic and print media, there were no reports on the presence of high waves along the coasts in March 2007. To reduce the large computational grid, we decreased the area of model domain. Therefore, the present study did not consider the storm surge generated by the tropical storm at the Cape of Good Hope (South Africa) in May 2007. As a preliminary study, we only considered tropical storms, which had tracts relatively near the southern coast of Java to NTB, such as the Cyclones Jacob and George in March 2007.

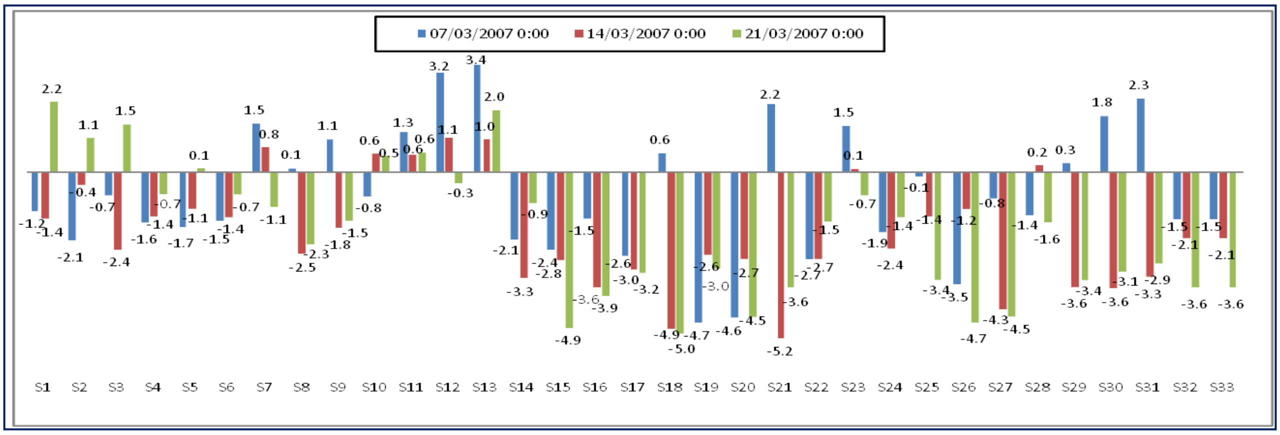

Figure 5 Sea level differences (in cm) between the computed results and those of the TOPEX Poseidon SLA at 00:00 UTC on 7, 14, and 21 March 2007 at the 33 locations (marked by Points 1 – 33 in Figure 6a)

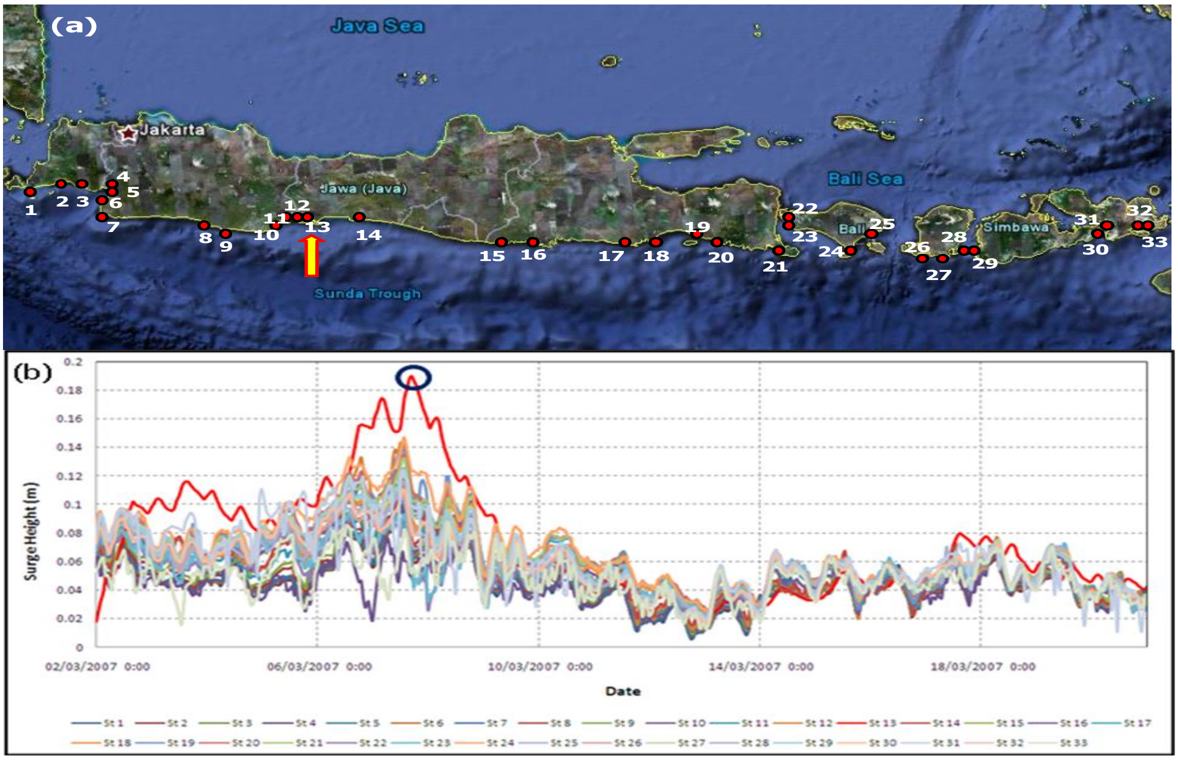

Figure 6 (a). Areas are most affected by the storm surge generated by the Cyclones Jacob and George, namely: (1). Tereleng Cape; (2). Panto Cape; (3). Layar Cape; (4). Pelabuhan Ratu-A; (5). Pelabuhan Ratu-B; (6). Cileuh Bay; (7). Ujung Genteng; (8). Cilauteureum Cape; (9). Gedeh Cape; (10). Parigi Cape; (11). Penanjung Bay (12). Citandui Bay; (13). Nusa Kambangan; (14). Karang Bata Cape; (15). Pacitan Bay; (16). Dukuh Bay; (17). Tapen Bay; (18). Lengkosono Bay; (19). Pelindu Cape; (20). Bandialit Bay; (21). Grajakan Bay; (22). Gilimanuk; (23). Candi Kesuma; (24). Tuban; (25). Kloto Cape; (26). Blongas Bay; (27). Gumbang Bay; (28). Ringgit Cape; (29). Labulawah Cape; (30). Cempi–A Bay; (31). Cempi–B Bay; (32). Waworada–A Bay; and (33). Waworada–B Bay. (b). storm surge heights at those locations (Figure 5a); the blue circle is the highest surge, occurred at the Nusa Kambangan (marked 13 in Figure 6a). Source of the map: Google Earth.

Table 1 shows detailed maximum horizontal distance of storm tide flooding, vertical run-up heights, and total water depth around the location of maximum inundation distance at 6 locations, which represent the areas at the western, central, and eastern parts of the southern coasts of Java, Bali, Lombok, and Sumbawa, namely Penanjung Bay (at the western part of Java, marked 11 in Figure 7), Karang Bata Cape (at the central part of Java, marked 14 in Figure 7), Pelindu Cape (at the eastern part of Java, marked 19 in Figure 7), Tuban (at Bali, marked 24 in Figure 7), Ringgit Cape (at Lombok, marked 28 in Figure 7), and Cempi Bay (at Sumbawa, marked 31 in Figure 7). Among the 33 locations in Figures 6a and 7, Cileuh Bay (marked 6 in Figures 6a and 7) and Waworada-A Bay (marked 32 in Figure 6a and 7) experienced minimum distance of storm tide flooding (table and figure not shown). An analysis of topography slope shows that the slope of topography may contribute to the distance of storm tide flooding. For instance, topography of the Penanjung Bay (marked 11 in Figure 6a) is gentle of about 0.044^{o} compared to that of the Cileuh Bay of about 0.148^{o}. This difference may contribute to the existence of distant storm tide flooding at the Penanjung Bay; whereas the steep slope of the Cileuh Bay decreases the amount of flooding.

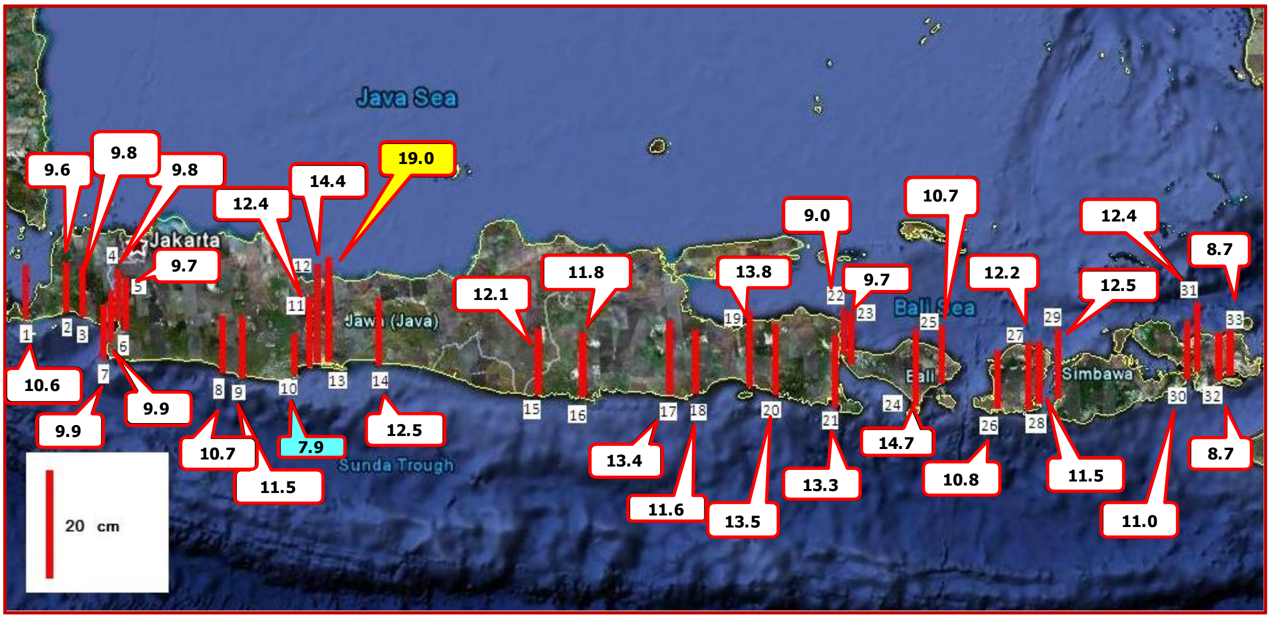

Figure 7 The maximum storm surge heights (in cm) at the 33 locations, which are most susceptible to the impact of the storm surge generated by the Cyclones Jacob and George in March 2007 (name of the locations mentioned and marked by Points 1 – 33 in Figure 6).
Source of the map: Google Earth

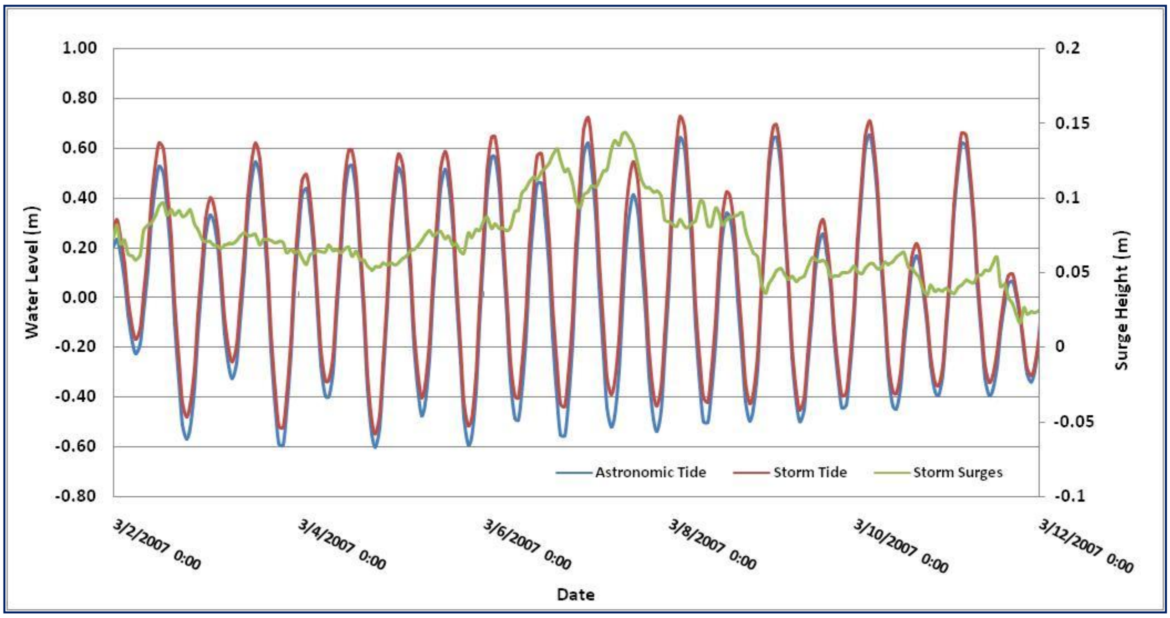

Figure 8 Astronomic tide, storm tide, and storm surge heights at the Citandui Bay (marked 12 in Figure 6a)

In this present study, the model results of surge height have been quantitatively and qualitatively verified with the TOPEX Poseidon SLA. In addition, the simulated results have shown the coastal areas of the southern coasts of Java to NTB which are most prone to the impact of high waves generated by tropical cyclones in the Indian Ocean.

The present simulated results of the most susceptible areas to the impact of storm surges are qualitatively similar to those reported in Kompas (19 Mei 2007) even though the considered tropical Cyclones Jacob and George in March 2007 and the tropical storm at Cape of Good Hope (South Africa) in May 2007 are markedly different. Kompas (19 Mei 2007) reported that the most prone areas to the impact of the big waves in May 2007 were the southern coasts of Cilacap and Kebumen where both areas are near the most susceptible areas to the impact of storm surge obtained from this study, namely Penanjung Bay, Citandui Bay, and Nusa Kambangan (near the southern coast of Cilacap, marked 11 – 13 in Figures 6a and 7, respectively) and Karang Bata Cape (near the southern coast of Kebumen, marked 14 in Figures 6a and 7).

Table 1 Maximum horizontal distance of storm tide flooding, vertical run-up heights and total water depth around the location of maximum distance of inundation

No.	*Stations*	*Run – up and Inundation (Flooding)*								
		Maximum Horizontal Distance of Inundation (m)			*Vertical Run-up at the Location of Maximum Distance of Inundation (m)*			*Total Water Depth around the Location of Maximum Horizontal Distance of Inundation (m)*		
		Storm+ Tides	*Tides*	*Storm*	*Storm+ Tides*	*Tides*	*Storm*	*Storm+ Tides*	*Tides*	*Storm*
West Java:										
11	Penanjung Bay	835.2	489.2	346.0	0.73	0.64	0.09	0.07	0.23	-0.16
Central Java:										
14	Karang Bata Cape	405.6	319.7	85.9	0.75	0.65	0.10	0.15	0.34	-0.19
East Java:										
19	Pelindu Cape	710.6	365.4	345.2	0.93	0.85	0.08	0.06	0.15	-0.09
Bali:										
24	Tuban	623.5	623.5	0.0	1.02	0.90	0.12	0.46	0.3	0.16
Lombok:										
28	Ringgit Cape	1112.3	1112.3	0.0	1.03	0.98	0.05	0.17	0.13	0.04
Sumbawa:										
31	Cempi Bay	4136.5	3874.3	262.2	1.10	0.90	0.20	0.14	0.09	0.05

The waves generated by the tides and cyclones attacked and inundated coastal areas of the southern coasts of Java to NTB. In the western part of the southern coast of Java, maximum distance of storm tide flooding existed at the Penanjung Bay (near Cilacap Regency, marked 11 in Figures 6a and 7), about 835.2 m with run-up height at the location of maximum inundation of about 0.73 m. In the central part of the southern coast of Java, the maximum distance of storm tide flooding reached about 405.6 m at the Karang Bata Cape (marked by 14 in Figures 6a and 7) with run-up height of about 0.75 m. In the eastern one, it occurred at the Pelindu Cape (marked by Point 19 in Figures 6a and 7) with the distance of flooding and water run-up height about 710.6 m and 0.93 m, respectively. In Bali, maximum distance of storm tide flooding existed at the Tuban (marked 24 in Figure 6a and 7), about 623.5 m with run-up height at the location of maximum inundation of about 1.02 m and in Lombok it occurred at Ringgit Cape (marked 28 in Figure 6a and 7) with the distance of flooding and water run-up height about 1112.3 m and 1.03 m, respectively. Meanwhile, in Sumbawa the maximum distance of storm tide flooding reached about 4136.5 m at the Cempi Bay (marked 31 in Figures 6a and 7) with run-up height of about 1.10 m (Table 1).

In Figures 9 and 10, we present examples of simulated inundation area and the total water depth along the storm tide inundated area at the Cempi Bay (marked 31 in Figures 6a and 7) and at the Grajakan Bay (marked 21 in Figures 6a and 7), respectively. In the Figures, the boundaries of the simulated inundation area after the storm tide event are shown as well.

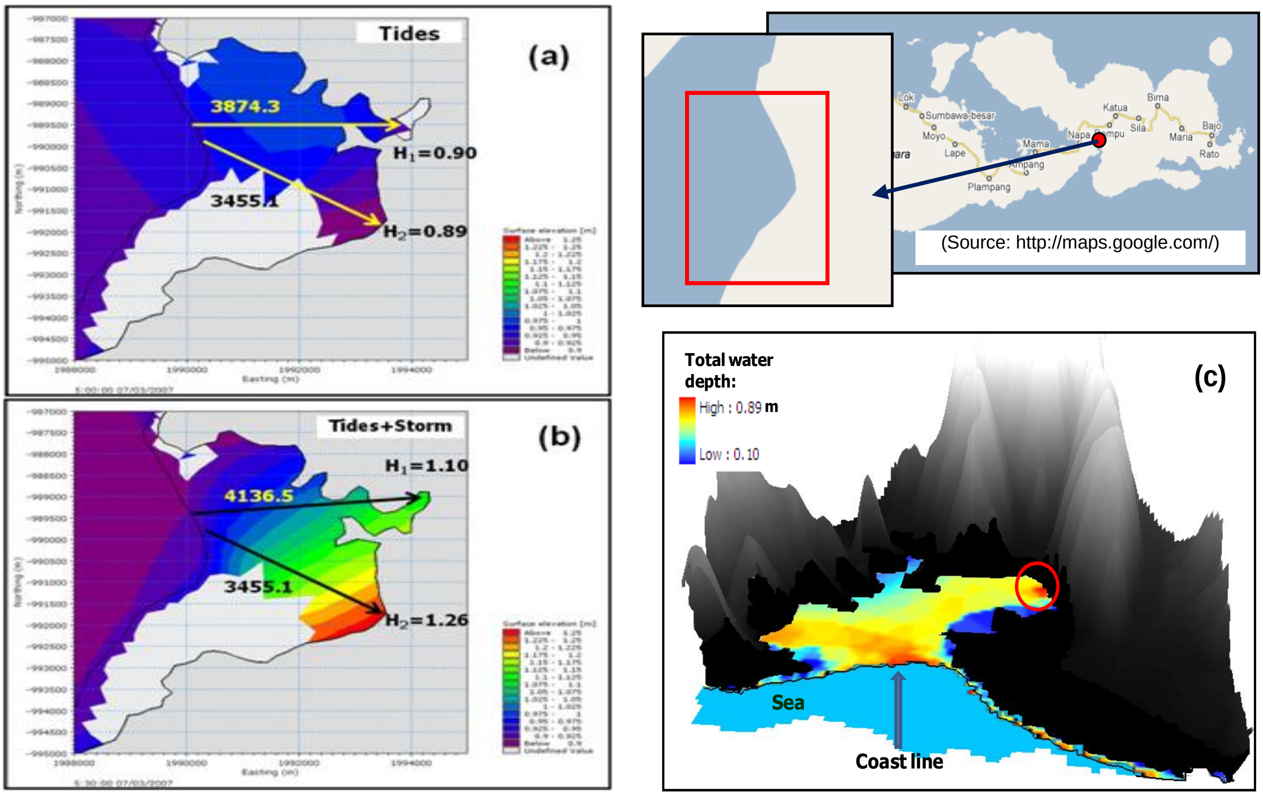

Figure 9 The simulated inundation area (distance and height of flooding, in meters) at the Cempi Bay (marked 31 in Figures 6a and 7), at 05:30 UTC on 7 March 2007. The figure shows topography contours of 0 and 3 m measured from the mean sea level (MSL); (a). Inundation area due to tides; (b) Inundation area due to storms and tides; and (c) Total water depth of the simulated storm tide inundation area (in meters)

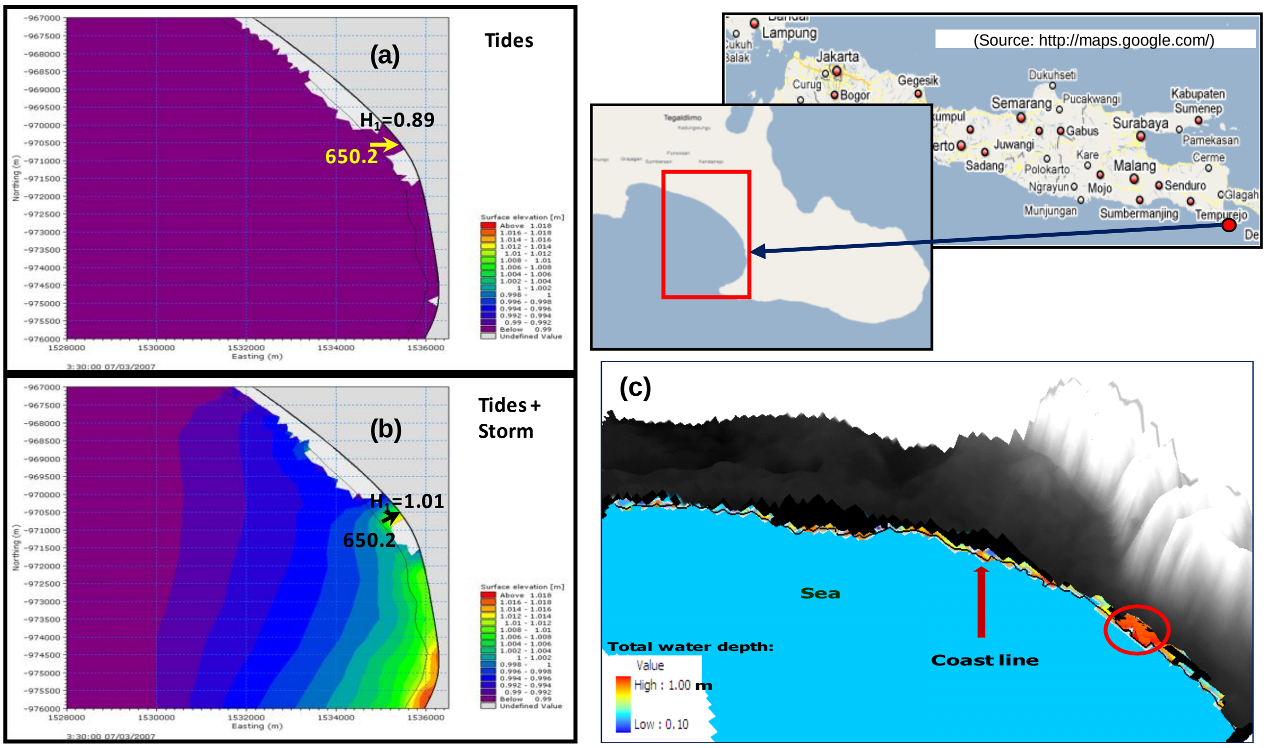

Figure 10 The simulated inundation area (distance and height of flooding, in meters) at the Grajakan Bay (marked 21 in Figures 6a and 7), at 03:30 UTC on 7 March 2007; (a). Inundation area due to tides; (b) Inundation area due to storms and tides; and (c) Total water depth of the simulated storm tide inundation area (in meters)

CONCLUSIONS

In this study, a 2D hydrodynamic model has been applied to simulate wave height, run-up, and inundation of storm tide along the southern coasts of Java, Bali, and NTB, generated by tides and the Cyclones Jacob and George in March 2007. The present simulated results showed that although the Cyclones Jacob and George in March 2007 did not generate high storm surges along the coasts of Java to NTB (surge heights < 20 cm), the coasts were still severely flooded. The highest surge existed at the Nusa Kambangan (a part of Cilacap Regency), about 0.19 m. Meanwhile, the maximum distance of storm tide flooding occurred at Penanjung Bay (in the western part of the southern coast of Java), the Karang Bata Cape (in central part of the southern coast of Java), the Pelindu Cape (in the eastern part of the southern coast of Java), Tuban (in Bali), Ringgit Cape (in Lombok), and Cempi Bay (in Sumbawa).

Storm tide investigation carried out in this study is important for simulation of current fields and surge height distributions, especially for the areas prone to the impact of storm tide flooding such as the southern coasts of Java to NTB. It is hoped that the results of this present study could be significantly valuable for designing both proper management plans and investment policies in the southern coasts of Java, Bali, and NTB.

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STRUCTURAL HEALTH MONITORING FOR CIVIL INFRASTRUCTURES USING WIRELESS SENSOR NETWORKS AND DISTRIBUTED PROCESING: OPPORTUNITIES AND CHALLENGES

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ABSTRACT

Civil infrastructures development grows rapidly. Health of the infrastructures requires to be monitored periodically. Manual monitoring is difficult and inefficient. Structural Health Monitoring (SHM) is a continuous-real time monitoring system of the civil infrastructure health. SHM conventional used cables as their media for transmitting data and power that cause high complexity and cost. Wireless Sensor Network (WSN) considered able to significantly reduce the problems, because it used a wireless data transmission and batteries mounted on each node for power supply. But, the designers must consider the limited resources of WSN (transmission bandwidth, processing capacity, and energy). Efforts to overcome the bandwidth are done by applying the distributed processing. The idea has been tried to investigate since about six years ago. But until this day, the WSN-based SHM is still far from realization. One reason was because the SHM's researchers come from various fields. They published their proposals on very various medias and forums; therefore the research was not focus. Objective of the paper giveS a direction for researcher to faster the realization of WSN-based SHM. Although closer to be implemented, several challenges still must be overcame such as how to prolong the network lifetime, limited processing capacity, and time synchronization. Our future research is to design the WSN architecture for SHM that has ability to overcome the problems. We will also develop an easy-used design software tool of the WSN-based SHM.

Keywords*: SHM*, *WSN, distributed processing*

INTRODUCTION

Along with community and economic development, civil infrastructures increase both in number and size. New infrastructures, buildings and bridges, are established with larger dimensions (bigger, longer, or higher) than before). The infrastructures are designed to use for a period of decades.

Maintaining safe and reliable civil infrastructures for daily use is important to the well being of all of us. Knowing the integrity of the structure in terms of its age and usage, and its level of safety to withstand infrequent but high forces such as overweight trucks, earthquakes, tornadoes, and hurricanes is important and necessary. The process of determining and tracking structural integrity and assessing the nature of damage in a structure is often referred to as structural health monitoring (SHM) (Chang, 2003).

Early identification and assessment of structural damage are necessary for ensuring that structures continue to meet life-safety standards over their operational lives. Structural monitoring systems consist of sensors installed in a structure, with response measurements communicated by coaxial cable to centralized data repositories where data are stored and processed.

Direct consequences of using cables to communicate sensor measurements to a centralized data repository are high system costs and labor-intensive installations (Lynch, 2006). The wiring problems can be reduced by a technology called *Wireless Sensor Networks (WSN)*. WSN, also called *smart sensors*, can significantly reduce the wiring problems because it uses a wireless media for data transmission and batteries mounted on each node for power supply. Illustration of comparison between traditional wired SHM with WSN-based SHM is shown in Figure 1.

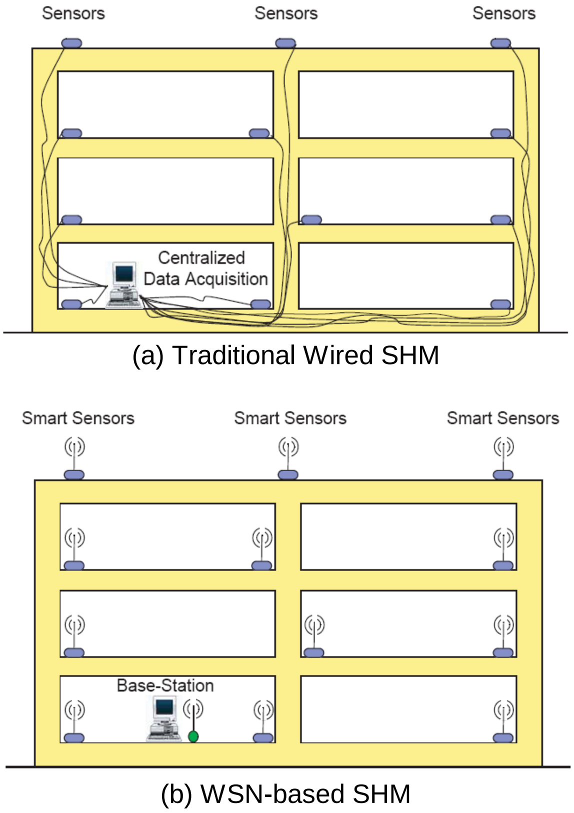

Figure 1 Illustration of traditional SHM and WSN-based SHM (Spencer et al., 2004)

However, a number of critical issues need to be addressed before this potential can be realized. Many researchers have been done towards the realization of WSN-based SHM. Many researchers from various regions of the world tried to contribute in the form of models, schemes, and algorithms to make the realization of the-WSN-based SHM be closer. In addition to reported progress, the researchers also noted the constraints they face. In addition to SHM's specific challenges, they must consider the limited resources of WSN (transmission bandwidth, processing capacity, and energy).

One significant challenge is that SHM applications always involve with a large amount of raw data. This large data, especially in centralized system, needs more power and bandwidth for delivering them to the processing center. In wireless, it is not a problem, but in WSN, which naturally, limited in power and bandwidth, it becomes a big challenge for implementation.

The majority of researchers believed that distributed processing or decentralized scheme for SHM can answer the problems above. This idea has been tried to investigate since about six years ago (Spencer, 2004). Some schemes have been proposed to realize it. But until this day, the WSN-based SHM is still far from realization.

One reason caused this condition happens was because the SHM's researchers come from various fields, i.e. civil engineering, mechanical engineering, electrical engineering, telecommunication, or computer sciences. They published their proposals on very various medias and forums, therefore the there were no coordination and made the research was not focus.

This paper tried to take inventory of research of WSN-based SHM has been done; their achievements and the constraints have been faced. Author investigated ten papers that proposed distributed processing schemes on WSN-based SHM, analyze their strengths and weaknesses, and gives alternative solutions for the challenges. Objective of the paper is giving a direction for researcher to faster the realization of WSN-based SHM. Author only investigated papers that proposed the scheme of WSN based SHM using distributed processing.

The survey methodology carried out in several stages. The first is to collect the relevant papers, and investigate the obstacles faced at the same time each researcher. Investigation of the existing paper is done for each aspect of WSN-based SHM with distributed processing. The next step is analysis of the achievements and the obstacles been faced. The author also tried to provide alternative solutions that may be applied to overcome.

Paper is organized as follows: Chapter II contains the general opportunities and challenges of SHM and WSN. This chapter is expected to give an early overview of research positions. Chapter III contains an investigation of the papers that presented each aspect. This chapter includes an inventory table. Chapter IV contains a comprehensive discussion of opportunities and constraints for WSN-based SHM, and gives alternative solutions for each challenge. Chapter V contains the conclusions and future research of the author.

GENERAL OPPORTUNITIES AND CHALLENGES OF WSN-BASED SHM

The principle of SHM is the process of implementing a damage detection strategy for aerospace, civil, and mechanical engineering infrastructure (Sohn, 2001). A *damage* of a structure defines as changes introduced into a system that adversely affects its performance

(Farrar et al.,1999).

As for civil engineering structures, changes in materials, connections, boundary conditions, etc., which caused deteriorated performance of the structure, can be defined as damage. For example, material aging usually reduces the load capacity of structural elements which leads to stress redistribution in the structure. This stress redistribution can result in loads that are substantially different from those expected based on the original structural design, potentially undermining the safety of the structure and even leading to its failure (Gao, 2005).

The basic idea of Damage Detection is that modal parameters (notably frequencies, mode shapes, and modal damping) are functions of the physical properties of the structure (mass, damping, and stiffness). Therefore, changes in the physical properties will cause changes in the modal properties.

Damage Detection has been investigated since about tens years ago. Many methods has been proposed with their strengths and weaknesses. Comprehensive reviews of damage detection and SHM have been done (Doebling, 1996; Sohn, 2001). Damage detect-ion also has been implemented on many infrastructures in some country using wired media SHM.

Wireless sensor networks (WSNs) have gained worldwide attention in recent years, particularly with the proliferation in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the develop-ment of smart sensors. These sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user. Smart sensor nodes are low power devices equipped with one or more sensors, a processor, memory, a power supply, a radio, and an actuator (Yick, 2008). A variety of mechanical, thermal, biological, chemical, optical, and magnetic sensors may be attached to the sensor node to measure properties of the environment. Since the sensor nodes have limited memory and are typically deployed in difficult-to access locations, a radio is implemented for wireless communication to transfer the data to a base station (e.g. a laptop, a personal handheld device, or an access point to a fixed infrastructure). Battery is the main power source in a sensor node. Secondary power supply that harvests power from the environment such as solar panels may be added to the node depending on the appropriateness of the environment where the sensor will be deployed. Depending on the application and the type of sensors used, actuators may be incorporated in the sensors.

General challenges of WSN are their limited resources, i.e. computation, power, and bandwidth transmission (Akyildiz, 2002). Additional problems for WSN if they were implemented for SHM are accuracy (minimum error/data loss), time synchronization, data-aggregation, and coordination inter-node to decide the damaged/undamaged condition (Spencer, 2004).

DISTRIBUTED PROCESSING SHM EMPLOYING WSN: PROPOSAL REVIEW

This chapter gives review of several aspects of distributed processing SHM employing WSN that has been presented by some researchers. Investigation is done to ten papers that partially or totally give contribution to realization of distributed processing SHM employing WSN.

Motivation

Almost researchers have been sure that distributed processing could reduce the amount of data rates from nodes to center (Mechitov et al., 2006; Gao et al., 2006; M.Wang et al., 2007; Zimmerman et al., 2008; Hackmann et al., 2008, 2010; Sim et al., 2009). Reducing the amount of rates will also minimize the power consumption (Gao et al., 2006; M. Wang et al., 2007; Zimmerman, et l. 2008; Hackmann, et al 2008, 2010). Distributed processing was also believed could enhance the reliability and robustness of the monitoring systems (X. Wang et al., 2006). The scheme also would improve response time of the systems (Mechitov et al., 2004).

Distributed Computing Strategy

Implementing distributed computing on WSN systems was needed a specific strategy due to the limited processing capability and capacity of the nodes. It’s very difficult if all processing tasks are done in the nodes. Designer should make partition of processing task between nodes and center.

Some proposed schemes have tried to applied this job sharing schemes (Mechitov, et al. 2006; X. Wang et al., 2006; M. Wang et al., 2007; Zimmerman et al., 2008; Hackmann, et al 2008, 2010; Sim et al., 2009) although almost of them, except Hackmann et al., not yet used a specific parameter (e.g. computation load, data rates, etc.) as indicator for task sharing. Hackmann et al. were analyzed the data flow parameter to get optimal partitioning between motes and base station (Hackmann et al., 2008).

Damage Detection (DD) Algorithms

Basically, SHM system is implementing Damage Detection (DD) algorithm on civil infrastructures (Sohn et al., 2001). Therefore, selection of the appropriate DD algorithms will affect the overall SHM performances. Research about DD has been done many years ago. The amount of literature related to damage detection is quite large. (Doebling et al., 1996).

The ten reviewed papers also vary in using the DD algorithms, but almost schemes used vibration-data-based DD algorithms, i.e.: *Damage Locating Vector - DLV* (Gao et al., 2006), *Distributed Damage Index detection – DDID* and *Collaborative Damage Index Detection – SDED* (M.Wang et al., 2007), *Damage Location Assurance Criterion – DLAC* (Hackmann et al., 2008), *Angles-Between-String-and-Horizon flexibility-based method -ASHFM and the Axial Strain flexibility-based method – ASFM* (Hackman et al., 2010). Only X.Wang implements Digital Damage Fingerprint (DDF) that used lamb-wave data.

To make a decision of damage or undamaged, each algorithm need parameters which cannot be obtained directly from sensors. Clearly, an intermediate process should be presented to convert raw data from sensors into parameters that be needed by the algorithm. The intermediate processes, also called parameter identification, become integrated part of DD processes.

Some parameter identification methods were proposed in the papers in accordance with the selected DD algorithm. DLV exploited the singular value decomposition of the difference of flexibility matrices of structures at the sensor location, before and after damage. To get the matrices from vibration data, several steps must be done. First, obtaining auto and cross-correlation functions from measured data. The functions then become input of the *NExT & ERA* algorithms to get modal parameters. The modal parameters were normalized to have a unit magnitude. The normalized parameters were used to count undamaged normalized constants. Finally, the flexibility matrix could be obtained after undamaged normalized constants were found (Gao et al., 2006)

Other parameter identification methods that are potentially implemented on distributed processing are Peak Picking (PP), Frequency Domain Decomposition (FDD), and Random Decrement (RD) Method (Zimmerman et al., 2008). The three methods above converted vibration data into parameters that had close relation with *frequency response functions (FRFs)* of the structures. PP obtained the parameters by Fast Fourier Transform (FFT) and followed by PP process. The FDD contained two process, FFT and *singular value decomposition (SVD)*. The RD methods converted data from sensors into frequency domain by FFT. After irrelevant data filtered out, the remaining data was taken back to the time domain using IFFT. After that, RD process was done for each window. Finally, zero crossing and logarithmic decrement technique were employed to automatically extract modal frequency and damping information.

Distributed processing performances to reduce data rates for the three methods are presented in Table 1 (Result for 20 nodes with 4096 data points).

Table 1 Comparison data rate transmission centralized and decentralized

Method	Bytes	Reduction (%)
Centralized	170880	100%
Decentralized PP	2128	1,25%
Decentralized FDD	7264	4,25%
Decentralized RD	1216	0,71%

Source: Zimmerman et al. (2008)

DLAC algorithm could be decomposed into four stages, which summarized in Figure 1 (Hackman 2008). Sim et al., (2009) combined local feature extraction and determination of global modal properties in their proposal. The first step exploited NexT and ERA. The second was obtaining the global properties that actually the union of the normalized local ones.

The ASHFM and ASFM were two flexibility-based damage detection methods that used natural frequency and mode shapes as their inputs (Hackmann et al., 2010). To get these parameters, Frequency Domain Decomposition (FDD) that contained five stages was exploited. The five stages are: Data reading by sensors, FFT, Power Spectrum analysis, Computing Cross Spectral Density (CSD), and Performing Singular Value Decomposition (SVD).

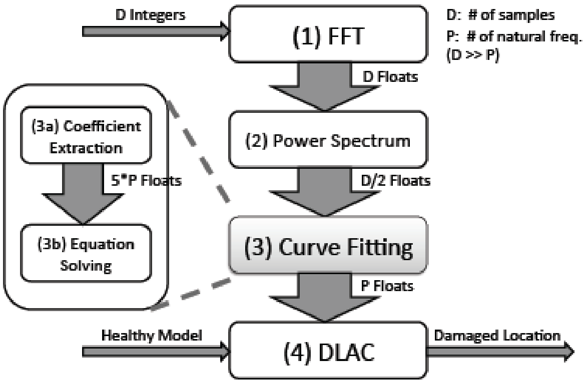

Figure 1 DLAC algorithm process

Structures Model for Analysis

In order to make analysis process more realistic, almost researchers used a specific structure as example. Several types that frequent used were: *truss structure* (Gao et al., 2006; Hackmann et al., 2008; Hackmann et al., 2010), *plate structure* (X. Wang et al., 2006; Zimmermann et al., 2008; Sim et al., 2009), *story building* (Mechitov et al., 2004; M. Wang et al., 2006), *beam cantilever* (Hackmann et al., 2008; Hackmann et al., 2010) and Long Span Bridge (Pakzad et al., 2008).

The type of structures also even affects the overall system design. Gao et al. has designed detail of their distributed computing strategy (DCS) based on the truss structures as shown in Figure 2. Almost rule in the community development stage on the strategy was associated with the truss structures. Mechitov et al. has used different number of story for different experimental sets.

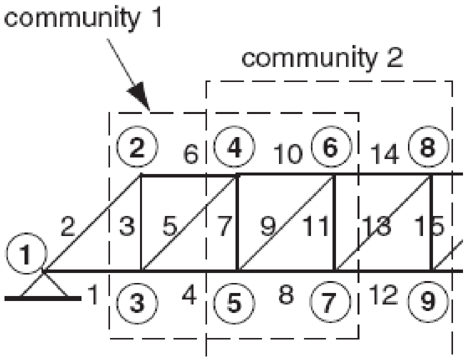

Figure 2 DCS Strategy on Truss Structure
Source: Gao et al. (2006)

Network Topology

One crucial aspect on the design of WSN system is network topology. Network topology is defined as the physical interconnection of the various elements (links, nodes, etc.) of a network. Network Topologies can be physical or logical.

In centralized system, topology that commonly used was star topology, where each node directly connected to the center. But, in decentralized one, hierarchical or clustering was common used. Although almost proposed distributed computing SHM schemes used same topology, in detail they were different.

Cottapalli et al. has proposed clustering topology that partitioned into two subsystems, therefore also called two-tiered network. The first subsystem consisting of a low data rate, low transmission range, energy constrained sensor units and the other subsystem consisting of high data rate, large transmission range coordinator units that are not energy constrained (Cottapalli et al., 2004).

Gao et.al presented hierarchical topology with coordination between head (called manager sensors) as shown in figure 3. The coordination links were pressented associated with damage detection algorithm that used. Really, in the proposed approach, each sensor could participate in multiple communities (Gao et al., 2006).

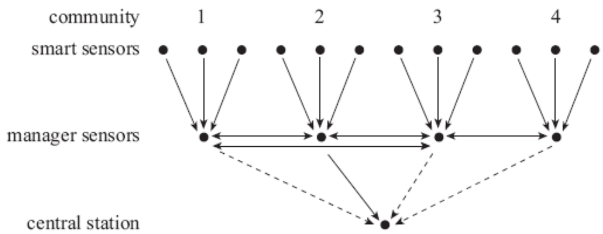

Figure 3 Hierarchical topology with coordination
Source: Gao et al. (2006)

M. Wang, et al. and Zimmermann et al. that facilitated DD algorithms that selected also presented additional links between sensors in hierarchical topology. In other hand, overlapping clustering also proposed by Sim, et al. as shown in Figure 4.

Multihop topology sometimes could be used if the physical structure needed, as presented by Zimmermann et al. and Pakzad et al. Pakzad used multihop because he arrange his sensor inline from right to the left.

Testing Instruments and Parameters

To validate their proposal, almost researchers used either computer simulation or miniature model. The common simulation tool was MATLAB (Gao et al., 2006; Hachmann et al., 2008, 2010; Sim et al., 2009). Another simulation was Power-TOSSIM (M. Wang et al., 2006). Miniature model or emulation was a prototype that instrumented with real devices. WSN nodes often used are Crossbow's Micaz or imote2 (Mechitov et al., 2006; M. Wang et al., 2006; Zimmernann et al., 2008; Hackmann et al., 2008, 2010). Two tests were done in real infrastructure, i.e. Theatre balcony (Zimmermann et al., 2008) and Main Span of Golden Gate bridge (Pakzad et al., 2008).

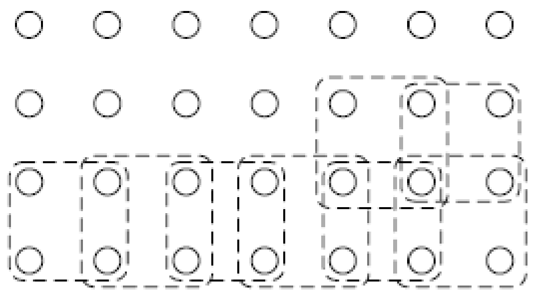

Figure 4 Overlapped clustering
Source: Sim et al. (2009)

To claim that their experiments were successful, researcher used various performance parameters. The most used parameter is modal identification result (Gao et al., 2006; X. Wang et al., 2006; M. Wang et al., 2007; Zimmerman et al., 2008; Pakzad et al., 2008; Hackmann et al., 2008, 2010; Sim et al., 2009). Another parameters are power consumption (M. Wang et al., 2007; Hackmann et al., 2008, 2010), latency (Pakzad et al., 2008; Hackmann et al., 2008, 2010), and time processing (Mechitov et al., 2006).

DISCUSSIONS

From review in previous chapter, we can see that all researchers agree that distributed processing was the best way to reduce the communication cost that means save energy consumption. Distributed processing, also called decentralized scheme, moved the tasks of processing data, partially or totally, from center to the nodes. Therefore, the information that sent to center is processing results that logically more compact than raw data from sensor.

In other hand, distributed processing gives more processing load to the nodes, which have limited power and processing capacity. Therefore, except Gao's, all the schemes in the proposal above applied the partial distributed processing due to limitation of WSN nodes. But, only Hackman et al. were investigated the optimization of partitioning processing between node and center. Hackman make optimization based on data flow on each stage of processing. To prolong the lifetime of the node, we must extend the optimization of partitioning processing based on data flow, power consumption and decision accuracy.

The scheme of distributed processing is depend on Damage Detection (DD) algorithm that used. Although almost used vibration data, the damage detection algorithms that used in above proposals were varied. Therefore, it's very crucial to make a comparison among entire DD algorithms and choose the most suitable one for distributed processing.

Another aspect that improves the network performance is topology of the network. Tree/clustering was a common-used topology because it was the most suitable for distributed computing. But, in the existing paper above, exploitation of cluster parameters were still inadequate. Only Kim et al. (2009) made a performance comparison of the monitoring due to the size of cluster. Whereas, researcher can maximize performance of the system by optimize the parameter of the cluster, i.e. size, dimension, density, choosing the clusterhead, etc. We also can implement dynamic clustering (Abbasi 2007).

Sleep scheduling also need more attention to prolong lifetime of the network. Hackman et al. (2010) proposes an interesting scheme of sleep scheduling that can be exploited deeply.

The testing environment is another challenge for SHM designer. It's impossible to test the performance of damage/damage detection on real infrastructures, because we can't wait until the infrastructures got damaged. Almost researchers used computer simulation or miniature model to validate their proposal. It's very important for us to have a tool that easy to use, and represents the real condition.

CONCLUSIONS

Although closer to be implemented, several challenges still must be overcome. Some challenges are: optimization of partitioning processing between node and center, choose the most suitable damage detection for distributed processing, optimization the parameter of the cluster, Sleep scheduling, and design of testing tool.

Our future research is to design the WSN architecture for SHM that has ability to overcome the problems e.g. how to prolong the network lifetime, limited processing capacity, and time synchronization. We will also develop an easy-used design tool, e.g. Matlab models, of the WSN-based SHM.

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APPENDIX

Table 1. Summary review of distributed process

	Distributed Processing Strategy	**Damage detection Algorithm**	**Experi-mental Structure**	**Network Topology**	**Testing In-strument**	**Test para-meter**	**Others**
Kottapalli-2003	none	none	None	Two-tiered clustering	Prototype WSN (2 clus-ter, each clus-ter contain 2 sensor + 1 coordinator)	None	Numer-ical es-timation of pow-er con-sump-tion and lifetime
Mechitov – 2006	Data aggrega-tion : mean, median, extre-ma, zero-crossing & peak detection	none	3 and 18 story build-ing model	Star (cen-tralized)	Mica2	1) Time processing 2) sensor precision	
X.Wang-2006	Multilevel deci-sion	DDF (digi-tal damage fingerprint)	CF/EP composite plate	Hierarchy/ Tree	Piezoelectric active sensor	Pattern	Not de-signed for WSN
Y.Gao-2006	Local decision with communi-cation between cluster	Damage Locating Vector (DLV)	14-bay planar truss	Hierarchy (Tree)	Matlab (finite element)	Normalize cumulative stress	
M.Wang-2007	Local as candi-date (DIDD) and upper for over-lap / multiple damage (CDED)	DDID & CDED	5-story building under seismic excitation	Two-tier system	1) Emulation w/Mica 2) Simulation w/ PowerTos-sim	1) Damage Index 2) Power consumption 3) Time	
Zimmerman-2008	Local processing (pa-rameter send to center)	PP, FDD, RD	Theater balcony	Multihop (conce-nated) with 3 scenario	Crosbow CXL02 on real theater balcony struc-ture	Modal identi-fication re-sult	
Pakzad – 2008	none	Power Spectral Density (PSD)	Main span of Golden Gate Bridge	Multihop (conce-nated)	56 node Mi-caZ on Gol-den gate structure	1) modal shape 2) loss rate	Band-width efficien-cy
Hackmann – 2008	Partitioning be-tween local and central using op-timization ener-gy	Damage Location Assurance Criterion (DLAC)	1) Canti-lever 2) truss	Star	Emulation (Imote2) + Java App. + Matlab	1)Natural frequency 2)memory capacity 3)Energy consumption 4) lifetime	Optimi-zation of task parti-tioning
SH.Sim – 2009	Local feature extraction and global decision	Eigensys-tem reali-zation (ERA) / Natural Excitation technique (NexT)	Plate	Clustering w/ fix plac-ing	MATLAB	Accuracy (Error) of natural fre-quency	Three scena-rio of cluster-ing
Hackman-2010	Two step: 1) Global searching 2) Intensive identification	Flexibility Matrix based	1) Canti-lever 2) Truss	Star	Emulation (Imote2) + Java App + Matlab	1) damage localization 2) latency 3) energy cost	

PROBLEM AND CHALLENGE OF RIVER AS WATERWAYS IN EAST KALIMANTAN

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ABSTRACT

Busang is a remote area and a part of sub district of Kutai Timur Regency in East Kalimantan. This area has been isolated by lack of infrastructure. People can go to Busang area through roadway and waterway. In order to understanding many problems of transportation in Busang area especially on waterway, a research was conducted in Busang. In this research, data were obtained using the direct observation and the structured interview. At present, the use of ships for carrying passengers and goods has been decreased. These problems are caused by the efficiency of travel cost by ship lower than by vehicle and also travel time by ship is longer in comparison with vehicle. Up to present, the river transportation is exist and used both a shorter trip and for carrying fuel oil. For a shorter trip, the small-sized ships are used by people go to their farm. The travel cost of ship especially for fuel oil from Samarinda to Busang area is IDR 360 per liter. In the future, the Atan River as waterway in Busang area has a big problem due to the massive conversion from forest to palm plantation and opening coal mining will reduce the water resources into river. This waterway can be maintained with controlling the water conservation at the upstream area of the Atan River by reforestation and managing an echo-friendly palm plantation, and a good monitoring for the activity of coal mining.

Keywords: *waterway, busang, east Kalimantan, travel cost, river Atan*

INTRODUCTION

Busang area is one of 18 sub districts of Kutai Timur Regency in East Kalimantan. The location of this remote area is N 00^0 $49^{'}$ $35^{''}$ and E 116^0 $33^{'}$ $13^{''}$. Sub district Busang consists of 6 (six) villages and its number of population is 5.971 people [1]. The travel length is approximately 225 km north of the coastal city of Samarinda and its area is about 3.722,16 km square.

The geo morphology of Busang area is a hilly area and at this area is available a river, namely the Atan River. There are enormous potential natural resources at this area such as coal, gold, and other minerals [2].

Busang area was a rainforest area and recently this area has been changed to become an agricultural area and one of the upstream areas of the Mahakam River. The majority of people who live at this area are farmers. They plant rice paddy, and recently many farmers try to plant the natural rubber trees. The lack of infrastructure particularly on the electrical power and the road network causes living cost is relatively high due to accessibility to this area from Samarinda and Tenggarong is difficult. This problem causes Busang area to become an isolated area especially in the rainy season due to vehicles cannot pass many locations. These locations become a heavy-muddy road because of a non-permanent road.

The majority of people who live in Busang are the Dayak Ethnic. The availability of the Atan River has an enormous amount of value to them due to this river can be used as waterway, water resources for drinking, bathe, toilet, dresses washing, and sources for food, such as fishes.

In 30-years ago, Busang area was the rainforest area. The illegal logging and the activity of many rainforest-based companies had caused this area changed to become the critical deforest area. At present, a part of this area has changed to become palm plantation area. The location of Kutai Timur Regency and of Busang on the East Kalimantan Map are showed in Figures 1 and 2.

Figure 1. Kutai Timur on map of East Kalimantan

Figure 2. Location of research in Busang area East Kalimantan [4]

In 2010, coal mining will be operated in Busang area. In general, mining activities also result in serious consequences for the environment and society–locally and globally. Problems have resulted from land clearance, particularly in the case of strip coal mining, processing, or waste products that many mines produce (see Figure 3). Mining destroyed natural habitats, polluted the air, soil and river [3].

Kutai Timur Regency is a region where has an enormous natural resources such coal and gas methane. Recently, there are many bigger coal-mining companies in various locations (see Figure 4). These coal mining produce about 50 million tons per year. At present, the activity of coal mining is explosively increasing and area of rainforest will decrease in a massive scale. Recently, many coal-mining areas are available at the upstream area of rivers. Decreasing the area of rainforest will decrease the deposit of water that flows into river.

Figure 3. Strip in coal mining

Figure 4. Coal mining activity in Kutai Timur

Many activities of coal mining created many problems to population settlements where is near location of coal mining. These problems cover dust and vibration due to blasting. The vibration has damaged many houses which were made of concrete. Former of many coal mining created a big hole that filled by acid water.

WATERWAY

The Atan River is average 100 meters wide and 6 meters depth in dimension. The profile of this river is U and V. This river consists of 6 (six) tributary rivers, including the Puh River, the Metumbung River, the Temengung River, the Menyu River, the Penjet River, and the Kelinjau River. The Atan River and other river such as the Telen River united in Muara Ancalong area. From Muara Ancalong area, the united river flows into the Mahakam River. In other words, the river from Muara Ancalong area is part of the Mahakam River.

The Atan River has a significant contribution to people who live at population settlements in Busang area. In other words, the existing of this river is the essentials to everyday life for people who live at this settlement. People use the Atan River not only waterway (Figure 5) and toilet (Figure 6) but also as water resources for drinking.

Figure 5. The Atan River as roadway

Figure 6. Toilet on the Atan River

In its history, the Atan River was waterway for shipping goods and passengers from Samarinda to Busang area. Based on this reason, a river plays a big role as infrastructure in transportation sector. On the same reason, all population settlements in the Busang area were traditionally built at the riverside (Figure 7).

Figure 7. Population settlements at the riverside

The Mahakam River is the downstream and the Atan River is as one of its upstream areas. The size of river added from upstream to downstream. The research for waterway has taken place from Samarinda to Busang, especially from Samarinda to Long Nyelong village. In general, waterway has used by farmers as infrastructure of transportation from their settlement to paddy field (Figure 9) and for carrying goods and fuel oil and goods from Samarinda to Busang area (Figure 10).

Figure 9. Using small-sized ship

Figure 10. Using medium-sized ship

Busang area is similar an island and this area can be accessed through roadway. The lack of infrastructure, such as the bridge on the Atan River is not available, causes Busang to become an isolated area. Vehicles cannot go directly to Busang area due to Busang area is surrounded by the Atan River. As replacement of bridge is a ship that crosses vehicles and a wood-constructed bridge which connects a village with a riverside of the Atan River (see figure 11).

The bridge was made of a local wood. This wood is not rotten in water and also has a natural protection against pest. The size of bridge is about 2 meters wide and its length depends on the length of bridge from village to riverside.

Figure 11. A wood-based bridge from village to river

Figure 12. Preparation to crossing a vehicle

The wooden-constructed bridge is able to carry 3 tons of an object on the bridge. After crossing this bridge, there is the ship services which can cross a vehicle from a village in Busang area to other riverside of the Atan River (Figure 12).

Up to present, all rivers for shipping goods and passengers in any countries have been reduced [5]. In the similar situation also occurred for shipping goods and passengers in Busang area, where the river as waterway has no prospect for shipping goods and passengers due to developing roadway which was built by many companies such as logging-based and palm plantation companies. In other words, recently transport cost of roadway is more efficient than waterway (Figure 13).

The disadvantage of non-permanent road is the heavy-muddy road surface occurred in the rainy season. In this condition, many vehicles cannot pass at various locations due to the surface of roads enveloped in mud and its depth is about 1 meter (see Figure 14).

Figure 13. Access to Busang area through roadway

Figure 14. A bad-condition surface of road

An impact of global warming on weather and a massive deforestation was caused the time period of the rainy season shorter and the dry season longer. The massive deforestation creates shallowness and reduces water resources to the Atan River. This caused a medium-sized ship cannot ship to Long Nyelong village especially in the dry season. The other impact of global warming is on the irregular-high intensity of the rainfall which causes flood on an irregular time (see Figure 15).

Figure 15. An irregular flood of the Atan River

In addition to causing the flood and shallowness, the effect of the massive deforest on the Atan River is the rate of flow lower and its water content a lot of lump especially in the rainy season. This river is not only used as waterway for carrying fuel oil and goods but also as transportation media for logs (Figure 16) and woods (Figure 17). The movement of logs on the river will endanger ships on the Atan River.

Figure 16. Movement of logs on the Atan River

Figure 17. Timber transport by small-sized ship

The other impact of shallowness on the Atan River is the depth of this river lower that causes the medium-sized ship cannot ship directly to Long Nyelong village because of the depth of the Atan River do not meet the standard requirement for shipping.

METHOD

In this research, method that used was a direct observation from the downstream of the Atan River to Long Nyelong village and semi-structured interviews to users who use the ship services of small- and medium-sized ship. Users who use services of both small- and medium-sized ship were interviewed, and the interviewer explained the purpose of the research and the tools of research for the respondents.

The interview has taken place at location of transfer point such as river port at riverside of Pulau Sentosa village and when small- and medium-sized ship had activities for loading and unloading. The direct interview was also done for crews and owners of ship so that data from the users of ship can be checked its validity. These data cover capacity of small- and medium-sized ship and transport cost for shipping fuel, and also their opinion about the future of river transportation in Busang, and information of waterway.

These data cover capacity of ship, transport cost, travel time for carrying fuel oil from Samarinda to Busang area. The average of transport cost of fuel oil was used in calculation. This research had taken time one week long at Busang area, from 22-26 February 2010.

Transport Cost of Fuel Oil

In general, fuel oil is transported by ship from Samarinda to Long Nyelong village with transfer point at Sentosa village. Fuel carried from Samarinda to Long Nyelong village by medium- and small-size ship. It starts shipping firstly by medium-sized ship from Samarinda to Sentosa village. At Sentosa village, there is a location of transfer point from medium- to small-sized ship. The transport cost of fuel oil is showed in this equation.

$$TC_{cf} = \frac{T_{mc}}{C_{mc}} + \frac{T_{sc}}{C_s}$$

where

TC_{cf} = transport cost of fuel (IDR/liter)

T_{mc} = cost of medium-sized ship (IDR)

T_{sc} = cost of small-sized ship (IDR)

C_m = capacity of medium-size ship (liter)

C_s = capacity of small-sized ship (liter)

In the above-mentioned equation, the capacity of medium-sized ship is 200 drums (1 drum = 200 liters), and small-sized ship has capacity of 20 to 25 drums. In general, fuel oil is carried from Samarinda to Busang two times per month.

RESULT AND DISCUSSION

Up to present, fuel oil is carried through waterway based on two reasons; firstly, the travel cost to carry fuel oil by medium-sized ship is lower than by vehicle and secondly, vehicle has a big risk for carrying fuel oil due to the bad condition of road surface at various locations.

Travel Time

In general, a medium-sized ship cannot directly ship until Long Nyelong village from Samarinda due to shallowness on the Atan River that flows into Sentosa village. Except in the rainy season, especially downpour in hours, this ship can ship until Long Nyelong village. In other words, a medium-sized ship could carry fuel until Long Nyelong if the depth of this river meets a standard requirement for shipping. In fact, fuel oil is transferred again to small-sized ship at location of transfer point at riverside of the Atan River in Sentosa village.

The result of the interview shows that up to present, the waterway is used for shipping fuel oil and goods. For carrying fuel oil and goods, the travel time of a ship from Samarinda to Busang area is about 17 hours. Although there is roadway, up to present, waterway is exist for carrying fuel oil (Table 1).

Table 1 History of river transportation in Busang

Information	Waterway
Before	Goods + passenger
At present	Fuel (majority) and goods
Size of ship	Small-sized ship (up to present) medium-sized ship (at present)
Travel time (hour)	17 hours
Travel length (km)	-

The problem is the number of medium-sized ship is limited. In other words, a medium-sized ship is only available one ship for carrying fuel oil and goods from Samarinda to Busang and from Busang area to Samarinda. The other problem will creates if demand for carrying of fuel oil and goods because of the growth of economy at this area.

Transport Cost

Normally, a medium-sized ship can carry fuel oil from Samarinda to Busang with capacity of 200 drums. Fuel is carried by this vehicle to location of transfer point at riverside of Sentosa village. From this transfer point, fuel is carried agein by a small-sized ship with capacity of 20-25 drums. In order to reduce the transport cost of fuel oil, many owners of a small-sized shops at Long Nyelong village buy fuel oil at transfer point and they carrying fuel oil again by their small-sized ship with capacity of 2 drums. Data and calculation of travel cost of the ships are showed in table 2.

Table 2 Fuel oil transport cost

Mode	Capacity (drum)	Price / ship (IDR)	Cost/liter (IDR)
Medium-sized ship	200	2,400,000	$(T_{sc}/C_s) = 60$
Small-sized ship	25	1,500,000	$(T_{mc}/C_m) = 300$

Transport cost of fuel oil from Samarinda to Busang area (TC_{cf}) is IDR 360 per liter. At present, the price of diesel fuel and gasoline in Busang area is IDR 7,000/liter. The common price of diesel fuel and gasoline is IDR 4,500/liter. It means that the cost of transport of oil fuel through waterway has a significant effect on the price of oil fuel in Busang.

The Future of the Atan River

The sustainability of the Atan River as waterway for people who live at population settlements in Busang area has been threatened owing to the massive conversion from rainforest to the palm plantation and to coal mining. In addition to reducing the amount of water that flows into the Atan River especially at the upstream area, all palm plantations will also need enormous water. Both deforest and a huge consume of water will reduce an enormous amount of water to the Atan River. The other impact of the existing of palm plantations and coal mining is the flood and the high flow of the river of the Atan River especially in the rainy season. In this season, the river carried also a toppled tree from the upstream area. In addition to waterway, this river is used for carrying logs from a forest area. The existing of logs on this river is very danger for a ship that carrying fuel oil.

The massive-opened palm plantations in Busang area cause the massive erosion and produce a solid waste. The massive erosion created due to the root of palms is not able to maintain rainwater and palms are planted without carrying the sustainable sand. In other words, the surface of sand of a palm plantation is cleaned without another-covered plant. The massive conversion has been caused the Atan River often flood especially in the rainy season. In the dry season, the rate of flow has been fast decreased.

Recently, the rate of travel of passengers and of carrying of goods increases significantly through roadway due to increasing accessibility and business of people from Samarinda to Busang area. Increasing transportation through roadway causes travelling by waterway decreased.

Due to the existing of the Atan River has a significant contribution to people in Busang area, the sustainability of this river must be protected from illegal logging and a massive conversion from forest to palm plantation, and coal mining so that this river can be sustainable and is not polluted from a waste of mining activities and palm oil industries which will be available in this area.

CONCLUSIONS

Up to present, waterway is exist and used for shipping fuel oil and goods from Samarinda to Busang with the reason of capacity and safety. The transport cost of fuel through waterway is IDR 360 per liter.

The rate of flow of the Atan River has been decreased due to deforest and the massive conversion from forest to palm plantation. This massive conversion causes often flood in the rainy season and decreases the rate of flow.

Due to shallowness on the Atan River goes to a massive scale, a medium-sized ship cannot ship to many villages in Busang area.

Due to the Atan River has an enormous amount of value for people who live at population settlements in Busang area, decreasing the flow of water and increasing the rate of pollution of the Atan River will threaten existence of people who live in Busang area.

Reforestation, managing of an eco-friendly palm plantation, and controlling the activity of coal mining will be able to maintain the sustainability of the Atan River as water resources for drinking, waterway and other sources.

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Policies and management

ANALYSIS OF CUMULATIVE IMPACT BETWEEN SMALL-MEDIUM SCALE HAZARD AND LARGE SCALE HAZARD IN INDONESIA

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ABSTRACT

Most of disaster risk study nowadays often focused on large scale, severe and infrequent hazard. Meanwhile small and moderate scale hazard do not gain sufficient attention due to insignificant losses if compared to the large scale ones, at the same time according to national historical disaster event database, the frequency is dominant throughout times. This paper tries to examine the impact, particularly to human lives and housing, of those low and moderate hazards using twelve years validated data (1997-2008) available on Indonesian Disaster Data and Information (DIBI) later the result will be compared to large scale hazard by performing statistical, composition and spatial analysis to understand how much its cumulative impact, composition of hazard, trend and how its geographical impact profile. The result shows that while the number much smaller compare to the large one, yet the effect was affecting wider area and suffers more people than the large ones. These findings would be useful to identify the cumulative impact and how it also significant matter to be considers other than large scale disaster.

Keywords: *disaster impact, historical disaster database, DIBI, extensive risk*

INTRODUCTION

The majority of disaster risk study, platform and practice nowadays were focusing on intensive risk, a large scale, severe and infrequent hazard event such as earthquake, tsunami and volcanic eruption. While for extensive risk, small-medium scale frequent hazard, did not gain sufficient acknowledgement from government, organization and society. There are several factors that might contribute on this fact. Start from low media exposure to lack of valid data source. But it is important to put it as priority to be focused on, as lack of attention would result on lack of preparedness which enables further damages. For example recent study by United Nations (UNISDR, 2009) put Indonesia in a relatively low risk country for floods. An act that could easily debated by most of Indonesian people.

This paper tries to present substansial scientific evidence on the impact of those low and medium scale hazards compared to the large scale hazard, using validated and official data from the Indonesian government.

INDONESIAN DISASTER DATA AND INFORMATION (DIBI)

Starting in July, 2008, Government of Indonesia through Indonesian Disaster Management Agency (BNPB) and with support of United Nations Development Programme has officialy launched Indonesian Disaster Data and Information, also known as DIBI.

DIBI is implemented using DesInventar methodologies. A methodologies with two basic characteristic, first is that it includes small and medium scale disaster occurance and its impact on human and infrastructure, and second it gives linkages of those occurance to the smallest geographical unit possible.

In its young age DIBI has managed to collect twelve years (1997-2008) validated data on disaster event and its impact. It consists of 6648 datacards, 19 types of disaster, and covers 33 provinces. These data previously collected by National Coordinating Body for Disaster Management under Vice President.

DIBI also began to be locally implemented in several provinces in Indonesia such as Aceh, Bengkulu, Jogjakarta and Kupang.

DEFINITION

As this study tries to see differences on the impact between low medium scale and large scale hazard therefore a definition is necessary to be defined. This study would also focused on natural hazard which result some social (eg. social conflict, terror) and non-natural (eg. epidemic, technological) disaster will be excluded. Based on the description above, there will be three group of event which consists of:

1. Non relevant records, this would includes social and non-natural events as previously described and according to DIBI consist of eigth types of disaster which are Terror/Sabotage, Plague, Transportation Accident, Epidemic, Conflict, Climate Change, Hunger and Industrial Accidents.
2. Small and medium scale events, this would include all climatological and geological hazards which fall into eleven types of disaster on DIBI. There is also a threshold which limits the impact to less than 50 dead peoples and less than 500 destroyed houses.
3. Large scale events, includes all kind of events which was not included in two groups above and having threshold more than above values. It is important to be noted that one disaster could be part of small and medium scale and also part of large scale event, what differs is the threshold of impact.

Those eleven types of disaster which are included in this study are:

1. Strong Wind
2. Floods
3. Floods and Landslide
4. Surge
5. Earthquake
6. Earthquake and Tsunami
7. Fire
8. Forrest Fire
9. Eruption
10. Landslide

Although DIBI also cover Tsunami yet due to there is no records of Tsunami impact in DIBI then this event is excluded. The data from 2009 would be excluded from the analysis since it is not validated, therefore this study limit the timespan from 1997 to 2008.

This paper also will focus on several impacts on human lives, consists of Deaths, Missing, Injured, Displaced and Affected and also impact on housing which consists of Houses Destroyed and Houses Damaged. This also resulted in removing Drought due to no direct impact on human lives and housing.

PRELIMINARY ANALYSIS RESULTS

All of the analysis presented below are generated using data and tools embedded in DIBI, since the data is coming from single source therefore it is called preliminary analysis, to perform thorough analysis more data source is needed.

Statistical and Composition Analysis

There were 4000 records matched into the definition for the small and medium scale events, below are the result tables:

No	Event	DataCards	# Event
1	EARTHQUAKE	103	58
2	EARTHQUAKE AND TSUNAMI	26	2
3	ERUPTION	30	23
4	FIRE	332	332
5	FLOODS	1,446	1,400
6	FLOODS AND LANDSLIDES	180	157
7	FOREST FIRE	37	37
8	LANDSLIDES	436	427
9	STRONG WIND	378	366
10	SURGE	81	65
	TOTAL	**4,000**	**3,815**

Seeing on the tables above we quickly identify that Floods dominate almost half of all small and medium disaster.

No	Event	Deaths	Missing	Injured	Displaced	Affected
1	EARTHQUAKE	186	19	2,412	74,871	8,296
2	EARTHQUAKE AND TSUNAMI	17	8	30	468,061	-
3	ERUPTION	6	-	1,255	147,504	1,050
4	FIRE	190	-	828	33,485	12,031
5	FLOODS	666	258	109,109	2,476,904	1,816,493
6	FLOODS AND LANDSLIDES	538	156	18,548	267,283	391,907
7	FOREST FIRE	8	-	13,483	1,460	1,690
8	LANDSLIDES	834	60	922	27,979	11,269
9	STRONG WIND	82	-	483	8,957	132,598
10	SURGE	5	-	193	21,224	19,838
	TOTAL	**2,532**	**501**	**147,263**	**3,527,728**	**2,395,172**

As we can see that during the past twelve years all small and medium scale disaster has caused more than 3000 peoples died or missing, injuring more than 147000, displacing more than 3.5 millions inhabitants and affecting not less than 2.3 million peoples. Landslides, Floods, and Floods and Landslide were dominating the results.

While for housing the impact of small and medium scale disaster is as follow:

No	Event	Houses Destroyed	Houses Damaged
1	EARTHQUAKE	6,473	14,476
2	EARTHQUAKE AND TSUNAMI	27	1
3	ERUPTION	7	-
4	FIRE	10,277	88
5	FLOODS	13,930	102,638
6	FLOODS AND LANDSLIDES	7,995	23,921
7	FOREST FIRE	-	-
8	LANDSLIDES	6,053	4,674
9	STRONG WIND	12,217	19,770
10	SURGE	2,978	2,325
	TOTAL	**59,957**	**167,893**

It shows that almost 60000 houses were destroyed and more than 167000 were damaged. While Floods and Landslides dominates on causing impact to human lives, in housing Floods also have the biggest impact followed by Strong Wind and Fire on destroyed houses. On damaged houses third rank was replaced by earthquake. On the other hand the result for the large scale hazard was as follow:

No	Event	DataCards	# Event
1	EARTHQUAKE	47	22
2	EARTHQUAKE AND TSUNAMI	5	1
3	FIRE	10	10
4	FLOODS	44	40
5	FLOODS AND LANDSLIDES	16	13
6	LANDSLIDES	2	2
7	STRONG WIND	7	7
	TOTAL	**131**	**93**

No	Event	Deaths	Missing	Injured	Displaced	Affected
1	EARTHQUAKE	7,100	1	48,795	2,465,021	177,735
2	EARTHQUAKE AND TSUNAMI	129,491	37,112	5,152	61,128	0
3	FIRE	0	0	0	20,738	196
4	FLOODS	284	161	40,655	675,937	59,067
5	FLOODS AND LANDSLIDES	617	27	14,640	132,603	13,819
6	LANDSLIDES	213	44	16	902	0
7	STRONG WIND	3	0	17	2,873	0
	TOTAL	**137,708**	**37,345**	**109,275**	**3,359,202**	**250,817**

While in the large scale events, despite the fact that Earthquake have the biggest number datacards yet in the event number in was the second, Floods was the highest. We can conclude that in large scale disaster earthquake have wide area impact reflected in the number of datacards. This conclusion also supported by the fact that 5 datacards in Earthquake and Tsunami resulting only single event.

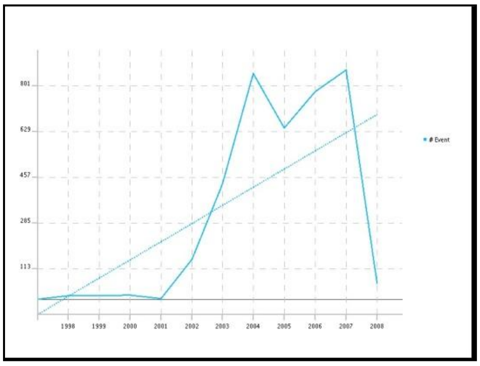
Yet this single event, 2004 Indian Ocean Earthquake, is the highest number in all scale and highly dominates the number of deaths and missing people. Even more if this Earthquake and Tsunami event does not happened then the cumulative impact of small and medium disaster would surpass the number of missing people. We could also say that Earthquake is dominant in this table, with Tsunami and without Tsunami.

The table below will give overview the impact of large scale events to the housing. Similar result also happens on housing, where Earthquake, Earthquake and Tsunami dominate, followed by Floods, Floods and Landsldes. The difference is that Earthquake gives higher impact in housing if being compared to Earthquake and Tsunami.

No	Event	Houses Destroyed	Houses Damaged
1	EARTHQUAKE	285,682	296,672
2	EARTHQUAKE AND TSUNAMI	181,062	584
3	FIRE	9,103	0
4	FLOODS	96,232	17,402
5	FLOODS AND LANDSLIDES	33,764	31,628
6	LANDSLIDES	184	0
7	STRONG WIND	8,464	161
	TOTAL	**614,491**	**346,447**

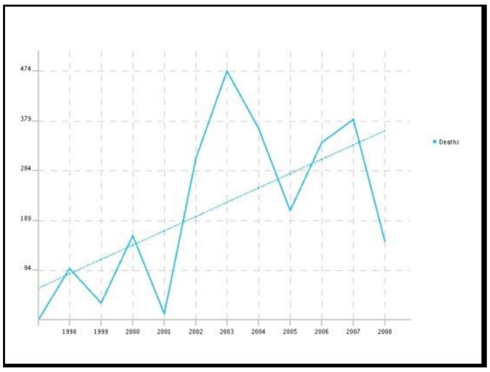
Trend Analysis

Trend analysis is done to gain additional insight from defined timespan, in this case from 1997-2008. First analysis will be done on cumulative event occurance, impact on lives and later impact on housing. Below is the result oftrend of small and medium scale disaster event occurance using DIBI graphic function.



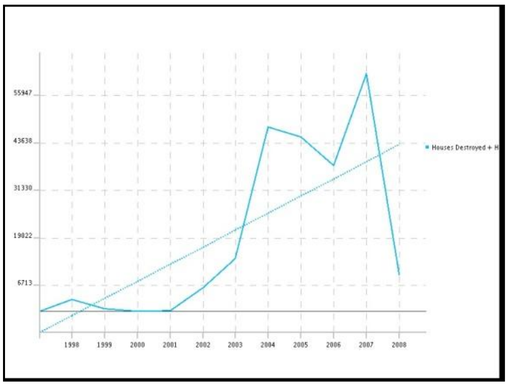
The trendline was created using linear regression function which was available in DIBI. The result shown here indicates how the trend started to increase sharply in the past 8 years and the possibility of increased occurance in the future is remaining high. This could also indicate that current preparedness or precaution is not sufficient. Thus further action of disaster risk reduction on small and medium scale disaster is needed to reduce victims and housing damages.

And next is the trend for death caused by small and medium scale events



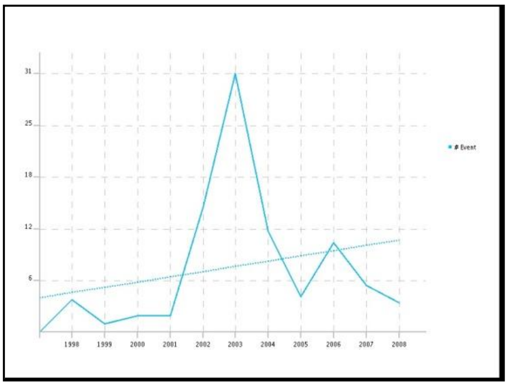
Even though the trendline slope not as steep as the occurance trendline and the last validated year data show the biggest decrease in the past 5 years, it it still significant matter to be reduced.

On impact of small medium scale disaster trendline can be seen below

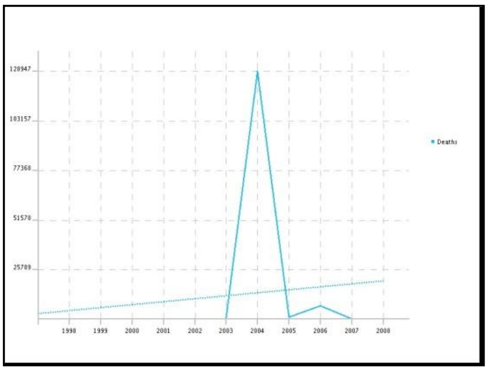


The result is similar with the previous graphic where last year data show significant decrease yet the trendline is remaining high for the possibility of future damage in housing.

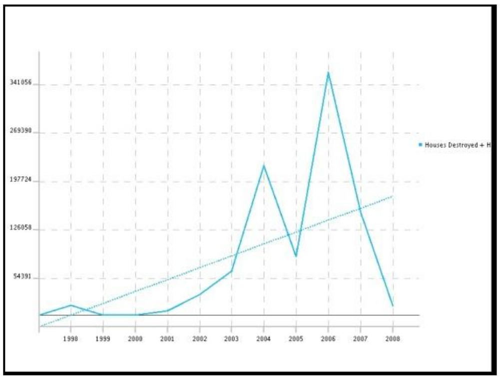
Next three graphic below will compare the result above with the large scale ones.



The trend above is started to decrease in 2004, but at the same year, one disaster causing record high on the impact to human lives described in the following charts



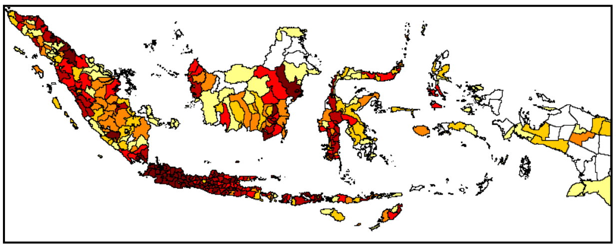
The 2004 Indian Ocean Tsunami above is also proving the importance of Earthquake preparedness to reduce victims in the future.



The impact of 2004 Indian Ocean Tsunami on housing was surpassed by Jogjakarta earthquake on 2006 as pictured in the chart above. The trendline is the steepest if compared to other two previous charts, which shows high vulnerability of housing in Indonesia.

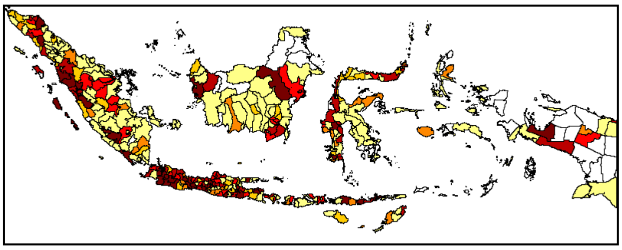
Spatial Analysis

On this analysis the impact of disaster events from geographical perspective will be analysed. The following map is the result for small and medium scale disaster based on the frequency:



Variable:# Event -		
Upper Limit	Color	Legend
-		No Data
2		
4		
7		
11		
18		
92		

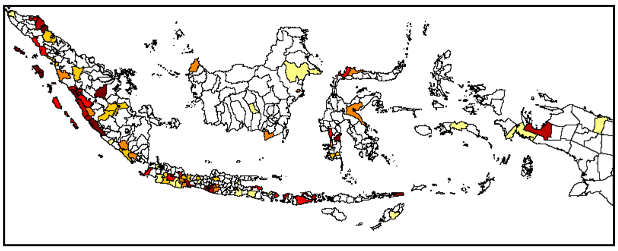
It appear that most disaster in small and medium scale were concentrated on Java island. West Java was the most frequent, followed by Central Java and East Java. Mixed results were happened in Sumatera, Kalimantan and Sulawesi. Next we will see its distribution by the number of death people:



Variable:Deaths -		
Upper Limit	Color	Legend
-		No Data
1		
2		
3		
5		
16		

On the map above the death distribution is more clustered in several centers, such as the shorelines of Sumatera, center of West Java, and north islands on East Nusa Tenggara.

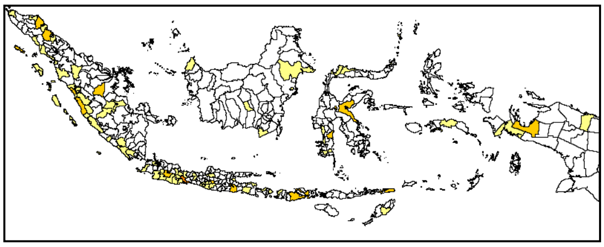
Next is the map for distribution of impact on housing:



Variable:Houses Destroyed + Houses Damaged -		
Upper Limit	Color	Legend
-		No Data
1		
31		
136		
316		
775		

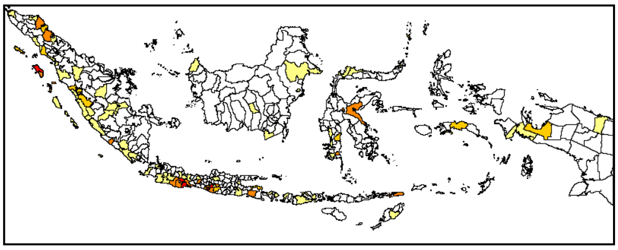
Tenggara, Sumatera and Sulawesi. Kalimantan is having the less impact, while in Papua having a lot of white area describe as no data available for that area.

Next are the analyses for large scale events in spatial distribution based on frequency of events:



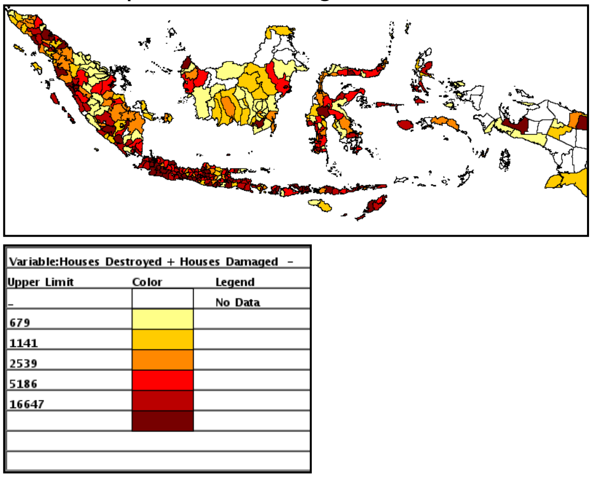
Variable:# Event -		
Upper Limit	Color	Legend
-		No Data
1		
3		
6		
9		
11		

The biggest differences with small and medium scale events based on the map above is that on large scale event, spatial distribution is really spesific in certain places, even in Sumatera and Java were located along the faultline. Below were spatial distributions for impact on human live



Variable:Deaths -		
Upper Limit	Color	Legend
-		No Data
8		
50		
350		
2500		
18000		

The map shows that the high numbers on deaths were usually concentrated on one or several adjacent district. Even when it uses logarithmic scale, the color is similar with the number of disaster occurance in the previous map. The next map describes large scale events impact on housing:



The results were slightly different on the impact on housing. More spatial distribution exists on destroyed and damaged housing, even on the area where the occurance of disaster is minimal.

CONCLUSION

From above analysis there are several conclusions that we could draw:

1. Small and medium disaster cumulative impact on human lives is quite high, even the number of affected people is ten time higher than the large scale ones.
2. The trendline for small and medium scale disasterocurannce and impact is also remaining high from time to time, surpassing all the trendline of the large scale occurance, impact on human lives and housing.
3. The spatial distribution of occurance and impact of small and medium disaster much more scattered in wider area coverage, whilst the large scale clustered in specific area.
4. This study could be used as evidence on the importance of giving more attention to reduce small and medium scale disaster.

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ADAPTIVE HAZARD MITIGATION: THE THEORY AND PRACTICE OF RESPONDING TO ENVIRONMENTAL CHANGE-DRIVEN DISASTERS

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ABSTRACT

This paper will explain the theoretical underpinnings, and several recent research applications, of a relatively new approach to hazard mitigation called "Adaptive hazard mitigation" or "AHM" (Doberstein 2009). The AHM concept emerged from the adaptive management tradition used increasingly in natural resource and environmental management. With adaptive management increasingly being referred to as an "emerging paradigm", there is a search for new areas such as hazard mitigation which might benefit from the theory and practice that underscores the adaptive management approach. Major benefits of adaptive management include enhanced socio-ecological system resilience and sustainability in the face of changing environmental conditions and human disturbances, and these benefits are thought to extend to hazard mitigation efforts in a post-disaster setting, largely by reducing exposure to environmental-change driven hazards. The theory base of AHM suggests that post-disaster mitigation 'experiments' should be attempted at differing scales in an effort to reduce vulnerabilities in a particular location, and that associated cycles of monitoring, evaluation of successes and failures, social learning, and ongoing adjustment of mitigation efforts should occur. Following an explanation of AHM's theory base, case studies on post-disaster hazard mitigation in Dominican Republic, Venezuela and Indonesia are reviewed. Using the AHM framework, the research gauges the extent to which post-disaster learning and knowledge (e.g., disaster causes, changing environmental conditions, and community vulnerabilities) has been translated into mitigation actions which are continuously adjusted. The paper concludes by suggesting that post-disaster hazard mitigation efforts should focus on limiting and controlling human-induced environmental change as a means of reducing hazard potential, and that because human-induced environmental change accumulates in different ways at local, regional and global scales, hazard mitigation responses must consider these multiple scales.

Keywords: *Adaptive hazard mitigation, disaster, environmental change, social learning, developing countries*

INTRODUCTION

Adapting to or mitigating the risks posed by natural hazards is recognized as a question deeply embedded in the larger question of how societies can foster sustainable development (White et al., 2001). Although mitigation has been identified by natural hazard researchers as one of the most cost-effective means of limiting disaster impacts and losses (Beatley, 1995; Burby, 1998; Abramovitz, 2001), there is little agreement about the most appropriate approach to use when designing a mitigation strategy.

Recognizing that many so-called 'natural' disasters are in fact multi-dimensional and triggered by the dynamic interplay of both natural and human causes, academics and development planning practitioners have called for improved hazard mitigation efforts that incorporate the multiple dimensions of natural hazards while factoring in the dynamism inherent in socio-ecological systems. This paper will evaluate whether exposure to such hazards, in the form of a disaster event, stimulates a search for systematic post-disaster knowledge, mitigation actions, monitoring, social learning and adjustment, or collectively what I refer to as 'adaptive hazard mitigation (AHM)' (Doberstein, 2009).

Globally, disasters and related physical, economic and societal damages are increasing rapidly (UNDP-BCPR, 2004), doubling each decade since the early 1960s (Pelling, 2003). By the late 1990s, globally 'significant' disasters reached 500-800 events annually, and losses from natural disasters have topped $80-$200 billion/year in recent years (White et al., 2001, 83; Pelling, 2003, 3; Adger and Brooks 2003, 33; UN/ISDR 2003, 6; Munich Re, 2008, 35), surpassing the global total of all foreign aid spending combined.

This phenomenal growth in disaster events and damages is explained, in part, by the increasingly dynamic interplay of both natural and human causes (e.g., extreme rainfall events combined with the cumulative effects of landscape transformation, ecologically-destructive land-uses, and poor human settlement decisions) (Brookfield, 1999; Abramovitz, 2001; White et al., 2001; Smith and Petley, 2009). These trends are expected to increase in the future as "climate change and continued environmental degradation of the natural landscape…make many nature-triggered disasters more frequent and severe" (Haque and Etkin, 2007). This body of literature calls for the translation of knowledge into hazard mitigation efforts which address the multi-dimensional causes of hazards and disasters (UN-ISDR, 2003; Smith and Petley, 2009), integrate hazard mitigation into development planning processes (O'Keefe et al., 1976; Mileti, 1999; UNDP-BCPR, 2004), and facilitate the adaptation of societies to a changing, more hazardous environment (Adger et al., 2001; Tompkins and Adger, 2003).

Hazard mitigation is a potentially powerful avenue of harm reduction for developing countries, with every $1 spent on hazard mitigation saving up to $7 in disaster relief and recovery (Abramovitz, 2001). However, I contend mitigation success hinges on accurate knowledge of the multiple dimensions of natural disasters, the formulation by a range of actors of mitigation actions linked to such knowledge, and continuous monitoring, social learning and adjustment of mitigation strategies at multiple scales. For this reason, post-disaster evaluation of hazard mitigation strategies is crucially important.

This paper will explain the theoretical underpinnings, and several recent research applications, of a relatively new approach to hazard mitigation called "Adaptive hazard mitigation" or "AHM" (Doberstein, 2009). The AHM concept emerged from the adaptive management tradition used increasingly in natural resource and environmental management. With adaptive management increasingly being referred to as an "emerging paradigm", there is a search for new areas such as hazard mitigation which might benefit from the theory and practice that underscores the adaptive management approach.

Major benefits of adaptive management include enhanced socio-ecological system resilience and sustainability in the face of changing environmental conditions and human disturbances, and these benefits are thought to extend to hazard mitigation efforts in a post-disaster setting, largely by reducing exposure to environmental-change driven hazards. The theory base of AHM suggests that post-disaster mitigation 'experiments' should be attempted at differing scales in an effort to reduce vulnerabilities in a particular location, and that associated cycles of monitoring, evaluation of successes and failures, social learning, and ongoing adjustment of mitigation efforts should occur.

Following an explanation of AHM's theory base, case studies on post-disaster hazard mitigation in Dominican Republic, Venezuela and Indonesia are reviewed. Using the AHM framework, the research gauges the extent to which post-disaster learning and knowledge (e.g., disaster causes, changing environmental conditions, and community vulnerabilities) has been translated into mitigation actions which are continuously adjusted. The paper concludes by suggesting that post-disaster hazard mitigation efforts should focus on limiting and controlling human-induced environmental change as a means of reducing hazard potential, and that because human-induced environmental change accumulates in different ways at local, regional and global scales, hazard mitigation responses must consider these multiple scales.

THEORY BEHIND ADAPTIVE HAZARD MITIGATION

There is a lengthy history of academic understanding that many 'natural hazards' are highly dynamic and multi-dimensional interactions between natural, hazardous phenomena such as extreme rainfall or unstable slopes, and the human occupation or disturbance of hazard-prone areas (see for example: O'Keefe et al., 1976; Burton et al., 1978; Hewitt, 1983; Cutter, 1994; Wijkman and Timberlake, 1984; Mitchell, 1990; Blaikie et al., 2000). Manuel-Navarrete et al. (2007) found many recent disasters in the Caribbean were of a multi-dimensional nature, with extreme rainfall events, ecosystem degradation, population growth, rural poverty, and poor human settlement choices and agricultural practices being common causal factors. Although there is a well-developed literature suggesting the *need* for hazard mitigation, a strong link has not been made between the dynamic, multi-dimensional nature of hazards, and mitigation models which can address such dynamism through continuous learning and adjustment.

Adaptive hazard mitigation emerged from the **adaptive management** approach (see Figure 1) used increasingly in natural resource and environmental management (Holling, 1986; Mitchell, 2002; Pelling, 2003; Sabine et al., 2004; Stankey et al., 2005). Norton and Steinemann (2001) describe adaptive management as an "emerging paradigm" containing elements of experimentation (management as a conscious experiment requiring constant monitoring and learning), multi-scalar analysis (acknowledging multiple scales of time and place) and place sensitivity (management which incorporates local and regional social and ecological concerns and needs). Major benefits of adaptive management include enhanced socio-ecological system resilience and sustainability in the face of changing conditions and disturbances (Folke, Berkes and Colding, 2000), and resilient, adaptive systems are understood to be able to cope better with hazards (Haque and Etkin, 2007). Adaptive management is often pursued through the development of institutions and governance systems that allow for learning and adaptive capacity (Folke et al., 2002) at all levels, local to international (UN-ISDR, 2008).

Adaptive management includes simple 'trial and error' experiments, 'passive adaptations' (i.e. choosing a single 'best choice') and 'active adaptation' (or "intentional multi-action programmes where active monitoring and adjustment of actions is carried out" (after Walters and Holling, 1990)). Trial and error adaptation is thought to be less than ideal for hazard mitigation purposes since 'errors' may lead to deaths in future disaster events and actually *increase* vulnerability before errors are detected.

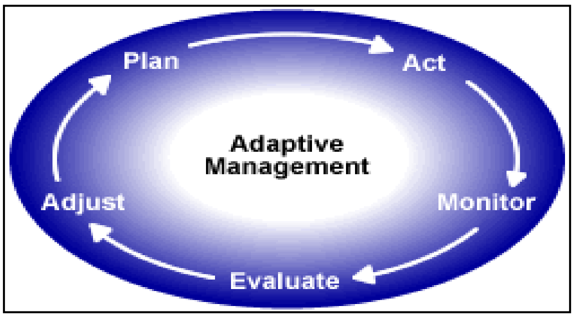

Figure 1 Adaptive management concept (NOAA Coastal Services Center, 2006)

The most obvious feature of trial and error adaptation is the lack of associated monitoring, learning and adjustment (Doberstein, 2009). The 'best' form of adaptive management, according to Walters and Hollings (1990), is active adaptation whereby a number of mitigation actions are attempted, and outcomes are monitored and adjusted to trigger desired conditions over the long term. Norton and Steinemann (2001, p. 477) agree, suggesting 'experimentalism' should be a core principle for adaptive management, but they also add that a multi-scalar perspective is needed for such experiemnets to be successful (i.e. placing the local hazard in a wider regional/watershed and even national context).

Social learning, in which problems and questions are identified and alternatives explored through collective dialogue and deliberation (Maarleveld and Dangbegnon, 1999), is understood to be a critical component of adaptive management (Tàbara and Pahl-Wostl, 2007) and its offshoot, adaptive hazard mitigation. Social learning links individuals, communities and collective decision-making bodies, or 'platforms', to decisions about management of societal problems such as disasters. Such collective, multi-scalar decision making is thought to facilitate societal adaptation to changing and often dangerous environmental conditions (Maarleveld and Dangbegnon, 1999). This links naturally with the "long-standing tradition within disaster research (which) has considered hazards and catastrophes as instruments of change in the structure and organization of societies" (Oliver-Smith and Hoffman, 1999).

Hazard mitigation, and **risk and vulnerability reduction theory** previously dominated by the physical sciences and engineering, is now informed by a wide variety of disciplines (Mileti, 1999), and the literature shows a range of theoretical approaches ranging from 'one-time' post-disaster approaches, to integrated pre-disaster 'sustainable hazard mitigation' (Beatley, 1998; Godschalk et al., 1998; Mileti, 1999), post-disaster 'build back better' approaches (Clinton, 2006; Kennedy et al., 2008) and continuous post-disaster 'adaptive hazard mitigation' (Doberstein, 2009). Central to this theory base is the idea that individuals, ranging from engineers to regional planners to disaster survivors, can collectively reduce the potential for natural hazards to cause disaster through the mobilization of what Friedmann (1987) calls "knowledge to action". In a post-disaster setting, the chaotic rush to simultaneously provide relief and begin reconstruction and mitigation presents many challenges.

It is partly for this reason I contend hazard mitigation strategies should take a long-term and adaptive view which acknowledges that mitigation efforts should be adjusted in the face of emerging knowledge and changing environmental conditions. Vulnerability to hazard of any given community is dependent on a number of changing social, physical, economic, land use and ecological variables, and hazard mitigation theory suggests each of these variables should be considered when designing or updating a vulnerability reduction strategy (Wildavsky and Dake, 1990; Cutter, 1994; Mileti, 1999; Blaikie et al., 2000; UNDP-BCPR, 2004).

Community-Based Disaster Management (CBDM) and **Recovery (CBDR)** literature provides significant guidance to the adaptive hazard mitigation concept, and it is understood that "community and peoples' power to mitigate, to improve coping mechanisms, to respond effectively, and recover…from environmental extremes are of paramount conceptual and policy importance" (Haque and Etkin, 2007, 272). The AHM approach recognizes "one of the most effective ways to improve the capacity of people to cope with the consequences of disasters is through (CBDR)" (Gaillard and Le Masson, 2007). Disaster-affected communities must *necessarily* be included in post-disaster decision-making about how to adapt to the presence of hazards, and the CBDR concept provides guidance for AHM, notably on how local, regional and national actors can be involved in mutual social learning and decision-making, and on the need to build community-level mitigation capacity (Maskrey, 1989; Bollin, 2003; Allen, 2006).

Lastly, **integrated resource management** and **ecosystem approaches to environmental management** suggest hazard mitigation efforts should focus on limiting and controlling human-induced environmental change as a means of reducing hazard potential (Mitchell, 1990). Human-induced environmental change accumulates in different ways at local, regional and global scales (Kates et al., 2001), and hazard mitigation responses must consider these multiple scales (Maskrey, 1989).

In summary, adaptive hazard mitigation refers to the suite of post-disaster mitigation 'experiments' attempted at differing scales in an effort to reduce vulnerabilities in a particular location, and the associated cycles of monitoring, evaluation of successes and failures, social learning, and ongoing adjustment of mitigation efforts based on 'lessons learned'. Although the literature acknowledges most disaster-affected communities respond to disaster through some form of post-disaster mitigation, these actions cannot be labeled 'adaptive' unless conscious monitoring is undertaken, and effective social learning and ongoing adjustment result in reduction of hazard vulnerability. Using an AHM framework developed from the theory base above, the following research gauges the extent to which post-disaster learning and knowledge (e.g., disaster causes, changing environmental conditions and community vulnerabilities) is translated into mitigation actions which are continuously adjusted.

RESEARCH METHODS

The research employed a comparative, multi-case study method of the post-disaster hazard mitigation strategies in three communities affected by debris flow disasters: 1) Pupuan, Bali (1999 debris flow), 2), Jimani, Dominican Republic (2004 debris flow), and; 3) North Vargas State, Venezuela (1999 debris flow). The case studies are multi-dimensional disasters with a number of causal factors identified in 'disaster event reports' as contributing to the overall disaster (e.g., extreme rainfall, forest/mangrove removal, ecosystem degradation, and/or settlement location).

Data collection for the research included 'grey literature' document collection and review using qualitative content analysis, participant observation of impacted communities, and unstandardized key informant interviews with hazard mitigation specialists and disaster survivors (n=20). Key informants included those from affected communities, government agencies, academic institutions, and NGOs with hazard mitigation interests. Unstandardized interviewing, in which interviewers "develop, adapt, and generate questions and follow-up probes appropriate to the given situation and the central purpose of the investigation" (Berg, 1995, 32) was used for all key informant interviews. Interview themes were modified as new information from interviews emerged, but included: 1) cause(s) of disaster; 2) mitigation actions undertaken or planned post-disaster and related monitoring/social learning; 3) actors involved in hazard mitigation (community→international); 4) time frame for mitigation; 5) adjustment of mitigation strategy over time, and; 6) barriers to AHM use and capacity-building needs.

CASE STUDIES

The first two case studies, the 1999 Pupuan, Indonesia and 2004 Jimani, Dominican Republic debris flows, have been described elsewhere in detail (Doberstein, 2006 and 2009) so this paper will present a brief overview of these cases.

1. Pupuan, Bali, Indonesia

On Jan. 7, 1999 a 'small-magnitude' 20m X 200m debris flow occurred during the rainy season in the village of Pupuan, Bali (IFRCRCS, 1999), also known locally as Timbul. This debris flow killed 40 residents who were cleaning out debris blocking an irrigation canal located at the base of a steep slope, burying workers in many metres of mud, sand, gravel and organic debris (INT #1).

As outlined in Doberstein (2009), the disaster had several contributing causes, including 1) a high rainfall event in the midst of an otherwise 'normal' rainy season; 2) significant forest modifications above the debris flow zone (e.g. plantation agroforestry, livestock pens, open fields or market garden cropping), including removal of vegetation from the slope which failed; and, 3) local fuelwood collection and selective logging to support Bali's tourism handicrafts market. The formerly-forested area above the debris flow was transformed into a series of open fields ringed by shade trees and other agroforestry species, and it is hypothesized that forest transformation has affected groundwater drainage and overland flow patterns during high rainfall events. Moreover, irrigated rice agriculture was being practiced at the toe of the slope that failed in 1999, and this also contributed to the disaster by providing the motivation for humans to be present in the area despite the heavy rainfall.

The research used the Adaptive Management concept outlined in Figure 1 in order to assess post-disaster responses in Pupuan. The first major finding was that no formal "Evaluation" or diagnosis of disaster causes was undertaken but that informal community social learning and evaluation of the event was evident. "Adjustments", which revealed both "Planning" and "Acting" were implemented post-disaster despite the lack of formal disaster evaluation.

Both structural and non-structural approaches were used to reduce risks post-disaster. The single structural adaptation used was the construction of a 500-m long metal and concrete covering over the irrigation canal where villagers were killed so there is no longer a need for villagers to clean debris in this hazardous zone (Doberstein, 2009). Non-structural adjustments included building a Balinese Hindu shrine with a list of the victims' names at the toe of the slope which failed, which led the locals to begin to consider the immediate area (including the slope which failed) as a 'holy place' where tree-felling, grass collection or agriculture is now forbidden (INT #1). The research did not reveal any type of formal 'Monitoring", yet community members continue to work in agricultural fields nearby, and locals regularly visit the new Hindu shrine ensuring that the slide zone has a relatively constant informal 'community monitoring' network focused on the slide zone.

The research revealed several missed opportunities that would have flowed from following an adaptive hazard mitigation approach. Firstly, there were no efforts made to produce a hazard map of the slide zone and or nearby areas. Secondly, physical monitoring of the slide zone (e.g. groundwater levels, soil movements, and vegetation regrowth) was not attempted, nor have there been attempts to mitigate possible human-induced environmental change (e.g. reforestation of nearby areas). At a regional-scale, it would have been useful to examine the degree to which Bali's growing handicraft industry might result in additional future deforestation, thus increasing slide risks.

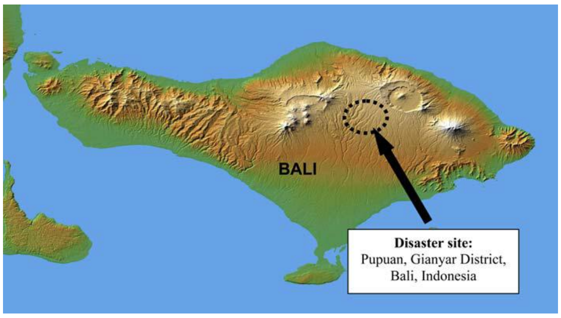

Figure 2 Location of the Pupuan, Bali, debris flow disaster
Source: NASA/JPL-Caltech (2004)

2. Jimani, Dominican Republic

On May 25th, 2004 a medium-magnitude debris flow (see Figure 3) killed over 400 of Jimani's 11,000 residents, displaced about 3,000 individuals, and destroyed more than 300 homes (INDRHI, 2004). In the hours leading up to the debris flow, a slow moving low-pressure system triggered over 500 mm (19.7 inches) of rain falling on the Haitian/Dominican Republic border regions, with over 250 mm received in the last 24 hours before the disaster.

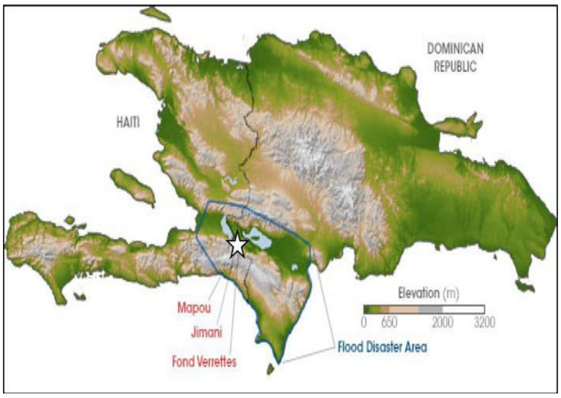

Figure 3 Location of Jimani, Dominican Republic debris flow disaster (NASA Earth Observatory 2004)

As outlined in Doberstein (2006, 2009) primary causes of the Jimani disaster included the intense rainfall event, the town's location on an alluvial fan, and deforestation in the upper catchment (85% of which lies in Haiti). Secondary causes include the erosion-prone geomorphology of the area, the poorly-draining hydrology of the watershed, and poor local capacities for weather forecasting, river monitoring, communications and evacuation.

In the six years following this disaster, both structural and non-structural hazard mitigation actions have been implemented (Field Notes 2005/2009). Structural approaches include a new levee/revetment system built out of old river channel materials, a bridge spanning the channelized river and flood-resistant housing. Over 150 flood-resistant houses featuring a second-story 'safe zone' were built on a lower-hazard part of the alluvial fan for debris flow survivors, and land immediately adjacent to the river channel has been rezoned as 'no development allowed'. Non-structural adaptations included many areas of communications and institutional improvement. The communications structure and organizational capabilities of the Dominican Civil Defense system were significantly strengthened in the year following the Jimani debris flow. As one interviewee noted, the disaster ''improved our organizational capacity… it was a major test. Now, we coordinate more on a regular basis within our organization and across other agencies'' (INT #2). However, Dominican/Haitian cross-border cooperation, watershed monitoring, and communications are still limited due in large part to Haiti's ongoing political, governance and recent earthquake-response crises.

Post-disaster responses in Jimani have been followed many aspects of the adaptive hazard mitigation concept. An evaluation of the disaster was carried out within a month of the event, and this evaluation resulted in significant 'adjustments', 'plans' and adaptive mitigation 'actions' (e.g. banning development in high-hazard zones, moving survivors to a safer location, building the levee/revetment system, improving communications). However, the research also revealed that 'monitoring' of the mitigation actions, and the associated social learning that might result, has been weak. To date there is still no basin-wide rainfall or river monitoring network established, and community members report that they do not like to think about or discuss the possibility of future disasters, and that the memory of the 2004 event appears to be fading within the community (INT #20).

A number of potentially useful adaptive hazard mitigation actions have not yet been pursued in Jimani. Firstly, to date there has been no effort made to attempt environmentally-related mitigation actions such as reforestation of the 'virtually treeless' (Aide and Grau, 2004, p. 1915) upper Soliette River watershed in Haiti. In the face of challenging security, political and recent earthquake reconstruction preoccupations, Haitian NGOs and government agencies have nowhere near the required capacity to attempt reforestation. One Dominican government scientist commen-ted on the role of such deforestation in the May 2004 disaster: ‘If the forest had been intact, we (still) would have had some flooding, but it would have been much less damaging’. In addition, an integrated river monitoring and rainfall early warning system has not yet been implemented, nor has any form of interim low-technology/low-cost warning system been created. For this reason alone, hazard mitigation adjustments were judged to be just ‘fair’.

3. North Vargas State, Venezuela

Figure 4 Location of 1999 Debris Flow disasters (Altez 2007)

The December 1999 debris flow in Vargas State, Venezuela (see Figure 4) is considered by some to be the largest debris flow disaster in modern global history (Wieczorek et al.,, 2002). At least 24 separate watersheds along a 30-50 km coastal strip produced almost simultaneous debris flows on Dec. 16, 1999 (Lopez et al., 2003; INT #9; Shige 2005). Approximately 15,000 to 30,000 people were killed, and up to 80,000 houses were destroyed or damaged to some degree (Larsen et al., 2001; Perez 2001; Lopez et al., 2003; Cardenas and Jimenez, 2005; Shige, 2005),

Two key causes of the disaster were identified by interviewees and secondary sources: 1) a two day extreme rainfall event producing over 900 mm of rain in the upper catchments (Lopez et al. 2003), and; 2) significant levels of unplanned urbanization on the multiple alluvial fans found in coastal Vargas State (INT #9, INT #10, INT #13, INT #14, INT #15). Although deforestation of the watersheds that triggered debris flows was initially suspected as a contributing cause, subsequent investigation revealed that the forests were largely intact, and that most of the watersheds flow out of a National park. Thus, deforestation has now been discounted as a contributory cause of the disaster (Int #10, Int #13).

Using the adaptive hazard mitigation concept as a guide, the research revealed that although post-disaster ‘evaluation’ was done fairly well (e.g. creating sophisticated debris flow inundation maps, gathering hydrometeorological data on the event), every other part of implementing the AHM framework was judged to be either ‘fair’ or ‘poor’. For example, despite international aid and disaster assistance totaling hundreds of millions of dollars (World Bank 2000, U.S. Department of State n.d.), reconstruction ‘adjustments’, ‘plans’ and ‘actions’ were summarized by interviewees as extremely slow, and ‘largely rebuilding the conditions of risk and vulnerability that existed prior to the 1999 event’ (INT #8; INT #13, INT #15).

Slow governmental and aid decision-making and responses meant that many survivors lacked the financial resources to rebuild in other less risky locations. The lack of timely decision making about urban rezoning (e.g. allowable reconstruction zones and ‘no development’ zones) led many residents to rebuild their damaged houses in areas that may still be rezoned as ‘no development’ zones *10 years after the disaster* (INT #10, INT #14).

Additional evidence of ineffective ‘adjustments’ came in the form of a failed government resettlement scheme for survivors: survivors were offered free housing and land over 400 kilometres away. Relocated families soon abandoned their homes, and many returned to the disaster zone to rebuild homes damaged in the disaster (INT #14, INT #15). Cardenas and Jimenez (2005, 5) summarized this failure, saying “After the disaster, the government tried to offer housing solutions outside the State of Vargas, but at the end of two years most of the population returned to the site, the (slow response) of the government to the reconstruction and recovery of housing forced people to rebuild their houses (by themselves), many of them in the same high-risk area.”

The research revealed many other examples of post-disaster ‘planning’ and ‘action’ failures in Vargas State. Firstly, eight years after the disaster, construction began on fifteen multistory apartment buildings in a riverside area heavily impacted by the 1999 debris flows. Secondly, even *ten years* after the disaster, a detailed rezoning plan which would clearly identify high hazard ‘no development’ zones still has not been formally approved. Arguably, the worst failure to ‘act’ related to housing damaged in the disaster: although over 80,000 housing units were damaged or destroyed in the disaster, the researchers were only able to document 20 houses built expressly for survivors. All other post-disaster housing projects mentioned by interviewees (INT #8, INT #13, INT #16) were 'market' rather than 'social' housing (i.e. they were available for purchase by anyone who could afford the housing), and several interviewees indicated that many of these units were purchased by real estate speculators to resell for profit (INT #8, INT #16). There have been no attempts to examine larger regional-scale forces that might affect future vulnerabilities (e.g. increased investment and population pressures in the region, changing climate patterns).

In summary, because there has been so little post-disaster improvement in community and individual vulnerabilities, post-disaster reconstruction efforts in Vargas State are judged by the researcher to have largely failed to reduce residents' vulnerability to future similar events. Post-disaster reconstruction has not proceeded using an AHM framework, and the reconstruction process has largely 'rebuilt risk'.

Table 1 Assessment of cases: post-disaster adaptive hazard mitigation?

AHM STAGES	Pupuan, Bali	Jimani, Dominican Republic	North Vargas, Venezuela
Evaluate	Poor	Excellent	Fair/Good
Adjust	Good	Fair	Poor
Plan	Fair	Good	Fair
Act	Fair	Excellent	Poor
Monitor	Fair	Fair	Poor

CONCLUSIONS

Post-disaster hazard mitigation efforts should focus on limiting and controlling human-induced environmental change as a means of reducing hazard potential. Since human-induced environmental change accumulates in different ways at local, regional and global scales, hazard mitigation responses must consider these multiple scales.

The AHM framework provides an ongoing 'roadmap' for how to act in dynamic and hazardous environments. However, as these cases have demonstrated (Figure 5), the framework is often not followed, or portions of the adaptive process are skipped altogether. The research also revealed that 'trial-and-error' adaptation has been practiced in all three cases, and this suggests that post-disaster hazard mitigation has not been seen through an 'adaptive management' lens. Only by considering hazards and disasters as an ongoing process of human-environment interaction, designing appropriate 'adjustments' when needed, and monitoring the results over time, can disaster reconstruction specialists hope to reduce risk.

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UTILIZING PHOTOGRAPHS FOR PRE-DISASTER MITIGATION: A PRELIMINARY STUDY

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ABSTRACT

Indonesia is a country that has high-risk of disasters including earthquake. Major earthquakes struck Indonesia recently has prove non-engineered buildings were the most common destroyed buildings. To prevent the further loss it is necessary to assess existing building condition, thus it can be seen that existed non-engineered buildings are either in earthquake-resistant condition or need to be retrofitted. Nowadays, the use of photograph has become very popular. As information sources, photographs recorded of the building condition provide significant information relating to the earthquake disaster preparedness. However, there are a number of problems related to using photographs to determine if the building conditions are resistant or irresistant because of uncertain or inexact information collected by looking at that photograph. To deal with the uncertain information from building photographs, it is proposed to use their characteristics and an assessment [made by direct assessment on-site] of their condition. The framework proposed for this is described. It is initially based on Bayes' Theorem. From 16 construction images as an example, the result revealed that 13 photographs demonstrate earthquake resistant building, whereas three photographs demonstrate earthquake irresistant building. In conclusion, proposed approach demonstrates how it is possible, using on-site photographs, to define building condition as earthquake resistant or irresistant.

Keywords: *earthquake preparedness, earthquake resistant building, photographs, Bayes' Theorem*

INTRODUCTION

Geographically, Indonesia lies between 92^o EL to 141^o El and 14^o SL to 7^{o}20 NL and lies at a meeting point of three major tectonic plates, namely the Indo-Australia Plate, the Eurasia Plate, and the Pacific Plate (Ministry or Research and Technology 2007). That condition renders some of the Indonesia's region vulnerable to earthquakes and tsunamis. These regions are Aceh, North Sumatra, West Sumatra, Bengkulu, Lampung, West Jave, Central Java, East Java, Bali, Nusa Tenggara, Sulawesi, Maluku, and Papua.

Recent major earthquake event in Jogjakarta, Jogjakarta is a part of Central Java, was on 27 May 2006. The figure of losses was significant. For destroyed building itself the figure was 154,000 houses completely destroyed and 260,000 houses suffered some damage (Jogjakarta and Central Java Preliminary Damage and Loss Assessment 2006). From that devastated figure, a non-engineered building was the most common house that had been destroyed or damaged. Therefore, it is necessary to understand the condition of building to ensure that new buildings are designed and old buildings are retrofitted to reduce their vulnerability to excessive damage during earthquakes.

In disaster economic loss assessment, it is hard to predict the loss soon after disaster hit. This is because pre-disaster condition data rarely available. Therefore, there is a need to assess pre-disaster condition, in this paper inclusive of domestic buildings or houses, and keep the information in database for further use.

Building/house information in the form of photographs is increasingly being used as a source of information. In particular, the photographs could be used to provide information concerning the earthquake resistant condition of the building.

The objective of this paper is to present the use of building photograps with the desire to promote earthquake-prepared building. This paper is a part of ongoing research which is to develop a method of photograph analysis that can be used to quick assess building condition on-site, either pre-disaster or post-disaster events. Therefore, this paper is designed to investigate how observation from records (as photographs) of current building condition can be used to identify earthquake resistant building.

This research has collected some digital photograph as data of building condition, and those data were stored. The photographs were taken from a village in Jogjakarta. The distance between the photographer and the object of photograph was varied so as to produce two main types of photographs, the 'whole activity' type and the detailed type.

The Federal Emergency Management Agency (FEMA) provides an approach to assess building condition for disaster-risk area. This approach has been adapted to construct the proposed guideline, which is an earthquake resistant non-engineered building checklist. The checklist has been used to make an assessment of building condition of collected data. The checklist for assessing the building condition is same for the two types of photographs. However, because of different detailed information shown by these photographs, an assessment of the type of photograph (close-up or distant) that allows the most accurate assessment of condition to be made can be different. The assessment was done completed for every photograph.

To incorporate the range of assessments of building condition a mathematical analysis has also been developed to make a reliable prediction of building condition. The analysis is used Bayes' Theorem, which can deal with inexact reasoning. The framework used for identifying methods of assessing the degree of belief of earthquake resistant building condition is shown in Figure 1.

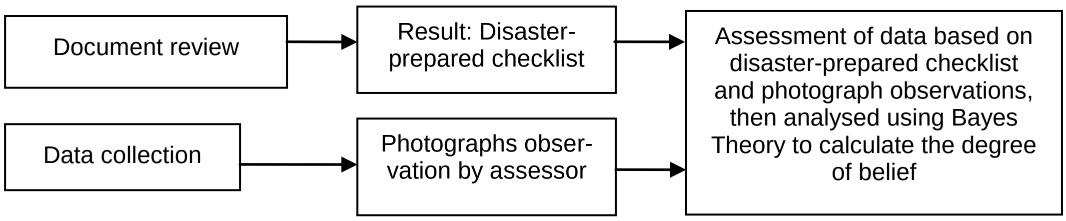


Figure 1. A Framework for assessing the degree of belief of disaster-prepared building condition

The assessment method has been developed using building condition as a trial to demonstrate how such a predictive tool can be used to assess and predict the condition of building. Once demonstrated as an effective assessment method the resulting method can be used as reference for quick assessment method on pre-disaster and post-disaster events.

CONCEPT OF BAYES' THEOREM

In order to make a predictive expert system in areas such as building condition assessment, the method of analysis must be able to incorporate that are true or false. For example, given an image in Figure 2, an event may be

"The bars were anchoraged each other"

and the proposition is

"The steel bars were secured connected"

Figure 2. Building reinforcing steel bars

Given that A is a proposition, the conditional probability *P(A / B)* can be interpreted as the *degree of belief* that A is true, given B (Giarratano and Riley, 1998). This type of *hypothesis* is used for some proposition whose truth or falseness is not known for sure on the basis of some *evidence*. The conditional probability is then referred to as the *likelihood* or *degree of belief*, as in *P(H / E)*, which expresses the likelihood of a hypothesis, H, being true based on some evidence, E.

$$P(H/E) = \frac{P(E/H)\,P(H)}{P(E)} \quad (1)$$

(Giarratano and Riley, 1998)

Where:

1. *P(H/E)* is a likelihood of hypothesis (H) given evidence (E). Refer to the example before about proposition and event, therefore this term can be interpreted as: the steel bars were secured connected given evidence that the bars were anchorage each other.
2. *P(E/H)* is a likelihood of hypothesis (H) that can cause evidence (E),
3. *P(H)* is a probability of hypothesis (H),
4. *P(E)* is a probability of evidence (E).

The Equation (1) is known as Bayes' Theorem formula.

In the real world, the more general and realistic situation is based on uncertain hypotheses and uncertain evidence. For the general case, assume that the degree of confidence in the complete evidence, E, is dependent on the partial evidence, e, by $P(E/e)$. Referring to figure 3, it can be stated that the evidence (E) is unstable machine, and the partial evidence (e) is the machine was placed on the weak soil. Thus, because the machine was placed on the weak soil then the machine was unstable. The complete evidence is the total evidence, which represents all possible evidence, and hypotheses, which comprise E. The partial evidence, e, is the portion of E that known. If all partial evidence known, then E = e and $P(E/e) = P(E)$.

More complex situation arises if there is compound evidence. Compound evidence consists of multiple pieces of evidence and expressed formally:

IF $E_1, E_2, \ldots$ *AND* E_N *THEN H*

For the example, using Figure 2, the state can be expressed that:

E_1 *is the bars have hooks*
E_2 *is the hooks anchoraged to other bars*
H is the steel bars were secured connected

Then the logic statement can be expressed the example formally:

"IF the bars have hooks AND the hooks anchoraged to other bars THEN the steel bars were secured connected"

So Equation (1) become

$$P(H/E_1 \cap E_2) = \frac{P(E_1 \cap E_2/H)\,P(H)}{P(E_1 \cap E_2/H)\,P(H) + P(E_1 \cap E_2/H')\,P(H')} \quad (2)$$

Where symbols are as before, and

- $P(H/E_1 \cap E_2)$ is a likelihood of hypothesis (H) given compound evidences E_1, E_2.
- $P(E_1 \cap E_2/H)$ is a likelihood of hypothesis (H) that can cause evidences E_1, E_2.
- $P(E_1 \cap E_2/H')$ is a likelihood of hypothesis complement (H') that can cause evidences E_1, E_2.
- *P(H)* is a likelihood of hypothesis (H)
- *P(H')* is a likelihood of hypothesis complement (H').

In this paper, the term hypothesis is refers to the likelihood that earthquake-prepared building condition is being observed. The term evidence is refers to attribute (of part of building), and the partial evidence is refers to sub attribute (breakdown explanation of the part of building).

EARTHQUAKE-RESISTANT BUILDING

Analysis

In this demonstration, the attributes are limited exclusively to those applicable to earthquake resistant of non-engineered building. There are four attributes for earthquake resistant non-engineered building. The attributes are: (a) foundation, (b) concrete frame, (c) wall, and (d) roof. These four attributes were specified to minimize the risk of building collapse or damage. Every attribute has sub attributes that provide clear explanation of earthquake resistant building. Simple checklist items (see Table 1) derived from these attributes and sub attributes are the best tools for gauging building's resistant and as such can be viewed as decision aids. Table 1 provides the attributes and sub attributes earthquake resistant building.

Table 1. The attributes and sub attributes for non-engineered earthquake resistant building

Attributes	Sub Attributes
Foundation	1. The foundation should be set in and clamped with a stable soil to prevent displacement 2. The foundation should be capable to support their own weight and at least four times maximum intended load without failure
Concrete Frame	1. The vertical frame should has reinforcing bars and the bars should be connected to foundation to prevent frame collapse 2. The horizontal frame should has reinforcing bars and the bars should be anchorage to vertical frame bars securely as will automatically keep the frames plumb, level and square
Wall	1. The wall should be connected to concrete frame with connection means 2. The opening on the wall should be secured by horizontal reinforced concrete
Roof	1. The roof tile should be secured to roof frame to prevent falling down hazard 2. The roof frame should be anchorage to concrete frame to prevent roof frame collapse

All of the sub attributes description refers to earthquake resistant, so that if the answer is "yes" than it can be referred to "resistant".

Assessment of Building Condition – Bayes' Theorem-Based Analysis

Assessment of building condition stated using terms such as 'yes', 'most likely yes', 'most likely no', and 'no', and need to be translated into mathematical terms.

The assessment was done by observed each photograph and give a score for a particular condition based on earthquake resistant checklist. For example, refer to attribute 1 (foundation), the observation focused at the part of the photograph which has foundation. Then, based on the checklist the score for the building condition for foundation was given.

In this analysis an earthquake resistant building has been given a score of 100% and an earthquake irresistant building has score of 0%, so the term 'most likely yes' has a score of 66.67% and the term 'most likely no' has score of 33.33%. By scoring the safe sub attributes *(e)* based on building condition degree of belief, then the degree of belief of each attribute *P(E/e)* based on hypothesis *(H)* can be determined. Because all of the partial evidence were known then degree of confidence of attribute *(E)* based on hypothesis *(H)* was referred to *P(E/H)*. Figure 3 will be used to demonstrate the analysis using Bayes' Theorem formula (Equation 1). The demonstration consists of three steps as follows.

Step 1:

See Figure 3. Suppose the rule stated that: "The foundation should be set in and clamped with a stable soil to prevent displacement (attribute 1= E_1, sub attribute 1 = e_1)". The information revealed by visual observation of Figure 3 suggests that the foundation was set in and clamped with a stable soil. It can be seen from Figure 3 that the foundation was buried in the ground (soil) and the soil seems compacted, and so the degree of belief to say that was yes was 100%. Likewise, for sub attribute 2 (e_2), the information revealed by visual observation of Figure 3 suggests that the foundation was capable to support their own weight and at least four times maximum intended load without failure and so the degree of belief to say that was yes was 100%. From this, the degree of confidence of evidence (E_1) given two partial evidences (e_1,e_2) = *P(E/e)* = 100% = 1.00

Figure 3. Building number 12

The probability of hypothesis *P(H)* was determined based on the number of events of hypothesis divided by the number of sample space, which is referred to the number of total events of sub attributes. The total events of sub attributes could be varied based on the detailed information from the images. If the entire sub attributes could be recognized from the photograph, then the number of sample space would be 36 (four probabilities of score per sub attribute multiply by eight sub attributes plus four probabilities of score for hypothesis).

Step 2:

The other information can be revealed from Figure 3 was that photograph shown all attributes with all sub attributes. Therefore the number of total evidences was eight. From this total evidences all have four possible events, so 32 events; the hypothesis itself has four possible events as well. And so, the total events become 36. P(H) was determined as four divided by 36, and so $P(H) = 0.111$

The probability of complement of hypothesis *(H')* was determined by subtracted the probability of hypothesis *(H)* from 100%. Likewise to determine degree of confidence of evidence given H complements.

After the entire variable for Equation (2) have determined, then the degree of belief of hypothesis *(H)* given compounded evidence $(E_1,E_2,..E_N)$ can be calculated.

Step 3:

- Calculate P(E/H):
  $P(E_1/H)$ = 100% (as shown from example 1).
  For attribute 2 (E_2): e_1= 100%, e_2= 33.3%, and so $P(E_2/H) = (\Sigma e_1,e2)/2$ = 66.65%
  For attribute 3 (E_3): e_1= 33.3%, e_2= 0%, and so $P(E_3/H) = (\Sigma e_1,e_2)/2$ = 16.65%
  For attribute 4 (E_4): e_1= 0%, e_2= 33.3%, and so $P(E_4/H) = (\Sigma e_1,e_2)/2$ = 16.65%
  $P(E_1 \cap E_2 \cap E_3 \cap E_4/H) = P(E_1) * P(E_2) * P(E_3) * P(E_4)$ = 100% * 66.65% * 16.65% * 16.65% = 1.85% = 0.0185 (this result as shown at Table 2 column A)
- Calculate P(H)
  To calculate P(H), shown from example 2. $P(H)$ = 0.111 (this result as shown at Table 2 column B)
- Calculate P(E/H')
  $P(E_1/H') = 1 - P(E_1/H)$ = 1 – 100% = 0%
  $P(E_2/H') = 1 - P(E_2/H)$ = 1 – 66.65% = 33.35%
  $P(E_3/H') = 1 - P(E_3/H)$ = 1 – 16.65% = 83.35%
  $P(E_4/H') = 1 - P(E_4/H)$ = 1 – 16.65% = 83.35%
  $P(E_1 \cap E_2 \cap E_3 \cap E_4/H')$ = 0% * 33.35%* 83.35%* 83.35% = 0% = 0.000 (this result as shown at Table 2 column C)
- Calculate P(H')
  $P(H') = 1 - P(H)$ = 1 – 0.111 = 0.889 (this result as shown at Table 2 column D)
- Calculate $P(H/E_{comb})$
  Refer to Equation 2, so to simplify $P(H/E_{comb})$ = (A*B)/(A*B+C*D)
  $P(H/E_{comb})$= (0.0185*0.111)/(0.0185*0.111+0.000*0.889) = 1.000 (this result as shown at table 2 column E)

All of the assessment process was stored in MS Excel spreadsheet

Preliminary analysis results

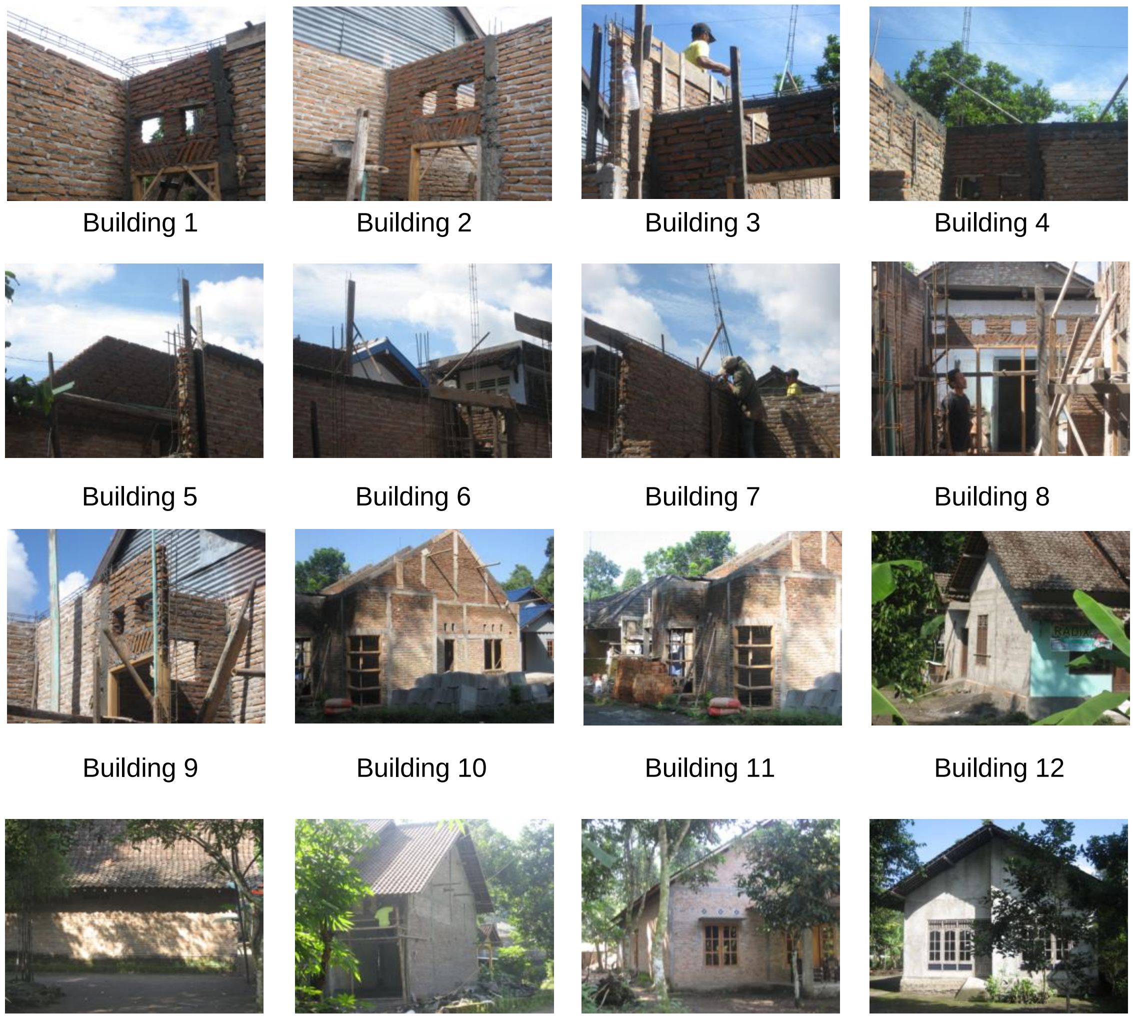
In order to "calibrate" the proposed approach, 16 photographs of building condition were used (see Figure 4). These 16 photographs were processed to compute the degree of belief that earthquake resistant buildings were being constructed. The calculation was undertaken using MS Excel spreadsheets using Equation 2 (as shown at example 3), and the result of that process was shown in Table 2.

Discussion

Interpretation of the results

The results can be used to assess the probability of the photograph showing an earthquake resistant building. For example referring to Table 2, row 12, it gives details of building number 12 (as shown in Figure 3).

The result can be stated as "earthquake resistant building" if the score of P(H/E) = 1. The photograph number 12 also revealed a result of P(E/H) = 0.018105 = 1.815%. If the score of P(E/H) closer with 100% it means that the building is most likely earthquake resistant, if closer with 0% it means that the building is most likely earthquake irresistant. Therefore, the result for building number 12, it can be defined as earthquake resistant but it classified as most likely irresistant.



Building 1 Building 2 Building 3 Building 4

Building 5 Building 6 Building 7 Building 8

Building 9 Building 10 Building 11 Building 12

Building 13 Building 14 Building 15 Building 16

Figure 4. A set of building photographs

Table 2. Degree of belief of earthquake resistant building

Photograph number	P(E│H)	P(H)	P(E│H')	P(H')	P(H│E comb)
	A	B	C	D	E=(AB)/(AB+CD)
1	0	0.250	0.835	0.750	0
2	0.165	0.333	0.835	0.667	0.089918
3	0.835	0.200	0	0.800	1
4	0.4489	0.250	0.1089	0.750	0.578778
5	0.2211	0.333	0.2211	0.667	0.333333
6	0.67	0.250	0	0.750	1
7	0.67	0.333	0	0.667	1
8	1	0.333	0	0.667	1
9	1	0.333	0	0.667	1
10	1	0.143	0	0.857	1
11	1	0.143	0	0.857	1
12	0.018105	0.111	0	0.889	1
13	0	0.111	0.27973	0.889	0
14	0.018105	0.111	0	0.889	1
15	0.018105	0.111	0	0.889	1
16	0	0.111	0.18602	0.889	0

By using this table, it can be seen that from 16 sample photographs, only three defined as earthquake irresistant building. However, from 13 photographs, three of them have scores less than 1. It means that although they defined as earthquake resistant building they most likely irresistant. Tables such as this can be utilized to check building condition when the database (table) is extended to cover all attributes of earthquake resistant characteristic. More significantly with a larger database it will be possible to provide pre-disaster building data.

Use of the result

The benefits of this proposed approach are:

- The checklist is simple and can used to quick on-site building condition assessment.
- The calculation is using MS Excel spreadsheet, so the degree of belief of current building condition can be calculate quickly.

The result from the calculation can be used to predict the condition of building either earthquake resistant or irresistant. If the result revealed that the degree of belief of current building condition is 0 then that condition refers to irresistant. So, the earthquake hazard can be detected and the occurrence of building damage because of earthquake can be avoided and can save lives.

CONCLUSION

Preliminary literature review revealed that non-engineered building is the most vulnerable building when earthquake hit. Furthermore, preliminary literature review also revealed that the availability of pre-disaster data is rare and it makes quick assessment of economic loss more difficult. Thus, the needs to detect building condition before an earthquake occur become very important.

This research has presented preliminary work to investigate building condition using photographs. Information from photographs usually uncertain, thus the Bayes' Theorem was used to define the building condition based on the degree of belief.

An example demonstrates how it is possible using this proposed approach, to identify and to detect building condition before an earthquake occurs.

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THE INTEGRATION OF ENVIRONMENT PERFORMANCE IN FINANCIAL STATEMENT: A NEW CONCEPT TO MEASURE FIRM PERFORMANCE

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ABSTRACT

The Objective of a firm is to get profit. In doing so, firms very often fail to conserve environment. In line with the demand on global environment conservation in the last decades, companies are trying to balance between the profits they want to obtain and the demands of their stakeholders on environmental issues. Unfortunately, the concept of environment performance in some cases is not very reliable. It is because till this day, especially here in Indonesia, the statements on environment performance which satisfy different stakeholders have not been standardized.This research tries to propose a model of an integrated statement on environment as well as on finance based on economical ecology and efficiency. It views company's operations as a process of input-output to produce goods and services. The concept of eco-efficiency bridges three players in the economy: companies, investors, and society (public and government). This perspective accommodates interests of all the players in the economy. The model of performance -which is eco-efficiency based- facilitates the stakeholders in making control and evaluation of the operational, financial and environmental performances of companies. Statement of environmental performance is integrated into financial statement, thus companies, investors, and public have the same media for issuing such statements.

Keywords: *environment, operational and financial performance, eco-efficiency*

INTRODUCTION

In compliance with the people's scrutiny toward environment problem and the pressure to the industrial activities about environment quality, the environment management becomes a very important thing for a company. The concencus of environment preservation that stresses on conservation and the continuity of natural resources (production) has become the world's main concern nowadays. By the existence of the global inclination about the concencus of natural conservation and the willingness to get the clean earth, the pressure toward the production process of any kinds of industries is also increasing. As a result, the companies have to think twice to be able to change their production technology in order to reach the economic sustainability.

The solution may be given to public companies or private sectors. Because the private sectors also take control of the economic growth, thus many parties are necessary to be involved in the economic planning of a nation. Businessmen, investors, and the society must work together to have and to take care of an efficient and transparent market, by publishing not only the financial performance but also the operational and environmental performances that they have reached. The publish of the environmental performance is important, moreover when it is related to the investors' behavior, which shows that the more information they get, the wider the investment scope they can choose.

In accordance with the environmental performance, the activity report system of companies in Indonesia is still less transparent for the outsiders for the purpose of monitoring the company and decision making for investment. In the future, the lack of transparency can result in the low optimism of the prediction of the company's sustainability.

Beside that, the assumption that ecological investment as a burden which will decrease the company's profit is an obstacle for the company's progress report. Thus, more serious efforts to find the more holistic (comprehensive) reporting system that shows the information balance for the economic growth or the business prospect and the protection toward the continuity of the environment are necessary.

World Business Council for Sustainable Development (WBCSD) has proposed eco-efficiency concept in the company performance report which combines economic and environment concepts. The formula of eco-efficiency is represented by calculation of product or service value toward environmental effect (the value per environmental effect).

Meanwhile, International Standard Organization (ISO) has recommended that international standard for environmental performance evaluation (ISO-14031) be used to evaluate the company's effect toward environment. ISO-14031 can identify the tendency of the company's activities relevant to the environment.

In accordance with the economic and environment point of view, it is always assumed that both issues can't be accommodated in one company planning which is based on profit orientation. This is because the cost of environment is always treated as company's burden. So, the social (environment) consideration is always neglected. In this point of view, the expense for environment is an action which is not efficient. That's why, in compliance with the environment issues, environment reporting system should be able to push efficiency. Based on *eco-efficiency* concept and ISO-14031, this research is aimed to explore company-reporting system which balances between the necessity of environment conservation and the reach for profitability in efficiency point of view.

REVIEW ON RELATED LITERATURE

Former Research

There is not certain form in the environment statement of public company in Indonesia. Many types of environment statements found in annual reports are different from each other. The beginning of this research shows that there are certain practices found in the company's environment statements. Some of them are environment discussions, the management statements about the environment fullfillment and other assertions which implicitly state awareness toward environment management. The classification of environment statement characteristics is a variable with quality dimention. Company included in high care list, for instance gets award in environment management sector, showing the high commitment toward environment management. Meanwhile, scope of statement is a quantitative dimensional variable. It means, the higher statement ratio the wider (the more) items of environment statement done by the company.

The wide of revealing itself is influenced by some factors; some of them are the push of environment management, which are the pressure of external side for management to do environment management, and proactive environment management, which is the company's internal awareness to do environment management proactively. Both variables are the key variables in non-financial perspective. The other factors that influence the wide of environment revealing are the stranger ownership composition, the company size (Cooke, 1989 in Suripto, 1999) and profitability (Singhvi, Desai, 1971 in Muslim, 2006, Neu et al., 1998).

Nevertheless, a characteristic variable and the revealing wide above have some weaknesses, especially if related to financial performance. First, characteristic variable of environment revealing is quality variable so that it is difficult to be standardized in certain form of company environment report. Second, the wide variable of environment revealing can vary from time to time, or from one of the company's object to the others. It is very hard to determine maximal item which represents the wide of environment performance revealing objectively.

Because of that, some researches that try to examine the relationship between environment performance and company financial performance failed to prove hypothessis mentioned. Some of the former researches about this for instance can be seen in Susi (2005), Sembiring (2004), Patten (2002), Stanwick and Stanwick (2000). Theoritically, the relationship between environment performance and financial performance should show positive corelation, because the higher financial performance the company is more able to do environment management and there is a push for management to reveal environment management. Nevertheless, some of the former researches even found negative relationship, and some of them failed to prove hypothesis. It can happen because company management with high financial performance does not need additional positive image to increase investor willing to their company. But for the company with low performance needs additional *good news* in their annual report to attract investor willing to their company.

This managerial behavior can give result to the deviate information toward the company. It means there is incorrect assumption or point of view in placing the theoretical framework to examine the relationship between environment performance and financial performance. Another factor is caused of the difference paradigm of social welfare with paradigm of the reach of company performance which is profit oriented.

Based on that phenomenon, the effort to meet, at least to balance paradigm between social (environment) need with company profit need is needed. The effort can be done through integrate ecology (environment) conservation concept into the company financial performance report.

Disparity of Information

It cannot be denied that there is different paradigm between environment and economy. Much kind of interest conflicts occur as a result of the existence of deviate communication among some parties with different interest, such as company business, investor and society. The deviate communication can be from the available of information, perception selectivity, and the concrete or inconcrete of the information (Sheu and Lo, 2005). The company often shows information about quite good environment, but their financial performance information doesn't show appropriate achievement (Jeffers, 1995).

Company report should be integrated holistically among operational, financial, and environmental performance. The three main groups (company, investor and society) need general basic for reporting system which refers to the concept of *one-stop reporting system*. In this model information system is formatted as good as possible so that investor, society, and company can evaluate operational, financial, and environmental performance more accurately and efficiently.

Framework of Integrated Environment Performance

A report shows economic, operational, and environment information, but there is not any clear relationship of value pattern among the three that can't be said as integrated report system (Shearlock et al., 2000). Information should be arranged systematically. Since the revolution industry happened 2 centuries ago, financial, factory, and equipment factors have become main sources in the production process. In another side, natural sources are often neglected and considered no relation with production process, although human cannot produce a natural source.

Nowadays perspective, economy requires the existence of four types of capital factors, namely human resources, financial resources, technology industry resources and natural resources capital. Human resources usually are in the form of labor and mind, culture and organization. Financial resources related to cash, investment, and other financial instrument. Technology industry related to infrastructure, machine, equipment and factory, while natural resources related to natural resources such as living circle system and ecosystem. The four capital sources form product through production process.

Integrated concept planning refers to efficiency paradigm. Eficiency refers to company effort concept in terminology input-output. In this perspective efficiency the company should try engineering production technology to get profit for the company or social environment. The alocation of natural resources effectively reflects the use of natural resources as minimal as possible which can bring maximal profit to nowadays and the next generation. Conservation activity to natural resources stresses on environment effect totally, and not partially such as limited on chemistry waste produced in production process. That is why, evaluation toward company environment performance should be seen from the environment effect point of view wholly related to the use of natural inputs, human resources, technology industry and financial resources owned to get useful product.

Evaluation toward the company performance wholly included integration of three (3) company performance factors, namely operational performance, financial performance and environmental performance, as shown in Figure 1.

In Figure1, it can be seen that in measuring each working can be determined sistematically by following input-process-output-feed back production line. Four (4) types of resources (human, financial, technology industry and natural resources) are the company's input production sources. On the other hand, there are products or outputs expected or unexpected. Expected output can be in the form of product, service and financial profit which can be measured with the profit before interest and tax (EBIT). The unexpected products are the pollutants such as emission and waste. Feedback can be determined from the ratio among many kinds of outputs with the available inputs. The ratio is reflection of the three performance measurement, they are operational performance, financial performance and environmental performance adjusted to each ratio value.

With the framework like in Figure 1, it can be seen the existence of complex relation among operational, financial, and environmental performance to determine the relevant policy. Report model which refers to integrate concept can be used to show the existence of *green accounting* and tax reformation. Framework like this also can help company to identify the balance between revenue and environment responsibility.

Economic performance report (eco-efficiency) can be used widely by company by using various indicators to monitor and to evaluate firms performance. For instance, to measure how far the product value on each gas emission issued is used measurement product value per gas emission with kilogram (or Rupiah value) per ton CO_2 equivalent (operational performance). This Ratio shows how far each air pollution effect by CO_2 gives benefit in creating product in certain amount. The measurement of financial performance can use traditional financial criteria such as EBIT, Capital Asset Ratio (CAR), Return On Assets (ROA) or use eco-efficiency ratio model to measure the reach of financial performance for certain material consumption. Briefly, eco-efficiency is ratio between output values per input value, or output value as a result of environmental effect.

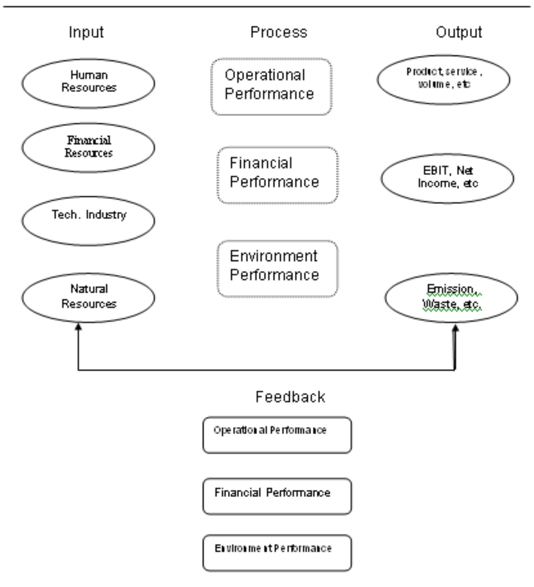

Figure 1 Working evaluation framework

Relation between Financial and Environmental Performance

Review done by Berthelot et al. (2003) shows that research about relation between *environmental disclosure* and financial performance is enough done. Some researchers usually use financial performance variable or capital market as predictor for environment performance (see Stanwick, 2000; Richardson, 2001; Cormier, 2001). In Indonesia research that examines the relation of both variables has been done by Susi (2005) and Sembiring (2004). However, some of the researchs, along with research done by Patten D.M. (2002), Stanwick S.D, Peter Stanwick (2000), fail to prove hypothesis telling the relation between environment performance and financial performance.

PURPOSE OF RESEARCH

This research is done with purposes to design company report model which mix ecology and economy paradigma using *eco-efficiency* concept approach.

BENEFIT OF RESEARCH

There are three basic benefits in this research, they are:

1. This research uses *eco-efficiency* concept which mixes two economy approaches and, to design financial performance and environment performance report system.
2. The final result of research in the form of environment integration in financial report model views the importance of report effectivity for the users, and because of that this research also uses information effectivity approach.
3. This research places ecology and economy concept in one framework, thus in the further research will be got strong place to stand on that support relation between economic performance and environment performance hypothesis.

METHOD OF RESEARCH

Analysis Unit

Manufacture companies (manufacture industry) are registered in Bursa Efek Indonesia (BEI) Jakarta. This research object is aimed especially for manufacture companies which potentially can pollute environment such as textile industry, papers *(pulp and paper)*, *chemicals*, *oil and gas*, *metals and mining*, and household equipments.

Measurement Indicators

Company, investor and society will need integrated information (financial report) badly to monitor and to evaluate company performance. The grading of financial analysis and company performance is based on traditional criteria as stated in ISO 14031 to determine input and output value criteria, and the criteria issued by WBSCD to determine eco-efficiency ratio. For more detail, input dan output data criteria in this research can be simplified as follow:

1. To measure operational performance, adapted from classic micro economy approach related to *total factor productivity* concept, labor productivity and production equipments. These are some of the indicators:
   a. *Output value/number of employees*
   b. *Output value/number of machines*
2. For financial performance, it is formulated from financial ratio available in annual financial statements, where generally the indicator for financial performance can be categorized into five ratios: liquidity ratios, leverage, efficiency, profitability, and market value. Measurement approach in this research will refer to some of the criteria, they are:
   a. *Asset turnover* (selling/total asset)
   b. *Net profit margin* (profit before lessen by capital cost and tax/selling)
   c. *Return on assets* (net income/total asset)
   d. *Return on equity* (net income/total equity)
3. To measure environment performance can be divided into two types. First, company's capability to change resources into *desirable output efficiently*, while on the other hand this performance is measured based on preventive behavior to the environment destruction effectively minimized the unexpected output. Some indicators used to measure the two types of environment performance are:
   a. Consumption of production materials efficiently *(tons of material/units of sales)*
   b. Energy use Intensity *(giga-joule/unit of sales)*
   c. Exhaust emission *(tons on GHG emissions/unit of sales)*
   d. Liquid waste emission *(tons of waste water/unit of sales)*

For more detail about INPUT and OUTPUT measurement indicators for the three types of the performance can be seen on the following Tables 1 and 2.

Table 1 Some of the chosen input indicators

Kinds of Capital	INPUT Indicator	Unit	Data Source
Human Resources	✓ The amount of labor	People	Financial Report
	✓ The amount of middle level manager	People	Financial Report
	✓ Total of work hours	Hour	Financial Report
Hardware	✓ The amount of machine	Unit	Industry Statistic
	✓ Factory wide	m^2	Industry Statistic
Financial Resources	✓ Short term debt	Rp.	Financial Report
	✓ Long term debt	Rp.	Financial Report
	✓ Insurance expand	Rp.	Financial Report
	✓ Share capital	Rp.	Financial Report
Natural Resources	Energy consumption		
	✓ Electricity	Gigajoule	Industry Stattistic
	✓ Coal	Gigajoule	Industry Statistic
	✓ Natural gas	Gigajoule	Industry Statistic
	✓ BBM	Gigajoule	Industry Statistic
	Material consumption		
	✓ Raw material	Ton	Industry Statistic
	✓ Half fixed material	Ton	Industry Statistic
	✓ Raw and half fixed materials that haven't been proceed	Ton	Industry Statistic
	Natural resources consumption		
	✓ Water	Meter cubic	Industry Statistic
	✓ Wood	Meter cubic	Industry Statistic
	✓ Mineral	Ton	Industry Statistic
	✓ The use of land	Hectare	Industry Statistic

Table 2 Some of the chosen output indicators

Kinds of Capital	OUTPUT Indicator	Unit	Data Source
The Expected Output			
Product and service	✓ Volume	Unit /kg/m2	Industry Statistic
	✓ Output value	Rp.	Financial Report
Financial output	✓ EBIT	Rp.	Financial Report
	✓ Gross margin	Rp.	Financial Report
	✓ EPS	Rp.	Financial Report
The Unexpected Output			
Emission / Waste	✓ Exhaust	Kg	Prokasih / KLH
	✓ Chemical waste	Kg	Prokasih / KLH
	✓ Solid waste	Kg	Prokasih / KLH
	✓ Liquid waste	m2	Prokasih / KLH
Other	✓ Garbage	Kg	Prokasih / KLH
	✓ Noisy	Desibel	Prokasih / KLH

RESULT AND DISCUSSION

Expected Product Values

Research is done on sample of companies potentially can pollute environment such as textile, *pulp and paper*, *chemicals*, *oil and gas*, *metals and mining*, and household equipments industries with the amount of 19 companies. The activity and operational of the research object result in the expected as well as the unexpected output. In 2006 the nineteen companies which become the research object have the expected output value (revenue) as can be seen on Table 3.

Unexpected Product Values

Naturally a company in having the expected output must also get the unexpected output automatically. It includes: exhaust (kg), chemical waste (kg), solid waste (kg), liquid waste (m^2), garbage (kg), and noisy (noise-DSB). As implied in its name, the unexpected output will give negative effect toward nature especially to the people living in this earth. The performance scoring should not only be based on the expected, but also the unexpected output must be considered by investor or common people to score a company performance. The unexpected output produced by research object company is as seen on Table 4.

Table 3 The expected output

Comp.	Output Value (Rp)	EBIT (Rp)	Gross margin (Rp)	EPS (Rp)
1	165.000.000.000	10.350.000.000	45.000.000.000	1,863
2	275.000.000.000	14.250.000.000	75.000.000.000	4,461
3	343.750.000.000	25.781.250.000	93.750.000.000	5,893
4	4.328.859.649.000	128.906.440.000	436.986.659.000	53,060
5	782.105.930.050	234.994.880.000	321.142.432.900	9,080
6	15.027.110.800	30.998.903.600	987.498.500	103,120
7	3.473.252.700	**576.535.200**	1.839.663.700	**5,000**
8	372.288.000.000	9.435.000.000	87.321.000.000	26,190
9	21.036.000.000	**5.316.000.000**	10.838.000.000	**3,000**
10	527.358.558.000	150.245.086.000	234.928.151.000	40,050
11	2.101.400.100.000	111.609.300.000	426.181.800.000	8,556
12	115.784.360.000	4.340.285.400	8.722.170.296	7,150
13	100.270.000.000	7.241.000.000	23.465.000.000	10,000
14	53.771.070.000	1.286.650.000	13.850.550.000	**19,420**
15	1.737.043.430.300	136.478.231.900	276.620.645.500	559,160
16	10.370.107.000.000	188.521.000.000	268.906.000.000	9,250
17	153.783.000.000	13.781.000.000	20.153.000.000	0,410
18	206.538.500	**1.459.614.300**	**77.716.220**	**140,000**
19	685.215.000.000	313.002.000.000	70.501.000.000	29,000

Company Performance

Conventionally, one of the public company performance can be seen from the share cost. The higher share cost is analog to the increasing wealth of the share holders. Without being realized, it needs quite high social cost for the achievement such as pollution, liquid and solid waste, noisy and another (unexpected output). Social cost dimention should also be included in performance measurement. This research tries to design financial report as well as company performance measurement by involving the unexpected output dimention.

Operational Performance

Performance is measured by comparing (ratio) between output and input, either labor or machine. Output data is as shown on Tables 3 and 4. For ilustration, operational performance shown five companies with 3 chosen ratio as seen on table 3. The ratio of operational performance is an indicator how efficient a company in doing its activities. Based on table 3, generally the higher ratio cost the more efficient the company. From the five companies listed on table 5, PT A seen from the operational performance is the most efficient, while PT D Indonesia is the most inefficient company.

Table 4 The unexpected output

Comp.	Exhaust (Kg)	Chemical Waste (Kg)	Solid Waste (Kg)	Liquid Waste (Kg)	Garbage (Kg)	Noise (DSB)
1	5.100.000	792.000	1.605.000	1.761.000	3.762.000	50
2	8.500.000	185.000	1.875.000	2.735.000	6.430.000	54
3	10.625.000	1.706.250	2.431.250	3.600.000	7.925.000	52
4	32.466.447	9.956.377	10.389.263	5.324.497	13.852.351	57
5	5.865.794	1.798.844	1.877.054	961.990	2.502.739	54
6	112.703	34.562	36.065	18.483	48.087	53
7	26.049	7.988	8.336	4.272	11.114	57
8	2.792.160	856.262	893.491	457.914	1.191.322	51
9	157.770	48.383	50.486	25.874	67.315	58
10	3.955.189	1.212.925	1.265.661	648.651	1.687.547	56
11	15.760.501	4.833.220	5.043.360	2.584.722	6.724.480	53
12	868.383	266.304	277.882	142.415	370.510	52
13	752.025	230.621	240.648	123.332	320.864	54
14	403.283	123.673	129.051	66.138	172.067	53
15	13.027.826	3.995.200	4.168.904	2.136.563	5.558.539	52
16	77.775.803	23.851.246	24.888.257	12.755.232	33.184.342	53
17	1.153.373	353.701	369.079	189.153	492.106	54
18	1.549	475	496	254	661	53
19	5.139.113	1.575.995	1.644.516	842.814	2.192.688	52

Table 5 Operational performance ratio

Comp	Output Value / Amount of Labour (000.000)	Output Value / Amount of Machine (000.000)	Output Value/ Working House (000.000)
A	2278	188.211	1.002
B	68	1.252	3
C	542	576.117	1.440
D	52	19	0,028
E	207	27.408	95

Financial Performance

Performance is measured by comparing (ratio) between an output and another output found in financial report, namely Balance and Lost Profit report. There are some financial ratio, such as liquidity, leverage, efficiency, profitability, and market value ratio. These ratio are common and the go-public company must show the ratio values so that it won't be discussed in this research.

Environment Performance

Environment performance can be divided into two types. First, company capability to change resources into *desirable output efficiently*. Second, on the other hand this performance is measured on preventive behavior of environment destruction by minimizing the unexpected output effectively.

Capability to Change Resources into Output

This ratio is almost the same as operational performance; the difference stress lied on the efficiency on the use of natural resources, such as water, electricity and land. This ratio will show how efficient a company uses the resources. For further description 5 companies are shown as well as environmental performance ratio seen from the efficiency of using natural resources aspect as shown on table 6. Based on ratio value on table 6 generally the higher the value the better the company's environment performance, because the more efficient in using natural resources. If the industry characteristic isn't controlled, means parallelized, then PT A and PT D are the most efficient in using natural resources.

Table 6 Environmental performance ratio

Comp	Output Value / Elecctricity Consumption (000)	Output Value /Raw Material (000)	Output Value/ Water (000)
A	494	26,000	9.145,000
B	4	0,077	56,000
C	69	0,496	615,000
D	67	19,000	124,000
E	3172	27.408,000	16,000

Preventive Behavior on Environment Destruction

This ratio shows how far the company prevents environment destruction caused of the unexpected outputs which are produced. One of the ways to prevent environment destruction is by minimizing the unexpected outputs which are produced. Some of the ratio showing preventive behavior on environment destruction of the five chosen companies will be shown on Table 7.

Based on ratio numbers on table 7, generally the higher the ratio value the bigger the company potency in destroying environment, because the bigger and the more waste thrown out. The five chosen companies, PT A has the biggest potency in destroying environment.

Financial Report Design

So far, most companies in the publication of financial report only state financial performance indicator, and never state environment performance explicitly. The new concept proposed in this research is publication of financial report which state either financial performance or environment performance.

Table 7 Environment performance ratio

Comp.	Chemical Waste / Amount of labor (000)	Exhaust / Working Hours (000)	Garbage / Working House (000)
A	6390,000	7515,000	3207,000
B	157,000	26,000	11,000
C	1247,000	10802,000	4609,000
D	119,000	0,215	0,092
E	478,000	714,000	305,000

Table 8 Brief financial report format of PT A

Ratio	Des-2005	Des-2006	Des-2007	Des-2008	Mar-2009
EPS (Rp)	43	53	62	45	4
DER (x)	5,5	5,5	7,13	7,75	7,56
ROA (%)	4,81	4,49	3,55	2,39	0,21
ROE (%)	31,34	29,25	28,96	20,97	1,78
GPM (%)	8,46	10,09	9,96	8,62	2,01
OPM (%)	5,74	5,81	5,85	5,54	-1,24
NPM (%)	2,57	2,21	2,24	1,23	0,55

Table 8 shows summary of a go public company's financial performance. Refers to the grading of financial analysis based on traditional criteria as stated in ISO 14031 to determine input and ouput value criteria, and criteria issued by WBSCD to determine the eco-effisiency ratio, then this research tries to give new concept for financial report integrated to financial and environment performance as shown on Table 9.

Table 9 Brief financial report format of PTA

Ratio	Des-2005	Des-2006	Des-2007	Des-2008	Mar-2009
Financial Performance:					
EPS (Rp)	43	53	62	45	4
DER (x)	5,5	5,5	7,13	7,75	7,56
ROA (%)	4,81	4,49	3,55	2,39	0,21
ROE (%)	31,34	29,25	28,96	20,97	1,78
GPM (%)	8,46	10,09	9,96	8,62	2,01
OPM (%)	5,74	5,81	5,85	5,54	-1,24
NPM (%)	2,57	2,21	2,24	1,23	0,55
Environment Performance					
Output Value / Electricity Consumption (Rp)	-	494	-	-	-
Output Value / Raw Material (Rp)	-	26	-	-	-
Output Value / Water (Rp)	-	9145	-	-	-
Chemicals Waste / Amount of Labor (kg)	-	6390	-	-	-
Exhaust / Working Hours (kg)	-	7515	-	-	-
Garbage / Working Hours (kg)	-	3207	-	-	-

Choosing Ratio

Based on identification ratio either operational, financial, and environment, not all can be used well and accurate as well as the company's objective performance indicator.

Input-output ratio or *eco-efficiency* ratio, not all of the ratio can be used well because of some limitations, some are industry homogenity factor. For example property industry will have different product with factories industry, such as cement, drugs and chemicals. The product difference implicates to the difference thing used to measure production volume. Properti industry uses unit, while industry with process production massal uses product weight measurement (ton).

Further, if we wish the effective ratio measurement for determining decision related to economic and environment performance, then each sectors of industry should be classified and measured the *eco-efficiency* ratio, so that the ratio size shows the clear precition and comparation. For instance, chemicals industry has different *eco-efficiency* rate ratio with paper industry. But the ratio measurement in various groups will make investor difficult to have the decision. The investor candidat should have good knowledge about company industry, good *eco-efficiency* ratio value for each types of industries and another fundamental factors outside the *eco-efficiency*.

Table 10 *Eco-efficiency* equipment resources compare to unexpected output

Resp.	Amount of Machine/ Exhaust	Amount of Machine/ Chemicals Waste	Amount of Machine / Solid Waste	Amount of Machine/ Liquid Waste	Amount of Machine / Garbage	Amount of Machine / Noise
1	0,00000039	0,00000253	0,00000125	0,00000114	0,00000053	0,040
2	0,00000082	0,00003784	0,00000373	0,00000256	0,00000109	0,130
3	0,00000028	0,00000176	0,00000123	0,00000083	0,00000038	0,058
4	0,00000071	0,00000231	0,00000221	0,00000432	0,00000166	0,404
5	0,00000290	0,00000945	0,00000906	0,00001767	0,00000679	0,315
6	0,00010647	0,00034720	0,00033273	0,00064923	0,00024955	0,226
7	0,00042227	0,00137698	0,00131961	0,00257485	0,00098971	0,193
8	0,00000501	0,00001635	0,00001567	0,00003057	0,00001175	0,275
9	0,00006338	0,00020669	0,00019807	0,00038648	0,00014855	0,172
10	0,00000228	0,00000742	0,00000711	0,00001387	0,00000533	0,161
11	0,00000121	0,00000393	0,00000377	0,00000735	0,00000283	0,358
12	0,00001958	0,00006384	0,00006118	0,00011937	0,00004588	0,327
13	0,00002527	0,00008239	0,00007895	0,00015406	0,00005922	0,352
14	0,00003224	0,00010512	0,00010074	0,00019656	0,00007555	0,245
15	0,00000069	0,00000225	0,00000216	0,00000421	0,00000162	0,173
16	0,00000023	0,00000075	0,00000072	0,00000141	0,00000054	0,340
17	0,00001127	0,00003675	0,00003522	0,00006873	0,00002642	0,241
18	0,00710118	0,02315602	0,02219118	0,04329987	0,01664339	0,208
19	0,00000486	0,00001586	0,00001520	0,00002966	0,00001140	0,481

Based on the analysis, *eco-efficiency* ratio must be chosen correctly that illustrates the balance composition between economy and ecology. From the discussion results, the most rational ratio to be used by each company from various types of industries are got. The ratio belong to the ratio group of unexpected output compare to expected output; input (Energy, and HR) compare to unexpected ouput, and financial output compare to unexpected output. The complete result can be seen on Tables 10, 11, and 12.

Table 10 shows comparation of company value from perspective the amount of physical equipment resources and the unexpected output. The value indicates the comparation of economy benefit and social loss occured with unexpected product like exhaust, chemicals waste and noisy. For example amount of machine and exhaust ratio for 1 company shows digits 0,00000039 (unit/kg) suggesting that each kilogram of exhaust produced by the operation of 0,00000039 unit machine. The bigger this ratio, environment performance caused by the better machine operation, means exhaust produced by the operation company's machine is smaller. In economy and ecology perspective machine resources gives very little effect toward environment destruction related to exhaust.

Table 11 shows the comparation of company value from electricity energy consumption perspective and unexpected output. Electricity energy consumption will lead company product which can destroy the environment. For instance, electricity consumption of 0,148 Kwh on sampel 1 company will produce 1 kg exhaust. The higher this ratio is the better because it doesn't produce high environment waste, it means operationally the company can keep the balance of ecology environment and economy achievement.

Table 11 *Eco-efficiency* resources input compare to unexpected output

Resp.	Electricity Consumption / Exhaust	Electricity Consumption / Chemicals Waste	Electricity Consumption / Solid Waste	Electricity Consumption / Liquid Waste	Electricity Consumption / Garbage	Electricity Consumption / Noise
1	0,148	0,953	0,470	0,429	0,201	15.100,000
2	1,066	48,973	4,832	3,313	1,409	167.777,778
3	0,094	0,583	0,409	0,276	0,126	19.134,615
4	0,270	0,879	0,843	1,644	0,632	153.605,211
5	0,591	1,928	1,848	3,606	1,386	64.233,667
6	35,997	117,382	112,491	219,494	84,368	76.546,830
7	6,837	22,296	21,367	41,692	16,025	3.124,772
8	0,069	0,225	0,215	0,420	0,161	3.772,510
9	34,276	111,768	107,111	208,997	80,333	93.235,414
10	1,347	4,392	4,209	8,213	3,157	95.136,768
11	0,620	2,020	1,936	3,778	1,452	184.253,491
12	6,327	20,630	19,771	38,577	14,828	105.651,462
13	7,106	23,172	22,207	43,330	16,655	98.962,722
14	242,100	789,457	756,563	1.476,220	567,422	1.842.167,491
15	0,048	0,157	0,151	0,294	0,113	12.095,538
16	1,931	6,296	6,034	11,774	4,526	2.833.509,434
17	5,704	18,599	17,824	34,778	13,368	121.823,056
18	1,990	6,488	6,218	12,132	4,663	58,151
19	0,042	0,137	0,131	0,256	0,099	4.153,846

On the contrary the smaller this ratio value the worse environment performance because of the electricity energy use. In other words, little economy sacrifice is able to produce environment waste (gas, solid, liquid, chemicals) in big capacity.

Meanwhile, Table 12 shows more representative characteristics which reflects the comparation between economy value and environment preservation value. To produce EBIT (profit before tax and interest) needs social sacrifice by producing environmental waste. In capital market world, ratio on table 5 reflects investor expectation, capital owner and consumer (social). Consumer isn't burdened by consuming company product because it has relatively little environmental effect. Management takes part in creating green product by producing high economy value. Investor candidat also gets relatively high security about product which does not destroy environment.

Table 12 *Eco-efficiency* output compared to unexpected output

Resp.	EBIT/ Exhaust	EBIT/ Liquid Waste	EBIT/ Chemicals Waste	EBIT/ Solid Waste
1	2.029,412	5.877,342	13.068,182	6.448,598
2	1.676,471	5.210,238	77.027,027	7.600,000
3	2.426,471	7.161,458	15.109,890	10.604,113
4	3.970,451	24.210,067	12.947,123	12.407,660
5	40.061,901	244.279,887	130.636,635	125.193,442
6	275.048,690	1.677.126,161	896.897,904	859.527,158
7	22.132,383	134.953,557	72.170,815	69.163,698
8	3.379,104	20.604,295	11.018,819	10.559,701
9	33.694,619	205.454,992	109.873,757	105.295,684
10	37.986,827	231.626,992	123.870,087	118.708,833
11	7.081,583	43.180,386	23.092,120	22.129,948
12	4.998,125	30.476,373	16.298,234	15.619,141
13	9.628,669	58.711,398	31.397,835	30.089,591
14	3.190,439	19.453,898	10.403,606	9.970,123
15	10.475,902	63.877,454	34.160,552	32.737,195
16	2.423,903	14.779,896	7.904,031	7.574,697
17	11.948,438	72.856,330	38.962,298	37.338,869
18	942.271,005	5.745.554,910	3.072.622,843	2.944.596,891
19	60.905,847	371.377,116	198.606,023	190.330,772

Financial Report Design

Financial report design at last will mix the format of financial report as seen on Table 7, but for financial performance the chosen ratio are taken as shown on Tables 8, 9, and 10. It was done because of the limit of input and output of various companies and industries are not homogenous.

CONCLUSIONS

From the result of research that has been explained before, the conclusions are as follows:

1. Company environment and economic performance model design in annual report can be formed from *eco-efficiency* concept approach.
2. Economic performance and environment performance ratio model design can be made using *eco-efficiency* concept objectively.
3. The good integrated economic performance and environment performance report model design is the ratio model which qualitatively has objective characteristics for management, capital owner or investor candidate and social / society.

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A PERFECT STORM, A PERFECT DISASTER, AND THE CHALLENGE TO RESPONSIVE DISASTER MANAGEMENT SYSTEMS

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ABSTRACT

In an archipelago situated in Southeast Asia, the Philippines with close proximity to the Pacific Ocean, is a typhoon and tropical cyclone-friendly country. While the citizens across the islands are very familiar with typhoon behaviors, anticipation of the probable disaster may still be underestimated and conventional preparation would not be enough. This past decade, the Philippines was visited by typhoons such as Xangsane, Fengshen, Ketsana and Parma that were all high-impact in strength and eccentric in behaviour. These were all perfect storms. According to the fourth assessment report of the of the UN's Intergovernmental Panel on Climate Change (IPCC), the trend and strength of tropical cyclones originating in the Pacific have increased and will continue to rise, each may be bringing a perfect disaster. A disaster is a form of chaos that is very inimitable, unpredictable and pertains to real-time monitoring before, during and after it takes place. And information communications technologies (ICT) as solutions can take a strategic role as far as preparedness, response and rehabilitation efforts are to be made. This paper intends to impart two pragmatic ways of utilizing ICT in disaster governance. The methodology entails systems analysis and rapid prototyping development approach in coming up with the ICT solution. First is facilitating cooperation among the different government agencies through a web-based Disaster Coordination System to address disaster management. A comprehensive workflow facility that permits remote exchange of data and transactions among regional centers, local municipalities and the national disaster coordinating council is the major feature of the system. Second is applying concepts of human resources but at the same time addressing the peculiarities of a volunteer in the design of a volunteer management system for the Philippine National Red Cross. The system utilizes web and mobile technologies.Both systems are perceived to be proactive and dependable references for policy-making.

Keywords: *disaster management, disaster coordination, government cooperation, volunteer management*

INTRODUCTION

In 2006, Typhoon Xangsane hit the Philippines, Vietnam and Thailand. Typhoon Xangsane was a Category 3 before it entered the Philippines (111-130mph), became a category 2 when it was about to enter the land territory. Then it became category 3 again with 125 mph maximum winds. The 125 mph became 185 mph from a category 3 to 4 then back to 3 before it finally left the Philippine area of responsibility (IFRC, 2006). Xangsane (with local name Milenyo) brought strong winds, widespread flooding and landslides in the northern and central parts of Luzon.

In 2008, Typhoon Fengshen (with local name Frank) was a Category 3 that devastated central Philippines, the Visayas and Mindanao, the two big islands in the south. According to PAG-ASA, Typhoon Fengshen had an erratic movement. From a predicted northwest movement, the typhoon took a curve west. The PAG-ASA attributed its erratic movement with a high-pressure area in the northern part of the country (Uy, 2008)

In September 26, 2009, tropical cyclone "Ketsana" brought an estimated 45cm fell in 24 hours, equivalent to a typical month's rainfall in the monsoon season and 6meters high flood in the major parts of Metro Manila." (COE-

DMHA.ORG, 2009) These were all *perfect storms*. A perfect storm is a term coined by Sebastian Junger referring to the occurrence of a storm that regenerated itself after intersecting with two other storms. As it regenerated, it became intensified, very strong and creating a gigantic wave in the sea. (Junger, 1997) So a perfect storm is seen as a result of an atypical and/or rare combination of storm behaviours resulting to aggravating or damaging events.

In the fourth assessment report of the of the UN's Intergovernmental Panel on Climate Change (IPCC), "frequency and intensity of tropical cyclones originating in the Pacific have increased over the last few decades" and will continue to rise. (Cruz et al., 2007) From 1990-2003, the Philippines have an average of 20 cyclones a year with 8-9 landfalls each year. (Ibid, p. 476) And each of these new cyclones does not just become strong but has certain uniqueness that can bring about a perfect storm and that likewise bring about perfect disasters.

A disaster is defined by United Nations as "a serious disruption of the functions of a community or a society causing a widespread human, material, economic, and environmental losses which exceeds the ability of the affected community or society to cope using its own resources." (de Guzman, 2003).

A disaster is perceived to be human-made when the community or society fails to cope. With the help of science and technology, attempts are being made to prevent or reduce the damage of disasters (ibid). But based on real experiences, whether natural or manmade, a disaster is a form of chaos that is inimitable, unpredictable and requires real-time data. In the case of typhoons or tropical cyclones, these may have similar manifestations but the movement and characteristics would be different from one another. It is likely that each has a certain persona. The Philippines that is frequently visited by typhoons and tropical cyclones is accustomed with typhoon behaviours in the past but not during this decade. Xangsane, Fesngshen, Ketsana and the recent Parma that visited the country two weeks after Ketsana did, were all high-impact in strength and eccentric in behaviour.

THE MODEL FOR THE DISASTER MANAGEMENT PROJECTS

A hazard such as typhoon, flooding or landslide can create or become a disaster, that even if technology can predict it or mitigate the damage, will still be characterized by peculiar behaviours and severed by other conditions like socio-economic, population, geographical location and climate conditions. Below is the Model of Disaster as a Form of Chaos used in this research and the development of the disaster management systems.

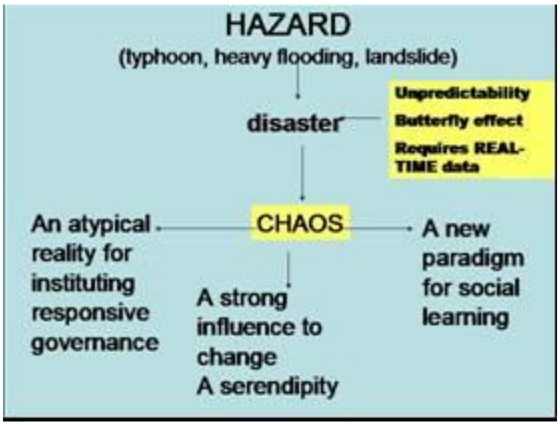


Figure 1 Model of disaster as a form of chaos

Chaos theory proposes that "given the complexity of the forces and processes that determine the weather, it can never be predicted beyond a short period of time ahead and that chaos theory sets definite limits to the predictability of complex non-linear systems." (The IMT, 2005)

Disaster as chaos similar to the perfect storm can bring about something positive or something negative, with the combination of events or circumstances taking place. In the model being presented, the disaster becomes an atypical reality for instituting responsive governance, serendipity or a strong influence to constructive change, and a trigger to a new paradigm for social learning.

In this light that Iinformation Communications Technologies (ICT) can play a strategic role. ICT can bring about various ways of responsive disaster management governance, can initiate a more progressive way of social learning and an influence for change be it in policy-making or even in planning directions.

Disaster management will have four major phases according to Cyganik (2003), and that would be mitigation, preparation, response and recovery. A good amount of planning and effort exerted in mitigation and preparation will result to a successful response. And recovery will entail longer time and higher budget.

Adopting this straightforward approach to disaster management and fused with the idea that ICT can introduce creative and practical solutions that initiatives on disaster management were undertaken.

In this paper, two disaster management projects for responsive governance are to be presented, namely, the Disaster Coordination System for national and regional disaster coordinating councils, and the Volunteer Management System for the Philippine National Red Cross.

These two non-commissioned projects were conceived in January of 2009 under the author's initiative and mentorship in the College of Computer Studies, De La Salle University-Manila. Each project had four developers and both functional prototypes were finished after ten months.

Careful systems analysis; coordination, interviews and data gathering among the respective and concerned government entities, and comprehension of the critical processes were done. To test the idea of ICT solutions, functional prototypes became the output benchmarks given a timetable of ten months. To ensure functional prototypes will be realized, rapid prototyping as a software development approach was done. Apart from these, survey of various existing information systems solutions and technology scan of different development tools were done. Both projects necessitate the use of PHP as a development tool and other open source solutions including the SMS and microblog applications.

A DISASTER COORDINATION SYSTEM FOR THE NATIONAL DISASTER COORDINATING COUNCIL

The National Disaster Coordinating Council

The National Disaster Coordinating Council (NDCC) was established under the Department of Defense and the Secretary of National Defense heads the NDCC together with the other heads of 18 departments/agencies as members. It is through the NDCC member-agencies that disaster preparedness; prevention, mitigation, and response carry out its corresponding tasks and responsibilities that are under the NDCC system (NDCC 2008)

NDCC serves as the President's adviser on disaster related programs undertaken by both government and private sector. NDCC serves as the top coordinator of all disaster-related issues and the highest allocator of resources. (ibid.)

Highlights and Major Components of the Disaster Coordination System

Two days before Typhoon Ketsana arrived in the Philippines, the National Disaster Coordinating Council released its first bulletin to warn residents in low-lying areas. The following day, NDCC raised another warning in Manila, Southern Luzon and the Visayas, and the typhoon was expected to intensify. The Philippine Atmospheric, Geo-logical and Astronomical Services (PAG-ASA) were translated the two warnings as ordinary forecast reports by. By September 26, Typhoon Ketsana uprooted 1million homes, killed 298 and destroyed Php9billion worth of crops and infrastructure (Morales, 2009)

It was very evident that an effective coordinating system between the surveillance agencies (like health, weather, peace and order etc.), the government member agencies, and local government units, private and non-governmental organizations should be in placed. A disaster coordination system may not be able to stop a disaster from happening but it can reduce the impact, raise preparedness, bring effective response and recovery. It will also provide a credible method of information dissemination.

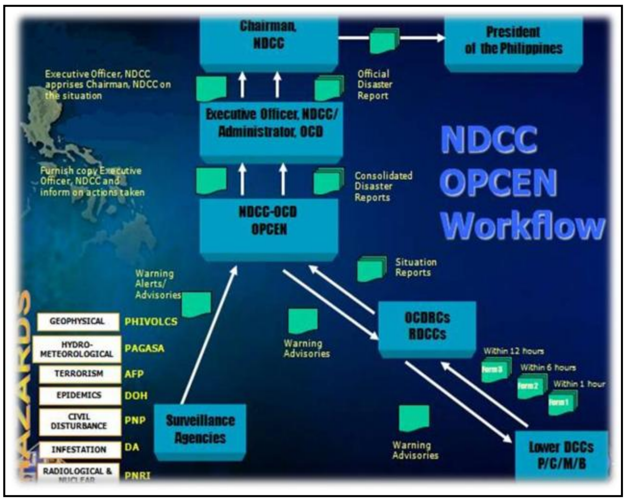


Figure 2 Workflow of National Disaster Coordinating Council operations center
Source: NDCC Website

The diagram above shows the NDCC workflow and reporting flow. The NDCC Operation Center serves as the hub of coordination and situation reports. And this is what the NDCC Disaster Coordination System is all about. It further puts the mechanism for various government agencies including the local government units to report and escalate disasters before, during and after it takes place through the secure web-based system.

Major Components of the Disaster Coordination System

Central Coordination Module

This is the tool that NDCC can use to synchronize various tasks and communication to be executed with the other member agencies. This module also employed a *microblog*, patterned after Twitter and it is used in two ways. First, the public can follow and see announcements from the NDCC, the official and the unofficial reports. Second, member agencies of the NDCC can send inter-DCS messages through the same *micro blog* to immediately report incidents seek help or provide help.

Document and Archives Module

Disaster document reports coming from surveillance agencies can be submitted in forms of scanned images or Word documents (.doc) allowing remote transactions to be done. These reports are consolidated into a final disaster report by NDCC. Metadata will be stored for each document. The final reports generated from the various disaster incidents are stored, archived and referred to for policy- making decisions of NDCC.

Figure 3 The Zouranoz Disaster Coordination System for NDCC, Main Screen

Fund Allocation Module

As a coordinating agency, the NDCC is dependent on the funds that will come from other member agencies and the Office of the President. Hence the module is designed to consider the protocols and existing procedures of the NDCC in allocating financial support to the various Regional Disaster Coordinating Councils (RDCCs) and local government units. This module generates routine and adhoc reports and ensures control measures that encourage transparency of governance.

All modules are integrated enhancing the NDCC workflow and allowing a more ubiquitous web-based reporting.

Figure 4 The list of the member agencies

Other Tools

The DCS is also designed to adapt some familiar and pragmatic tools that will allow the users of the system to find it highly usable.

1. Authentication using the *captcha* in the registration is employed.
2. A timer serves like a widget to alert the members of the council on the submission of reports.
3. Disaster icons were designed to create interest and enhance user interface of the microblog.
4. The DCS has used PHP as the web development language to allow flexibility of customization and portability.

Cooperation Between Government Agencies

Given the critical role of NDCC, it should be able to cope to fast and accurate information dissemination among various government agencies. NDCC should also provide ways and means for authorized government representatives to conveniently report, communicate or even submit documents and transactions while a disaster is taking place or even after it takes place. NDCC cannot afford to delay response to the victims as well as other people in need. NDCC should also hasten recovery efforts of local government units and should process the funding requests with control measures in placed. NDCC's coordination role is always critical. NDCC's coordination role should also empower other agencies to participate, take initiative to support and respond, and enjoin all stakeholders to collaborate.

And all of these are being addressed and pulled together by the DCS that was developed. Cooperation among government entities, trust on the NDCC advisory, empowered document workflow and coordination, efficient fund allocation and response are strengthened through this ICT solution. The DCS has the great potential to build a culture of responsive, efficient and effective reporting from the NDCC to and from the other government agencies.

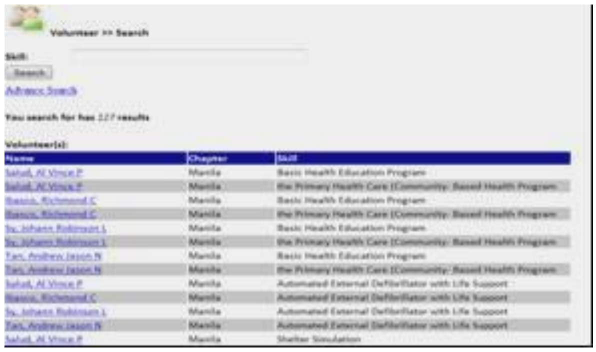
A VOLUNTEER MANAGEMENT SYSTEM FOR THE PHILIPPINE NATIONAL RED CROSS

The Philippine National Red Cross

The Philippine National Red Cross (PNRC) was created in 1947 its roots can be traced as far from the revolutionary government days of the Philippines. It has become the premiere humanitarian organization in the country. The volunteers and members of this organization are committed to quality life saving services that serve and protect not only the life but also the dignity of people especially the poverty-stricken Filipinos that are affected by unfortunate events (PNRC, 2006). At present, PNRC experience continuous increase in the number of volunteer applications every year. There are over 300 active volunteers distributed in the main headquarters and 96 local chapters.

PNRC has been having issues in storing, retrieving and manipulating data about their volunteers. And ICT provides great opportunity to address these issues through the E-VAS Volunteer Management System.

The E-VAS Volunteer Management System was designed and developed with the thorough understanding of the processes of Philippine National Red Cross (PNRC). The tasks and activities of the volunteers were taken into account and translated to allow more flexible participation. Below is the volunteer cycle that was adopted. Moreover, in the E-VAS system, any volunteer can join or enlist as a walk-in, online registrant or through any of the PNRC chapters.



The E-VAS consists of *pre-deployment module, deployment module and the post deployment module*. The *pre-deployment module* has a sub-module which is the *volunteer administration*, the *deployment module* has the *volunteer profiling* sub-module and the *volunteer monitoring* sub-module is the sub module of the *post deployment module*.

The Volunteer Administration sub-module is concerned in gathering information about the volunteers, storing and manipulating this information in order to support the operations of PNRC. This is also used during emergency and disaster operations. Training requirements will also be addressed and managed.

The Volunteer Profiling manages the skills inventory. It is responsible in giving PNRC the right volunteers for specific necessities based from their skills and trainings. This module will ensure that the right volunteers are deployed in the disaster areas. This will give PNRC a glimpse of the capacities of each chapter and give decision-makers basis in planning and implementing deployment.

The Volunteer Monitoring sub-module tracks all the deployment-related activities of the volunteer and determines the amount of volunteer work rendered for recognition purposes. The sub-module also renders deployment reports every 6 hours to efficiently monitor the volunteers and assists PNRC to determine whether to deploy or not other volunteer teams.

The E-VAS approach to the system development captures the requirements of PNRC, employs doable system architecture, and encapsulates all the volunteer activities and processes making it a very receptive to the volunteer needs. In addition, the use of the short messaging system (SMS) of a mobile phone is applied in all the modules and provides immediate way of communicating with the volunteers. Whether routine or adhoc reports, flexible report generation can be executed conveniently through the system.

Raising Volunteerism and Citizen Participation

A volunteer is an individual who expresses to perform or chooses freely to do a service. To volunteer to help is a noble intention that should not be put to waste. And to volunteer is good citizenship. And ICT plays a strategic role to know, to support, to manage, to monitor, and to recognize citizens who volunteer to the Philippine National Red Cross. The use of the short messaging system (SMS) facility with the web-based volunteer management system creates an empowering and ubiquitous PNRC services. And this system merits the attention of PNRC.

Further, the volunteer management system determines the volunteer capacity the country has as far as disaster management is concerned.

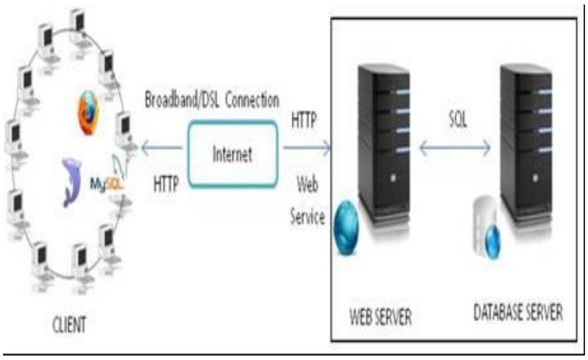


Figure 10. The system architecture diagram of the E-VAS Volunteer Management System

CONCLUSIONS AND FOLLOW THROUGH STUDIES

According to Aktan (1993), a pure public good and service that is by nature indivisible, draws positive external economies. 'External economies are defined as the consumption and/or production activities of an economic unit which affects, the benefit and/or cost functions of other economic units either positively or negatively.' (ibid, p. 124)

Disaster management has not been there in the past decades. But it is a pure public good and service. And now, it has become a formal public good and service that can involve the government, voluntary organizations, outsourced or contracted parties to deliver the goods or render the services. Involvement of private and public entities is crucial to the delivery of the service. And its impact may be positive or negative to the other economic units or entities as described earlier.

The creative and pragmatic use of ICT can effectively deliver a pure public service that will benefit all societal stakeholders. The Disaster Coordination System and the Volunteer Management System can prove and show that ICT solutions are possible. These ICT solutions need not be very costly and complex in design but can bring unimaginable culture of cooperation in good governance and encourage high level of citizen volunteerism and participation.

Presently both National Disaster Coordinating Council and the Philippine National Red Cross do have web presence through each of its websites but working systems are not yet in placed. To realize the strategic use of the systems, the government should look into these Disaster Coordination System and the Volunteer Management System. The DCS and the VMS give the opportunity for the government to take a leap into better, trustworthy governance.

One recommendation to the systems is to expand collaboration and coordination activities with external and bigger institutions outside the Philippines.

Other on-going ICT-related research projects are the (1) disaster mitigation system utilizing disaster mapping & simulation for the provincial disaster coordinating council that models a province with three major watershed dams, with mountainous terrain and low-lying areas ; (2) and a social network system to harness disaster preparedness knowledge hopefully creating a community of practice. It is also recommended that collaboration with the researches on the science of disasters be done.

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ENDNOTES

DCS – Disaster Coordination System
E-VAS/VMS –the E-VAS Volunteer Management System
LGUs- Local government units
NDCC – National Disaster Coordinating Council.
PAG-ASA - Philippine Atmospheric, Geological and Astronomical Services
PNRC – Philippine National Red Cross
RDCC – Regional Disaster Coordinating Council
Surveillance agencies – refers to the government agencies responsible for reporting any disaster outbreak. Example: PAG-ASA, Department of Health, the Philippine National Police.

Social aspects and education

TOWARDS URBAN CONSERVATION IN THE CITY OF SOLO, INDONESIA

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ABSTRACT

This paper explains theoretical studies concerning urban heritage conservation. One of the frequently occurring problems in urban heritage is obsolescence. During the rapid process of urban development, regeneration of urban historic quarters is important in establishing and maintaining the character and identity of a city. This could be done by recovering the urban areas from obsolescence through renewal of the physical fabric as well as by revitalizing their economic life.The city of Solo, Indonesia, provides an example how the Municipality through revitalization programs of several historic public open spaces has started some efforts concerning urban heritage conservation. Through the case studies, this papers tries to identify main problems faced by urban heritage of Solo especially by those historic public open spaces. It also intends to look at how the Municipality dealt with these problems through revitalization programs. It also tries to analyze several dimensions in urban conservation of both historic parks before and after the revitalization programs.This paper concludes by addressing several lessons learned from the case studies, that substantial identified problems concerning conservation and socio-cultural aspects were resolved through revitalization programs. Despite the city's success in restoring their original function as public space as well as rehabilitating the decaying structures within the areas, some challenges still remain concerning the issues of authenticity and sustainability of the urban heritage.

Keywords:urban conservation, urban heritage, revitalization, historic public space

INTRODUCTION

The term heritage is used to represent a kind of legacy that has been bequeathed by the earlier generations to be passed on to the current and future generations. Ashworth and Turnbridge (1990:105 in Timothy and Boyd, 2003:3) define heritage as: *"The contemporary uses of the past… the interpretation of the past in history, the surviving relict building and artifacts and collective and individual memories are all harnessed in response to current needs which include the identification of individuals with social, ethnic and territorial entities and the provision of economic resources for commodification within heritage industries."*

Timothy and Boyd (2003) argue that the majority of heritage supply is urban in location. Urban heritage comprises not only individual buildings or monuments of historic interest, but also the physical attributes of buildings, public spaces and urban morphology (Orbaşli, 2000). The term 'heritage' acknowledges not only the non-economic values of the asset – in contrast with 'resources' which implies the consideration of its economic values – but also its bequest which further implies certain obligations and responsibilities (McKercher und du Cros, 2002).

FROM MONUMENT PRESERVATION TO URBAN CONSERVATION

The concept of conservation in many countries has developed in similar ways. At first, preservation policies were concerned with the "pastness" of the past, but afterwards, conservation and revitalization policies were about creating and maintaining "a future for the past" (Tiesdell, *et.al,* 1996). It developed from creating inventories of historic buildings to enacting legal frameworks for conservation of historic urban quarters.

At present, conservation is no longer considered a purely defensive activity (Breitling in Cain, 1981). The concept of conservation is more dynamic compared to that of preservation, since preservation is merely intended to maintain the historic building intact, while conservation aims at "*strengthening unique character of the building as well as maintaining the harmony between the old environment and new development in accordance with public aspiration*" (Reynolds, 1978, as quoted in Budihardjo, 1984).

OBSOLESCENCE AND URBAN CONSERVATION

One of the frequently occurring problems in urban heritage is obsolescence. Obsolescence can be defined as diminished utility, the reduction in the useful life of a capital good (Tiesdell, et al, 1996). The phenomena of obsolescence on a city-wide scale demand the spatial rearrangement for improving relationship between areas and urban management is necessary to control the continuous change in the city (Thomas, 1996).

During the rapid process of urban development, regeneration of urban historic quarters is important in establishing and maintaining the character and identity of a city. This could be done by recovering the urban areas from obsolescence through renewal of the physical fabric as well as by revitalizing their economic life through utilization of historic buildings. According to Tiesdell, *et al*., (1996: 166), *"the revitalization of historic urban quarters involves two processes which inevitably conflict: the* rehabilitation *of buildings and areas which seeks to accommodate the consequences of economic change and* preservation *which seeks to limit change and to protect the character of historic buildings and areas."* Therefore, a compromise between both issues is required. The resolution should be based on the protection of the spirit of the place – the *genius loci* – as the most important feature of an historic urban area.

Physical conservation of historic property should be undertaken in accordance to conservation principles as indicated by some charters concerning cultural heritage, including the Burra Charter. The Burra Charter promotes a careful approach: *"do as much as necessary to care for the place and to make it useable, but otherwise change it as little as possible so that its cultural significance is retained."* Some physical conservation measures are known as: maintenance, preservation, restoration, reconstruction, and adaptation. These measures must be carried out with attention to the value of authenticity of the historic property. The degree and magnitude of permitted change and the implementation of controls in relation to the historic character of the quarter is therefore necessary. The control of change in such areas needs to be a negotiated process involving the reaching of consensus (Tiesdell, *et al.,* 1996).

The broadened concept of conservation from individual building preservation to urban area revitalization and improvement requires integration to overall context of urban planning. The various aspects of planning like current and future land-uses, traffic circulation, as well as the demographic and social composition in such areas become involved in conservation issues (Ashworth and Turnbridge, 1990: p.15).

Figure 1. Broadened concept of conservation according Ashworth and Turnbridge (1990, p.15), summarized by Author

According to Orbaşli (2000), urban conservation has three dimensions that are interrelated and overlapped to each other. They are physical, spatial and social dimensions, which are encompassed within time as the fourth dimension. The characteristic of an urban conservation is not solitary, but rather multifaceted projects where many aspects and various parties are interconnected.

URBAN CONSERVATION IN THE CITY OF SOLO, INDONESIA

Unlike those developed countries, Indonesia as a developing country has not done very much on the field of urban conservation. Indeed, the conservation of historic sites in Indonesia is not a new issue. The significance of the conservation of cultural heritage has been recognized as early as 1931 in the *MonumententOrdonnantie* Number 19 (*Staatsblad* Year 1931 No. 238). The law was then replaced by the Property Law of the Republic of Indonesia No.5 Year 1992 *(UU No.5/1992)*. However, a legislation on urban conservation is still absent.

Table 1. Dimensions of urban conservation and their characteristics according to Orbaşli (2000), summarized by Author

Dimension	Characteristics
Physical dimension	Building conservation (covers projects involving old buildings, group of buildings, new structures). the building fabric, the urban pattern, streets, open spaces, green areas and urban vistas.
Spatial dimension	The urban planner's view of the city as a hole, including relationship between spaces and their use, circulation and traffic, and the internal and external space relationship.
Social dimension	Difficult to define, but the most important one, as continuity of conservation can only be achieved through the continuation of urban life.

Like in other cities in most of developing countries, conservation issues have always been confronted with modern development. The rapid growth of population in big cities along with the extensive flow of urbanization continuously demands urgent developments and improvements, such as basic infrastructures provisions, housing, jobs, traffic and transportation improvement, and slum upgrading as priorities. These demands are so pressing that urban conservation still at its beginning. At present, those problems are also being experienced by Surakarta, which is popularly known as Solo, the second largest city in Central Java Province.

Based on completed heritage inventories carried out in 1989, the Surakarta Municipality passed the Mayor's Decree No. 646/116/I/1997 regarding historic buildings and areas of Surakarta in 1997. There are seventy historic buildings, monuments and urban sites that have cultural significance to the city listed in the Decree and are protected under Cultural Property Law. The cultural heritage is arranged into six categories:

1. areas or districts
2. traditional buildings
3. colonial buildings
4. religious buildings
5. gates, memorials, bridges and street furniture
6. parks and public open spaces.

(Source: Decree of Mayor of Surakarta City No. 646/116/I/1997 regarding historic buildings and areas of Surakarta in 1997)

Nevertheless, the absence of regulations concerning the protection of the listed urban heritage has led to various problems. Conservation and social-cultural aspects were two among various problems identified in several urban heritage of Solo(Agustiananda, 2005):

1. Conservation aspect: vacant and decaying historic property
   a. Public property the problem might have resulted from the lack of concern or attempts to maintain those buildings and areas → also correlates with the lack of regular funding and incentive/disincentive schemes for conservation from the government or local authority.
   b. Failure or no serious attempts to find new uses for historic buildings and area
2. Socio-cultural aspect: informal vendors in or near historic monuments and areas:
   there are many illegal structures and informal vendors packed in or near the historic areas. This phenomenon is part of the excess of the economic crisis and social unrest of the city in 1998. Informal sectors were one of the worst hit economic sectors that caused many people to lose their jobs.

However, the condition became different when the new mayor was elected in 2006. Mr. JokoWidodo, with his vision and mission to reaffirm Solo as the City of Culture, the Municipality of Solo started to pay more attention to urban heritage. One of the main physical development program carried out by the Municipality is the revitalization of historic public space, which was designated as historic buildings and areas of Solo under category *Parks and Public Open Spaces*.

Revitalization of Historic Park of Monumen '45 Banjarsari

This park was once a field for battle training and horserace of the Mangkunegaran Aristocracy named Villa Park surrounded by residential neighborhood.

Figure 2.Villa Park, the initial park, circa 1900 (Bruggen and Wassing, 1998)

To commemorate the place where "the Four Day Battle" of the local with the Dutch in the 1945, a memorial was built in the area in 1976. Until before 1998, the park has become one of the favorite urban spaces. After the economic crisis hit Indonesia in 1998, informal vendors began to occupy the area.

To restore the park to its original function as urban green area, the Municipality started a revitalization program. This program was a great task in terms of coping with possible mass reactions as well as great budget required for compensation.

This program was completed in about eleven months, consisting various phases: *inventory, new market design and construction development, public meetings, relocation process, and monument and park restoration.*

Through a persuasive and sensible approach, the Municipality finally succeeded in relocating 989 informal vendors to its newly built market through an attractive traditional transfer procession. The park itself was restored to its original function as public space for various activities like recreation, sports and flag ceremony.

The revitalization project consisted of: 1) maintenance and repair of the monument; 2) replanting of the vegetation; 3) rehabilitation of the street and pedestrian walkways; and 4) setting up of children playground. A comparative analysis of dimensions in urban conservation before and after the revitalization program of Balekambang Park is shown in table below.

Table 2.Analysis of dimensions in urban conservation before and after the revitalization program

	Before	After
Physical dimension	▪ The informal vendors built temporary shelters in the park. ▪ Their 'kiosks' were made abruptly of used building material, causing a chaotic view as well as depletion of the physical structures. ▪ It had led to degrading environmental condition in the area.	▪ The memorial was rehabilitated, playgrounds and sports grounds were built, plants and grass were replanted, and infrastructures in the area were repaired. ▪ The park was reborn, and once again it turned out to be the favorite public space in the city.
Spatial dimension	▪ Informal marketplace created traffic and circulation crowds. ▪ The neighborhood's function as residential area was disturbed and spatial harmony within the district was damaged.	▪ Traffic and circulation was recovered and internal and external space relationship was improved. ▪ The historic park regained its function as public space that not only serves surrounding residential neighborhood but also becomes an urban landmark
Social dimension	▪ The area flowed down in the social structure. The informal vendors who illegally inhabited this area were marginal community. ▪ Before the project began, the Municipal Agency for Informal Vendor Management carried out an inventory. ▪ Inventoried vendors were invited by the municipality to a number of public meetings to discuss about them and the city's future. The forum finally decided on the relocation as an indispensable measure.	▪ The municipality built a two-storey market building for their relocation in the urban periphery. ▪ To support this relocation, the municipality: -improvedtransportation management to ensure public accessibility to this market. -gave various facilities, including permits and other required documents, management training, investment subsidies and bank loans. ▪ Occupying a legal place, they obtained guarantee for their business continuity.

Figure 3. Monumen 45 Park (2005), before the revitalization program, crowded with informal vendors (Author's collection)

Figure 4. Monumen 45 Park at present, after the revitalization program (Author's collection)

Figure 5. PasarKlithikanNotoharjo, the market built to accommodate informal vendors post-relocation.

Table 3. Analysis of dimensions in urban conservation before and after the revitalization program

	Before	After
Physical dimension	▪ During its twilight period, physical structure of the area is worn out. ▪ Actors and actresses of kethoprak together with their family built and lived in semi-permanent dwellings within this historic area. These had created not only unpleasant view but also environmental problems. ▪ The structure of *kethoprak* building became decaying as less and less people came to see and no budget for its maintenance. Eventually part of the park became a slum area.	▪ During revitalization program, all decaying and illicit structures in the area were torn down. ▪ The park was replanted by a range of vegetation to restore it as botanical garden, bearing an ecological function as the city's air cleaner and water/nature reserve. ▪ To recreate Balekambang not only as nature reserve but also as center for culture and arts, several new structures, like a new building for art performances and open-air theatre were built, and some others construction projects, like art gallery and workshop were planned to be built in the future.
Spatial dimension	▪ When the area developed into a slum and dilapidated neighborhood, this historic park suffered from several functional problems. ▪ There was discrepancy with its original function as an historic green area that was intended not only as bio-conservation area but also a public space. ▪ The failure in its functionality had certainly made it an unproductive urban asset.	▪ The revitalization program restored its function as an urban green open space, and also improved its circulation and accessibility. ▪ Distance between buildings to be built within this park is considerable, keeping low building ratio of the area. ▪ Based on the program master plan, the built area is much smaller than the green open space → conforms to the building order.
Social dimension	▪ Like the case of Monumen 45 Park, Balekambangflowed down in the social structure. ▪ People who inhabited semi-permanent dwellings inside the complex lived in limited infrastructures and services. ▪ Within this deprived condition, a concealed prostitution area started to develop in the area. ▪ These disadvantaged social and cultural circumstances had contributed to the declining image of the historic park.	▪ The revitalization program has managed not only to restore the park to a desired natural condition like that of the past, but also to return its image as a public space. ▪ Ilegal structures were demolished and its inhabitants were relocated in advance.Relocation for them meant not only to make a better livelihood, but also to improve their quality of life.

Revitalization of Historic Park of Balekambang

PartiniTuin, or popularly called Balekambang, was a public recreational park built by the Mangkunagaran VII by the end of 1921. In the vicinity there was also Partinah Bosch, a small man-made forest. Both green areas had various plants, including those of rare species, and became an important green open space of the city.

A pond, along with a small wooden structure or shelter called *bale,* was built inside the PartiniTuin. From a distance, the bale looked as if it floated (*kambang)* in the pond. Therefore, the park derived its name Balekambang, the floating wooden shelter.

During the course of history, local drama *kethoprak* and traditional dances were frequently performed to the public park. Starting from 1970s, many people visited this park to see kethoprak performing. Then in 1987, Balekambang became more popular and reached its peak. However, afterward, its popularity fell down to its trough.

Considering its historic and cultural significance, the Municipality carried out a revitalization program for about a year from the preparatory, execution until finishing phases. The program was completed in 2008. A comparative analysis of dimensions in urban conservation before and after the revitalization program of Balekambang Park is shown in table below.

Figure 6. Balekambang Park (2005), before the revitalization program (Author's collection)

LESSONS LEARNED FROM URBAN HERITAGE CONSERVATION IN SOLO

The concept of conservation had developed from monument preservation to area conservation, which not only about conserving buildings from the pasts but also maintaining harmony between the old and the new environment in order to strengthen the character of an historic area or town. This could be achieved through urban regeneration, which recovers historic buildings and urban areas from obsolescence as well as revitalizes their economic life.

Figure 7. Balekambang Park at present after the revitalization program (Author's collection)

The city of Solo has demonstrated preliminary efforts in urban conservation through historic public spaces revitalization. In the case of Solo, substantial identified problems concerning conservation and socio-cultural aspects were resolved. Revitalization projects of both historic parks succeeded in restoring their original function as public space as well as in rehabilitating the decaying structures within the areas. The economic continuity of local community, including the informal vendors, was retained. The image of both parks has been brought back and became public green open space over again for the residents' leisure activities.

A compromise is necessary in dealing with the process of revitalization of historic urban areas as it involves conflicting issues, like preservation versus rehabilitation/restoration. The two case studies of historic urban space revitalization in Solo demonstrate that both opposing issues have not been treated in a balanced manner. Despite its success in physical rehabilitation, poor consideration was given to the authenticity of historic structures during the restoration projects of both public spaces. In fact, a particular attention should be given to this issue, so that the degree and magnitude of the permitted change and implementation of controls should be decided and applied in the urban revitalization.

Another challenge remains in urban heritage of Solo that revitalization programs intended to improve urban areas were carried out moderately by projects and not as comprehensive programs. Creation of special working group in each historic public space, consisting of officials of public institution, hired professionals as well as leaders of the local community is crucial in order to achieve sustainable heritage management. Above all, it is necessary for the Municipality of Solo to develop a legal framework for urban heritage conservation that is integrated to the overall urban planning.

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HERITAGE CONSERVATION AND DISASTER MITIGATION

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ABSTRACT

Is there any relationship between heritage conservation and disaster mitigation? Is there any preparedness to maintain our heritage conservation area from any vulnerability? In this time, we live in unpredictable weather and natural disaster. Earthquakes, volcanic activity, and other vulnerability become some hazards for heritage conservation area. We don't know where and when the disaster will happen. As far as we know, heritage conservation area is consists of tangible and intangible heritage. Sometimes, we have mapping and documentation data that concern with those one. But, it is not final process. We must prepare the worst alternative (disaster) in order to protect the heritage site from the damage. Pre and post disaster preparedness become an important thing to think. Risk analysis study, planning mitigation efforts, emergency response, creates emergency equipment safety and also movable artifact, must be planned. So, sustainable preservation and comprehensive approach to the historical milieu are one alternative to maintain this historical site. Before sustainable preservation model implementation, many identify issues and conducts basic research on mitigating disaster damage to cultural heritage have been proposed for creating the proper strategic. There are assessing the values of cultural properties and their vulnerabilities, assessing traditional procedures for mitigating disasters, create disaster mitigation technologies, and create disaster mitigation planning and policy. Interrelated with intangible heritage (community and human activities), we must create the sustainable community. A sustainable community is the community model that fosters the local population to concern their historical site and environment. The result from these approaches indicates community's awareness of the place. After measuring awareness, and understand the community's current condition, we can deliberate on what sustainable communities strategic we can properly build of the place. So, beside encourage the local community we can correct the negatives condition of the place with removing the negative and making a positive. While the problems are solved, we can retain the sustainability of the place and keep the community's spirit, and it will considerably enhance the character of the whole area, and help define an image for historical site.

Keywords: *heritage conservation, disaster mitigation, sustainable preservation, sustainable community*

THE IMPORTANT OF HERITAGE CONSERVATION

Heritage conservation areas are important part of our urban fabric. They are a significant thing that forming an urban tissues. Based on What, Why, How Preservation, we know that a heritage conservation area is essential because can be optimized as:

1. Part of our lives & livelihood.
2. Identity & sense of place
3. Historic value
4. Architectural & arstitic merit
5. Economic benefit
6. Tourism Potential
7. Inspiration and Educational Purposes

SUSTAINABLE COMMUNITIES IN HERITAGE CONSERVATION AND DISASTER MITIGATION

And what is about the relationship between heritage conservation and disaster mitigation? Actually, the heritage conservation areas show their existence. But, sometime we can't predict what will happen in the future. In this time, we live in unpredictable weather and natural disaster. Earthquakes, volcanic activity, and other vulnerability become some hazards for heritage conservation area. As seen in many countries where cultural assets are irreplaceably lost or severely damaged. We don't know where and when the disaster will happen. So, we must prepare the worst alternative (disaster) in order to protect the heritage site from the damage.

The first step that must we do is mapping aspect about the characteristic of heritage area, like:

1. Nature (existing natural environment): landform, topography, surface water, soil, vegetation, ecological nisches, climate.
2. Culture (social & Cultural system): historic phases of area development, existing public & quasi public infrastructure, zoning, land use, new development proposal, city structure, activities.
3. Gestalt (appereance): view into & out of the area, visual orientation, spatial definition, sense of place/identity making, entrance point & gateways, building & structure.

Mapping aspect in physical and physical characteristic is a vital process. Because heritage conservation has interrelated with tangible heritage, intangible heritage, and abstract heritage, so mapping all of the aspect means conservation data itself. This mapping aspect is included in pre disaster mitigation (preventive action). In this proses, it has correlation with assessing the values of cultural properties and their vulnerabilities strategic.

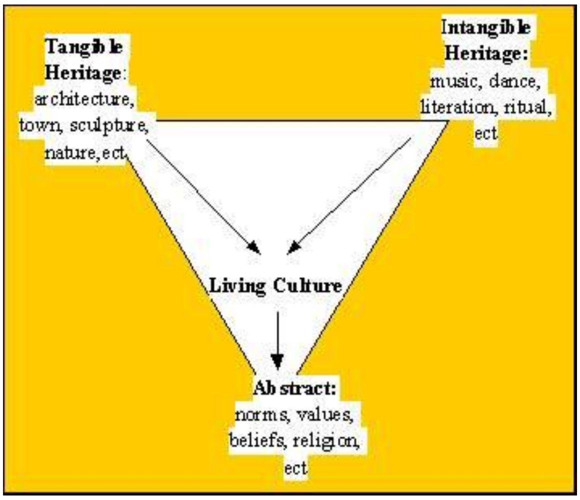

Figure 1. Mapping aspect of living culture
Reference: Andy Siswanto available at www.library.usu.ac.id

According to Sektiadi & Ayuati, 2006 and Rits-DMUCH, 2009 studies, there are two step, pre and post disaster mitigation in heritage conservation area.

Table 1. Step of disaster mitigation

Pre Disaster Mitigation	We must prepare the risk for cultural heritage as: • the integration of cultural heritage assets into existing disaster management plans and; • The use of preventive approaches that improve or maintain the condition of heritage assets to ensure survival of the heritage and its significant messages during and after natural disasters. • using a risk management approach to preservation issues, like: identifying all risks to heritage, assessing the magnitude of each risk, identifying possible mitigation strategies, and evaluating the costs and benefits associated with each strategy.
Preparedness for post disaster	▪ Planning for the heritage, including movable artifacts and documentations ▪ Planning for safety equipments system ▪ Planning for land use evacuations ▪ Managerial Planning and staff education ▪ Prioritization

Reference: Sektiadi & Ayuati (2006) & Rits-DMUCH (2009)

So, pre and post disaster preparedness become an important thing to think. Risk analysis study, planning mitigation efforts, emergency response, creates emergency equipment safety and also movable artifact, must be planned (Sektiadi & Ayuati 2006). Beside that, collaborative managerial in pre and post disaster mitigation needs to be underlined.

Beside physical artifact (tangible heritage), we must think about intangible heritage (community). Interrelated with intangible heritage and sustainable development paradigma, we can create sustainable community. A sustainable community is the community model that fosters the local population to concern their historical site and environment. The result from these approaches indicates community's awareness of the place. After measuring awareness, and understand the community's current condition, we can deliberate on what sustainable communities strategic we can properly build of the place. So, beside encourage the local community we can correct the negatives condition of the place with removing the negative and making a positive.

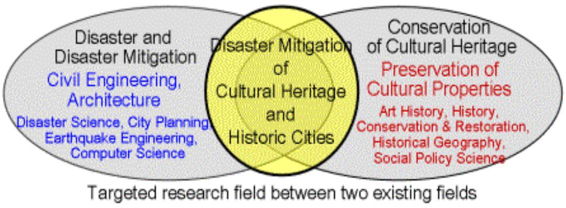

Figure 2. Collaborative managerial (knoweledge and stakeholder) in disaster mitigation
Reference: Rits-DMUCH, 2009

While the problems are solved, we can retain the sustainability of the place and keep the community's spirit, and it will considerably enhance the character of the whole area, and help define an image for historical site. In this process, it is included in sustainable preservation and comprehensive approach to the historical milieu as one alternative to maintain this historical site. Beside that, it will integrate in assessing traditional procedures for mitigating disasters.

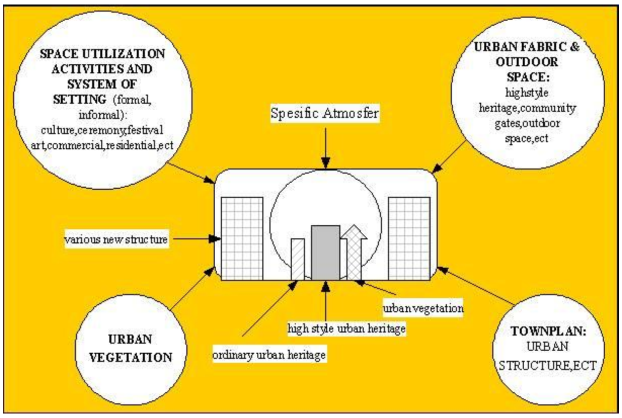

Figure 3. Dynamic Conservation
Reference: Adhisakti

Creating sustainable communities is very important process. From this point, we can maintain the life of cultural heritage as part of dynamic conservation and also for the world's sustainability.

According to sustainable preservation concept, we know that preservation not only preserves the historic character of older towns and cities, but also can embedded energy 39% of of maintenance and operations for the entire life of the building (WBDG, 2010). Preservation keeps our nation's history and culture alive and keeps our planet still live.

Figure 4. Importance of World Sustainability
Reference: Baker, 2006

LEARNING SUSTAINABLE COMMUNITIES IN HERITAGE CONSERVATION AREA

Kotagede

Interconnected with upper statement, we will discuss about the disaster mitigation in Kotagede Yogyakarta. Kotagede is one of the heritage area that has a high cultural level and typical life of people, both physical culture (Tangible Heritage) and non – physical (Intangible Heritage). Regions Kotagede as a Heritage Culture has the physical potential (Tangible Heritage), especially old buildings that have ± 50 years old. Those buildings are the Traditional Javanese House (a settlement with architectural fence complete with pendopo) with many kind of decorative multiformity, Kalang House with building typology that affected by Colonial architecture, China, Islam and Traditional Javanese House and non-physical potential (Intangible Heritage), that is a local characteristic culture that can be seen as handicrafts, arts and religious rituals.

As far as we know, earthquake 27th May 2006 had destroyed Kotagede and make people were injured or die, damage for this area, and break the cultural activities. This condition becomes worst because of wrong restoration particularly on java traditional centre. Stone deterioration because of ageing and climate effect made the situation more serious.

The human activity in this complex may define into research, conservation, cultural and tourism activity. Some supporting infrastructures, for examples museum, offices, restaurants, souvenir stalls, and performance stages, were buried after the earthquake. As the final impact of the disaster, some values were lost, such as architectural, historic, aesthetic, religious, and economic. So, we need a strategic formulation in post disaster in order to minimize impact of the disaster that has occurred and in unpredictable time.

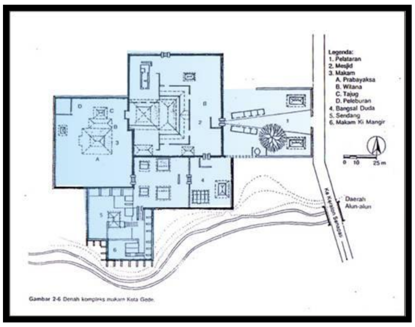

Figure 5. Physical structure of Kotagede
Reference: Wiryomartono in Oktaviyani (2008)

Before

After

After

Destroyed Pendopo

Figure 6. Damage in Kotagede after earthquake
Reference: Oktaviyani (2008)

The first we must do is mapping ‘living culture’ aspect.Based on Octaviyani research (2008), we know that mapping aspect of Kotagede’s living culture (that still eksis in) is like Table 2.

Then, according to Sektiadi & Ayuati (2006) and Rits-DMUCH (2009) studies, we must plan about the risk analysis as a plan for Post-disaster preparedness. After earthquake, some observations must be held to gain the condition of the temples, movable artifacts and documentations. Dangerous stones and valuable artifacts must be removed and stored in safe place. Restoration and rehabilitation can be done after evaluating all aspects, such as building structure and socioeconomic condition. Safety equipments have to be prepared for evacuation, first aid, and to avoid damage continuation. All institutions that are related to emergency response (hospital, police, governmental disaster response team) have to be coordinated. For evaluating the condition of the heritage, some experts must be involved, such as archaeology, civil engineering, geology, biology, and meteorology. Coordination with some experts in social discipline, such as anthropology, sociology, and psychology, must be done to recover public's attention.

Table 2. Mapping Aspect in Kotagede

SPATIAL KAWASAN	KARAKTERISTIK ZONASI	SITUS	BATAS ZONASI
ZONA INTI	- Kawasan Bersejarah. - Pusat/ aktivitas bersejarah dari berbagai etnis masyarakat hingga saat ini. - Kawasan Aktivitas Ritual Keagamaan.	- Watu Gatheng dan Watu Gilang (Cungkup)	Kampung Alun – alun, Kel. Purbayan
		- Alun – alun : Pemukiman Kampung Alun – alun	Kampung Alun – alun, Kel. Purbayan
		- Kompleks Masjid Besar Mataram Kotagede	Kampung Sanggrahan, Kel. Jagalan
		- Pasar Kotagede	Kampung Sayangan, Kel. Jagalan
ZONA PENYANGGA	- Pemukiman penduduk dengan berbagai macam arsitektur. - Ada aktivitas masyarakat Kotagede ke wilayah inti untuk melakukan ritual pada hari, bulan tertentu serta menunjang aktivitas penduduk (Pelaku Aktivitas).	- Kampung Dhondhongan	Kampung Sayangan, Kel. Jagalan
		- Rumah Kalang (Anshor Silver)	Tegalgendu
		- Rumah Kalang	Kampung Jagalan, Kel. Jagalan
		- Rumah DeretNon Vegetasi	Kampung Mranggen, Kel Prenggan
		- Rumah Deret Asli	- Kampung Nyamplungan, Kel. Prenggan - Kampung Kebohan, Kel. Purbayan
		- Rumah Tradisional Jawa (Rumah Joglo)	Kampung Alun – alun, Kel. Purbayan
		- *Kotagede Between Two Gates* (Rumah Berasitektur Pagar)	Kampung Dalem, Kel. Purbayan
		- Pelatihan dan Pentas Seni Budaya Setempat	Kampung Pasagen, Kel. Purbayan
ZONA PENGEMBANGAN	Kawasan yang tidak memiliki keterikatan atau keterhubungan langsung dengan Kawasan Inti dan Kawasan Penyangga karena keberadaannya tidak dipengaruhi lokasi cagar budaya tersebut.	- Showroom Kerajinan di sepanjang Koridor Utama	Jl. Mondorakan, Jl. Tegalgendu
		- Pengrajin (skala kecil) pada Daerah Belakang	Kel. Prenggan, Daerah Kemasan
		- Norma/ Tata Tertib	Kawasan Kotagede

Sumber : Hasil Analisis, 2008

So, these are strategic formulation in post disaster in order to minimize the disaster in unpredictable time. What’s about the community and socioeconomic condition? We must plan the sustainable communities like in Japan and another vulnerable city in the world. The sustainable communities must be part of sustainable development in heritage conser-vation area.

A sustainable community is a sustainable, eco-friendly, maintaining the well-being of the community and striving towards increasing sustainability of heritage conservation area. The key component of equity and sustainability is equal access to benefits of existence and involve the community and specific subgroups such as women, children, and the elderly. A community management that established in this area can create an effective community development corporation. So, we must enhance the sustainability of the area before and after disaster by activated the role of subgroup communities.

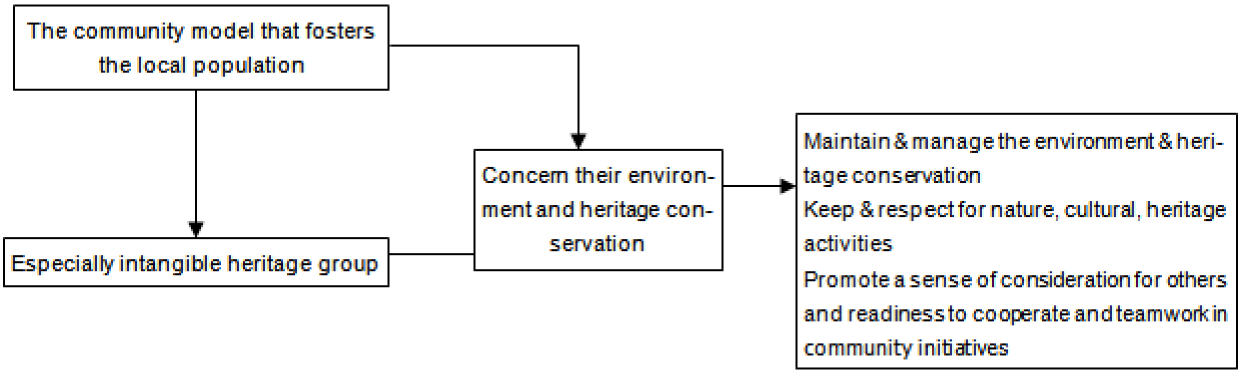

Figure 7. Sustainable communities model
Reference: Analysis, 2009

Town watching can be one solution to create this sustainable community. According to Shaw and Takeuchi (2010) town watching is a participatory technique used in community or neighborhood planning in order for residents to recognize problems as a group and put forward solutions together. The use of town watching has been extended to dealing with disaster and safety related physical issues such as safe or unsafe places and evacuation routes; we shall call this disaster town watching.

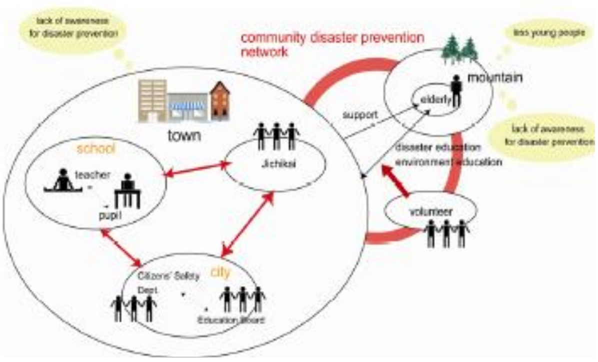

Figure 8. Town Watching Framework
Reference: Shaw and Takeuchi (2010),

2. THE OLD MULTIETNIC ALONG SEMARANG RIVER

Semarang River's role started to change when merchant transportation was done through the land-way. This was resulted from the building of push de Groote Postweg street and also the appearance of train in 1881. The phenomena influenced the arrangement of settlement along the river. Settlement orientation (building and its public activities), changed from through the river into the land. Transportation facilities became more varied, not only ship, but also there was a habit to use buggies and sedan chairs (Wardhani 2000).

Nowadays, the areas that become parts of Semarang old city undergo a physical, social, and economical degradation as a result of decreasing environment's quality. This degradation started from 1970s when the Old City Area got trapped on the flood problem, which cannot be handled until today. The existence of flood is influenced by the development of lower area of Semarang that is very fast since early of the New Sociopolitical Order until today.

All the more, the old city (included the Old Kampong along Semarang River) is included the 'rob' (tides/drowning) area. Tides, flooding, and drowning are the chronic problem, causing extensive damage to settlement everyday. High tides occur eveyday. The recent improvement project has attempted to combat this conditions bybuilding up the street level. However the scope of these improvements is limited and progress is slow. Also, the raised sheetshave diverted water into the residential properties (Aldrianzah 2000). In many kampongs (Malay Kampong), the ground water is polluted by saltwater intrusion.

Beside flooding, drowning, and tides problems, the others problems are poverty, crowded, sanitation, and building conditions. According to Aldrianzah, etcetera's (2000) research, most of the old Kampong are in poor condition, as the people constantly deal with poor drainage, water stagnation, poor sanitation, the dumping of waste all over the place including in the drains, and the encroachment onto public space, especially along public footpaths.

The quality of buildings varies considerably. Many are dilapidated and drowning. A Kampong Improvement Program of the Indonesian government has raised the level of roads and paths by 50 centimeters. Some householders have also raised the floors of their houses 15 centimeters while others use minor dykes to prevent flooding. Based on data, there are 48% building that's in dull conditions, because of raised the floors of their houses.

Figure 9. Raised the floors in Kampong Melayu houses
Reference: Wardhani (1997)

The heritage buildings are being compromised by new development. As the old multiethnic kampong in Semarang, it contains variety significant heritage buildings. Their retention should be part of any potential redevelopment of the area. However, without careful conservation and investment, they will remain dilapidated. An awareness of conservation in the community and clear urban design guidelines for redevelopment need to promulgate.

A sustainable communities formulation in this kampong is of course different with the Kotagede's problem. Adaptation and adjustment of the building and environment maybe can be a one solution. Beside that a governance regulation is needed. To support and empower the community, being adaptable with this situation, with the specific spatial plan.

To solve the problem, the Municipality of Semarang makes an Urban Design Guidelines (RTBL) in specific area in these kampongs (Malay Kampongs and Pecinan), with seek need assessment from the community. According to the dialogue between the government and the community, the guidance formulated in many key issues, like: (i) To solve the flooding problem, Municipality of Semarang need to involve the local community and private enterprise, (ii) The environmental quality is deteriorating, (iii) The arterial river, Kali Semarang, is contaminated and used for rubbish disposal. So, to upgrading living standard in this area, the role of family and the women (by dasawisma) are needed to assist in the education of community.

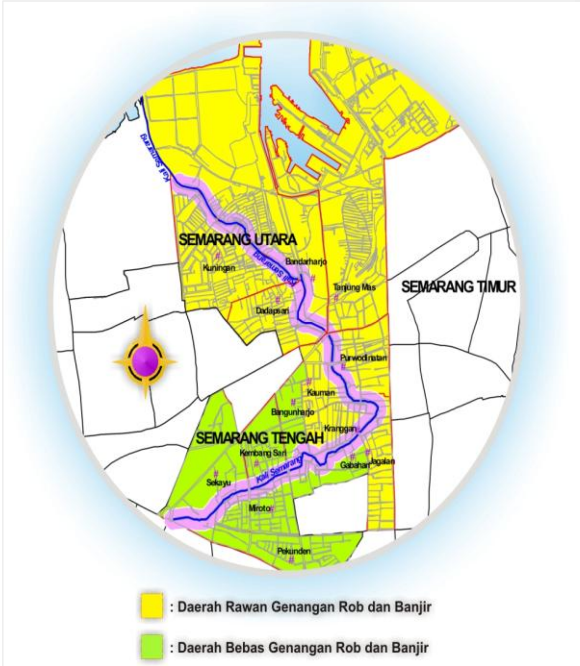

Figure 10. Map of tides, drowning-flooding in the Old Kampong along Semarang River
Reference: Anwar in Kurniawati (2006)

The most social problem is that most of the people are unemployed and the remainder is employed in unskilled occupations. The residents therefore suffer from poverty. Revitalising these kampongs will require enhancing resident's skills and creating opportunities for work.

The residents in these kampongs lack political and economic power. They do not have an effective community network or organisation to deal with governments and private sectors. This situation needs to be remedied.

So, this lesson learned teaches us about the important community role to keep the sustainability of the place, to keep the community's spirit, and it will considerably enhance the character of the whole area, and help define an image for historical site. Without their participation, mobilization, and their responsibility, this process is nothing. The sustainable communities are the social capital to maintain the positive image of historical conservation area.

CONCLUSION

1. In this time, in unpredictable weather and natural disaster, we must preparedness to maintain our heritage conservation area from any vulnerability.
2. We must prepare the disaster in order to protect the heritage site from the damage

with pre and post disaster preparedness.

3. Mapping aspect is a part process in pre disaster mitigation (preventive action).
4. Sustainable preservation and sustainable communities on the historical milieu are one alternative to maintain this historical site.
5. The sustainable community is the social capital to maintain the positive image of historical conservation area.
6. Disaster town watching has been extended to dealing with disaster and safety related physical issues such as safe or unsafe places and evacuation routes.
7. Activating the role of subgroup communities and empowering the community to being adaptable with disaster situation is the government duty.

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BHISAMA RADIUS SURROUNDING THE TEMPLES AS REGULATOR OF BALINESE URBAN SPACE

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ABSTRACT

Unlike other places, island of Bali has experiencing pressure friction of strong urban space function as the best attraction tourism in the world. In many areas, it's easy to met collision of urban space function which disagrees with allotment of it. Such as tourism accommodations that build impinge river border, coastal and bank. Some collisions even smirch the area close to Hinduism sacred place --religion that embraced most Balinese traditional society. Tourism accommodations and another commercial function had been building near by the temple, without concerning rules which had specified by government, and religious order organized by the indigenous administration. In order to preserved area surrounding these sacred places, Hindu Dharma Council had organizing what is known as bhisama radius surrounding the temple. It is told in bhisama, within 5 km radius in Sad Khayangan (6 major temples in Bali), shall only be build function that can increase value of the temple's spiritualities. But nowadays, there has been collusion when bhisama is not adhering by society especially by the owner of the land nearby. There are many hotels, restaurant, golf court, etc which build close to the temple. Although these temples located in mount, hill, and bank edge which by scientifically is a balancing area of the ecosystem, and in religious aspect is also trusted as a sacred area which can not defile. If we can take it as important deal, bhisama radius surrounding temple has the occasion to be applied in broader urban space concept, not only arranging function around the temple. This is enabled because bhisama still trusted as order degraded by God to prevent disaster; only the Hindu Dharma Council formalizes it. By composing bhisama as part of the society's faith, trespasser of bhisama not only will grant by formal sanction, but also social punishment from its surroundings.

Keywords: *bhisama, temples, Balinese urban space*

INTRODUCTION

"Shall the temple be ensured so they will not even suffer with their new environment" (Prof. Dr. Ida Bagus Mantra -Former governor of Bali, 1994)

In order to protect Balinese culture and religion as well as environment, there are some local regulations. The regulation explicitly mentioned religious regulation - known as *bhisama* - issued by Indonesian Hindu Council (PHDI), therefore more than regulating land plots where investment are not allowed, it carries religious content which has to be protected. Furthermore the regulation is a well thought product which accommodates every related side, including religious holly zones, tourism areas, residential, industry, and protected forest.

This paper discusses how the existence of *bhisama* as the control role in Bali. *Bhisama* especially regulate environment surrounding the temple.

Bhisama is a religious decree, a local Indonesian/ Balinese term referring to a kind of informal regulation regarding to Hindu related issues which is issued by the Hindu Dharma Council (PHDI/Parisadha Hindu Dharma Indonesia-Priest Association). The member of council is mostly consisting of Hindu highest priest and also important people in Indonesia Hindu society.

One of the *bhisama* regulations is about the rules of Surrounding Sacred Site Temple of 5 kilometers radius. Generally speaking, the regulation prohibits any parties to build anything other than temple related building (such as villas, hotels, restaurants etc) in radius of 5 kilometers of a temple. This rule is only applied for certain temples belong to Kahyangan Jagat temple, literally meaning the big temple of which the worshipers come from not only from the village where the temple is located, but from all over Bali/ Indonesia. These temples are Pura Besakih, Pura Ulun Danu Batur, Pura Uluwatu etc.

It is clearly understood the reasons why the council issuing this regulation and that is to protect the holiness of the temple especially from the growing of the tourism industry in Bali. It is unacceptable, let say, there is a hotel/ resort/ pub, right next door for those temples. Unfortunately, there seems to be an 'underground movement' in Bali recently in order to shutting down the *bhisama*. This will lead into a conspiracy to destroy Bali. This movement which can be a seminar, an open discussion, a march etc, is mainly aimed at reducing the 5 kilometer rules into less distance let say 2 kilometers or 3 kilometers and even 1 kilometer. If this happens, there is no doubt that Bali will be destroyed as the investors are free to build anything really close to the sacred site temple. Bali will be known not as the island of thousand temple anymore, but the island of thousands villa.

But in the contrary, there are 10 villas in near Uluwatu Temple that violate Uluwatu sacred zone. Uluwatu is one of the six temples in Bali that have rule which prohibited it surrounding 5 km radius to be built other than to support temple function as a sacred place. The 10 villas were variously found to have broken zoning laws on "set back" from canyons and ravines; zoning use rules; and building permits requirements.

Meanwhile, local residents in the Uluwatu area expressed their displeasure with the visit by local lawmakers and regional officials without including local residents as representatives in the process. Many local landowners have called on the government to change the 5 km *bhisama* zone surrounding Uluwatu Temple. Villagers have complained that they are compelled to live "off their lands" and enforcement efforts are limiting their income capabilities. Local-land owners have steadfastly rejected suggestions to sell their land to the government as a means of ending the long-stand dispute (Bali Discovery Tours, 2008).

Temples in Bali usually reside in areas with specific geographical condition. Like canyons, ravines, hillside, or even at near coastal lip. Thereby, the areas also have disaster gristle characteristic.

Bhisama which is limiting the development surround temples, initially addressed to take care the temple's existence as sanctum. So it's sacred vibration do not annoyed by other activities which do not relate to the temple. At the temple's environs is prohibited to build hotel, motel, and any other tourism facility. Though because the unique situation of temple, generally it also sometime is desirable to be tourist attraction activities, which are not related to it, many function as sacred place.

But *bhisama*'s function apparently is not only as guardian of the temple's spirituality. With *bhisama*, all of the stakeholders can determine which area may not be build up, and what the area main function. With the attitude to taking care chastity surrounding the temple, government and local resident can agree on these things.

THE DICUSSION: BHISAMA VS FAMILY NEEDS

Bhisama is a local order with to arrange, settling, and instructing Hindunese for better life, thus it may not be impinged, because will affect dreadful, like accident, disaster, and other (Gautama, 2001). *Bhisama* reside at highest position after Weda and uttered have legal power. In their sacred bible, Hinduism elaborating what is called with sacred area and places: mountain, lake, *campuan* (meeting point of two or more river banks), coastal, sea, etc, believed have sacred values. For it the reason temple is generally founded in such places, because there is a holy people and Hindu people can get holy wits.

Bhisama is The *Sabha Pandita*'s "product" which ratified by *Mahasabha Parisada Hindu Dharma Indonesia* with consequently that has power that bond Indonesian Hinduism people. In *Manawa Dharmasastra* XII.108 express, if there is matter which not yet clearly expressed in Weda's philosophy (*Dharma*), hence which was have authority to determine the answer is *Brahmana Sista* (Hindus priest practiced) with ruling which have legal power. Relating to *Sabha Pandita*'s status as highest element in *Parisada* in charge specify *bhisama*, hence *bhisama* rank in at the highest after *Weda* and expressed to have legal power. In *Manawa Dharmasastra* XII.110 expressed that anything which has been specified by *Brahmana Sista* with holding position in The *Parisada*, owning valid legal force, anyone even shall not argue them. Hence *bhisama* is the source of Hindu law in formal understanding.

Bhisama in Hinduism custom in Bali, present since the epoch of *Maharsi Markandeya* through *Danghyang Nirartha* (Ritiaksa, 2008). *Bhisama* also can definite as a guidance execution to clarification and explanting Hinduism beliefs, yielded through solution of the *Brahmana* professional (*Sabha Pandita*) pursuant as foundation Hindu's law.

According to those *sloka*'s decree, utterance or decision of a *brahmana* expert assumed to have legal force, during this not yet been expressed in sacred book as regulation arranging this life expressly. This rule has open opportunity for interpretation to habit applying in life of Hinduism people (Dana, 2005).

There has been some *bhisama* that established by PHDI which also have been specified, such as *bhisama* concerning alms, Hinduism *pandita* (priest), rights and obligations deed for Hinduism people, and *bhisama* the radius chastity of temples.

There have been mentioned above, that chastity area for Hindu Bali society is mountain, lake, *campuan,* coastal, sea, etc. Those sanctums have radius chastity which called *alas kekeran* (chastity area) with *apeneleng, apenimpug,* and *apenyengker* for its dimension. For *Sad Khayangan* temple use apeneleng agung dimension (minimize to apart 5 km from the temple), for Dang Khayangan temple using *apeneleng alit* dimension (minimum 2 km from the temple), and for *Khayangan Tiga* temple and others using measure of *apenimpug* or *apenyengker*. At Balinese traditional measure, *apenimpug* is distance that obtains by throwing stone equal to adult grasp, *apeneleng* is boundary distance ability of one man's eye to see into, and *apenyengker* is limited to wall.

In reference to development, by the area of temple's sacred radius shall only there is building which related to Hinduism religious life, for example *dharmasala* (lodge place for people which wish followed religious activity in the temple), *pasraman* (education facility of spirituality for people who wish to follow activity in the temple) and other, for amenity of Hindu people conduct religious activity. Those building should supporting Hindu people activity to conduct ritual, understand their spirit, *tirtayatra* (holy journey to request and guide of forgiveness), *dharma wacana* (Hinduism learning method related to religious activity), *dharma gita* (the Psalms stemming from holy bible with a purpose to nearing Hindu people feeling with *Ida Hyang Widhi Wasa* and also to socialize holy teaching of *Weda*), *dharma sadhana* (alms), etc. *Bhisama* temple's radius chastity then becomes commandment by *Parisada* Center No. 11/Kep/I/PHDIP/1994 25 January 1994 which strengthened with Decision of Bali Governor No. 33/ 2003, and continued with By Law of Bali Province No. 3/ 2005.

PHDI in their attempt to take care the sacred area and also the improving *Tri Hita Karana* (three nature balance concept, at implementation of the building it existence with *parahyangan, pawongan,* and *palemahan*), expressing all construction facilities activities and basic needs that carried out by private sector and government have to involving Hindu people and request permission from the *sulinggih* (Hindu priest) starting from planning, execution, and observation phase of it.

Bhisama sacred radius of temple compiled to prevent temple's sacred area collision is stop. But *bhisama* is product of *sabha pandita* through *Pasamuan Sulinggih* PHDI Center assisted by *Sabha Walaka* and Official Member of PHDI Center, so that known as religion norm. Norm religion sanction for the trespasser is depended from people's belief at their religion teaching.

It can be concluded that temple's *bhisama* compiled not even for the shake of sacred spirit of the temple only, or for natural preservation and also Balinese culture, but also for the shake of continuity of Bali's economics. The specifying of *bhisama* is a phase in development in Bali.

These places have sacred radius, is called *alas kekeran* in *apeneleng*, *apenimpug*, and *apenyengker*. *Sad Khayangan* temple, temple which can be worship by any source of clan, is measured by *apeneleng* which is 5 kms from the temple. In traditional measure, *apenimpug* is a distance by the thrown of stone equal to grasp by adult, *apeneleng* is visible distance between an object and a point where one starts to lose sight of an object, and *apenyengker* is limited to wall. In area of sacred radius of the temple shall only building which related to Hindu religious life, like *dharmasala, pasraman* and other, it is for amenity of Hindunese to conduct their religious activity. Radius *bhisama* sacred of this temple then become Verdict of Parisada Center No. 11/Kep/I/PHDIP/1994 in 25 January 1994 which strengthened with Verdict of Governor Bali No. 33/ 2003, and continued with Regulation of Province Bali No. 3/ 2005.

It have been mentioned that in by law Bali

Province No. 3/ 2005 and in *bhisama* arrange regional or sacred radius of *kekeran* area of *Kahyangan Jagat* temple is five kilometer. In this radius shouldn't be allowed there is building other than temple facility. But in this time there have happened collision of sacred radius. One of the examples happened in *Uluwatu* Temple in Badung regencies. Probably because given the amenity by Badung local authorities or ignorance and perda of *bhisama* this, at least tens villa in *Uluwatu* temple area-Badung regencies threatened unloaded, because build in sacred area one the *Sad Khayangan* temple.

Figure 1. Location of Pura Luhur Uluwatu

Governor of Bali, Made Mangku Pastika affirm, during this time Badung regency fight many By Law of Bali Province No. 3/ 2005. This is happen because this by law does not arrange coherent sanction for executive. Governor also explains his side has committed to uphold the order truthfully.

According to *Ida Pedanda* Made Gunung in Balipost (2008), *bhisama* is an order that compiled to protect and saving island of Bali. He express that PHDI *bhisama* which managing the problem of sacred area surrounding temple is a step in Bali's development towards so that existing of sacred area remain to be taken care its sacred atmosphere.

Chief of PHDI Center Sabha Pandita *Ida Pedanda* Sebali Tianyar in Jawapost (2008) has stating that the problem of *bhisama* has been discussed in *mahasabha* in Kendari before. In that moment is decided *bhisama* sacred area is still the unchanged, it is as long as five kilometer for *Sad Kahyangan*'s temple. All parties, which attend mutually, agreed to that condition as a mean to hedge sacred area as the Bali's fortress. According to him, *bhisama* do not made promiscuously. Even before it has been formulated in number, that is for the *Sad Kahyangan* temple with sacred radius of 5 kilometers, there understands with form of *apeneleng* and *apenimpug*. This concept has a very strong purpose to protected sacred area from earlier. So that when there is anxiety to rework *bhisama* he does not dare to conduct it, because sure will suffer sin.

But I Gusti Made Ngurah in Balipost (2008) holds a different view from above. He is affirming that the balance concept shall be considerate to avoid difference interpretation of the *bhisama*. In the problem approach, it shall be returned to Hinduism source of punishment which comes up with *Atmanastuti*. It mean, as soon *bhisama* made by hence its represents as the Hinduism law. As does with national source punishment, hence *bhisama* also can be evaluated and adapted for the actual condition in the society according to *desa kala patra*. As the product's religion ceremony, *bhisama* surely have the obligatory power for the sake of community. According to him, *bhisama* untill now is still applicable. But in the approach of *bhisama*, surely have to be adapted for existing growth and condition in the society.

Figure 2. One of the hotels near Pura Luhur Uluwatu that impinge radius of *bhisama* sacred place surrounding the temple

According to Badung Regent A. A. Gde Agung in Nusa Bali (2008), *bhisama* is still abided by. But in the execution have to be adapted for existing condition or according to village concept of *desa kala patra*. According to what have mentioned before, Ketut Suiasa which is member of regency house representative (DPRD) Badung, *bhisama* is not bonding and the applying have to be adapted for the existing condition. Enabled also that *bhisama* is altered and adapted for new condition. *Bhisama* ought to have the dynamic character. *Bhisama* should be able also to accommodate existing value in its community, which also become its follower.

I Gusti Made Ngurah, lecturer of IHDN (Institute of Public Hindu Dharma) Denpasar who is also the former Religion Chief Office emphasize, *bhisama* that has issued by PHDI don't have absolute power because in governance system in Indonesia not all of people problems can be solved by Parisadha only. It is since by the custom village autonomy. For that, the existence of custom institute along with all the product of like *awig-awig,* etc, was surely considered for continuity of custom village as the worshiper's temple.

This affirm that environment always have affecting on or give contribution to prosperity and spirit growth. But when that environment's situation is less compatible or ugly hence there is break maintenance balance and worse it can turn to the instinct flange for apathies, and eliminate creativity.

Therefore, it's important to secure environment as one of the important aspect in the society's culture. Sacred places with its calm and quite surroundings, when sudden in around it founded huge buildings, villa, or golf course though a few human is manifests of industrialization process which will be able to bring influence to lessen sacred feeling or lessen people's felt in stability their believe in executing their religion belief. Temple or sanctum will felt hurt by attendance of these commercial buildings.

For Hindu people, sacred place having history in relation to saint as place to get or apocalypse of holy wits, hence that sanctum become centers of *tirtayatra*. Considering the increasing of requirement for people to conduct *tirtayatra*, hence ought to if place surrounding the temple or these *tirtayatra* spot reside in a wide environment so that emerge peace and calm feeling.

In one of the Hindu's bible, that called *Reg Weda* (8.6.28) it has been mentioned: "In peaceful and calm place, in mountains, at meeting of the rivers bank, there are all the Maharsi get holy and sacred wits. While in the *Atarwa Weda* (12.1.38) expressed: "Earth where they build sacred place and conduct *yadnya*; where there have been attached bold and high pillar and also continue to be performed prayer, that sacred place make us prosperous". Particularly more Hindu people basing their life with nature religious social, ought to in arranging environment through approach of religious social also, because religious social aspect give continual and long-range economic impact.

So, it can be said that *bhisama* temple sacred have already precisely, in consequence all parties have to uphold it. Not even for the shake of the temple sacred, natural beauty and continuity and also Balinese culture (nature and culture at the same time), but also for the shake of continuity of Bali economics which orienting far to the future.

THE NEEDS BY BHISAMA IMPLEMENTATION

Tens of thousand altars in Bali pursuant to some characters that can be divided to become only four types that are *Kawitan temple, Kahyangan Desa temple, Swagina temple* and *Kahyangan Jagat temple*. *Kahyangan Jagat* temple alone can divided to become another four type that is Kahyangan Jagat which is build under the conception of *Rwa Bhineda*, *Catur Loka Pala*, *Sad Winayaka* and *Padma Bhuwana*. Meaning and what philosophy which there are at the base of founding the *Kahyangan Jagat* temple?

There are some temples that have doubled function; they can function as *Rwa Bhineda* temple, *Catur Loka Pala* temple and also as *Sad Winayaka* temple as well as *Padma Bhuwana* temple. Besakih in Karangasem and Batur temple in Kintamani is consider the temple of *Rwa Bhineda*. Example of *Catur Loka Pala* temple is Lempuyang Luhur in east direction of Bali, Luhur Batukaru temple instruct west, Andakasa temple in southward and Puncak Mangu in North direction.

Temple that constructs under the *Sad Winayaka* conception is generally referred as *Sad Kahyangan* temple. Not less than nine papyruses express the existence of *Sad Kahyangan* temple. But each papyrus state different temple each other. This was happened because when Bali becomes nine kingdoms, every one of them has each perception of *Sad Kahyangan* temple. Some is same and some is different also.

According to Chief of PHDI Bali I GN Sudiana, M.Si., *bhisama* that is made by *sulinggih* in Parisada on 25 January 1994. In the third point of this *bhisama* has already elaborated how Hindu people have to look after chastity of the temple. It also detailed the reason of it. It is because to many buildings that has been too close to the temple in Bali. But in the reality when applying *bhisama* there have been many constraints in the community other than the lack of socialization. Later *bhisama* infused to Bali Province By Law Layout, elaborated if for the *Kahyangan Tiga* Temple the building distance is 25-50 kms, *Dang Kahyangan* Temple distance is 2 kms, and *Sad Kahyangan* temple is 5 kms.

To making sure *Kahyangan Jagat* temples remain to everlasting hence PHDI Center has released *bhisama* concerning *bhisama* temple sacred area. It has released by the PHDI Center in 25 January 1994 is a product to continue Hindu system belief in Bali, especially concerning existence of *Kahyangan Jagat* temple. Distance of temple that including this *Kahyangan Jagat,* namely custom village closest with *Kahyangan Jagat,* generally apart *apeneleng agung* (around five kilometers).

This *Kahyangan Jagat* temple specially which is pertain as *Kahyangan Jagat* is *Kahyangan Jagat Rwa Bhineda*, *Kahyangan Catur Loka Pala*, *Sad Kahyangan* temple and *Padma Bhuwana* temple which is residing in nine angle of Bali Island. While *Kahyangan Jagat* temple which is pertained, as *Dang Kahyangan* is *Dang Kahyangan* temple apart with *apeneleng alit* distance more or less than two kilometer. While for the *Kahyangan Tiga* temple and others is apart with *apenimpug* and *apenyengker* distance.

Terms of *apeneleng agung*, *apeneleng alit*, *apenimpug* and *apenyengker* altogether is terms which are already in Hindu people culture tradition which there are since for centuries. Especial target of temple's *bhisama* sacred area arrange balance behavior of human being in exploiting nature in order not to solely make for the sake of tentative earthly life. Exploiting of space in this universe should be used well balanced to fulfill requirement of character life both earthly and immaterial with the base philosophy of *Tri Hita Karana*.

This *bhisama* sacred area of the temple is made to prevent collision concerning existence of the temple shall not continuous. But, this *bhisama* is product of *pandita* through *Pasamuan Sulinggih* PHDI Center assisted by *Sabha Walaka* and Daily Official Member of PHDI Center. This *bhisama* is pertained religion norm. Religion norm sanction for the trespasser of depended from confidence of people at their religion teaching.

Within *bhisama* is to take care of sacred area surrounding the temple in order not to occur and pollution of negative vibration. If around the temple have occur and pollution of negative vibration because happened various activity of life which disagree with gone into effect norm religion in temple area, is what else added with environment which have pollution, can cause temple shall no longer transmit chastity and continuity of environments.

Existence of temple with its environment shall be arranged in such a manner so that can earn it as the adequateness facility of spiritual. Thereby temple with its facility can give deeper contribution of spiritual to their worshipers which are making temple as media to return their spiritual energy. In consequence, *bhisama* sacred area surrounding the temple agree the existence of various facility which supporting existence of temple as media of spiritual.

They can build up around the temple such as *dharmasala*, *pasraman* and other building which its function to existence the temple as media to strengthen spiritual aspect of people. *Dharmasala* is building as a place lodge person for whom who is has wished to follow various religious activities in the temple from a distance. This *dharmasala* in their management system can collect expense from the people that lodging as expense to give service to people.

Dharmasala is not hotel as public place. Who may stay in *dharmasala* is special them will follow various religious activity in the temple. *Pasraman* is a facility providing facility education of spirituality to prepare people to follow various activities in the temple. Beside and *dharmasala* of *pasraman* just earn build up by other facility in sacred area of the temple as long as that thing support temple existence as the area of as spiritual media.

The regulation explicitly mentioned religious regulation - known as Bhisama - issued by Indonesian Hindu Council (PHDI), therefore more than regulating land plots where investment are not allowed, it carries religious content which has to be protected.

Furthermore the regulation is a well thought product which accommodates every related side, including religious holly zones, tourism areas, residential, industry, and protected forest. Therefore revising the regulation will be very difficult, and needs really strong reasons. "Even when revision is really needed the process has to involve each and every related stakeholder. It needs thorough consideration. And the only acceptable goal is to give better protection to Bali

Meanwhile, it is said that local residents in the Uluwatu area expressed their displeasure with the visit by local lawmakers and regional officials without including local residents as representatives in the process.

Many local landowners have called on the government to change the 5 km 'no build" zone surrounding Uluwatu Temple. Villagers have complained that they are compelled to live "off their lands" and enforcement efforts are limiting their income capabilities. Local landowners have steadfastly rejected suggestions to sell their land to the government as a means of ending the long-standing dispute.

Inexistence sanction problem punish of *bhisama* sacred area surrounding the temple, according to Karyasa, because *Bhisama* PHDI leave from Hinduism teaching moral values. *Bhisama* is a kind of religious advice which only showing promises to society to adhere or functionary in taking policy. If *bhisama* impinged, make proper to be questioned how far society moral commitment and functionary. More there is no desire upholds *bhisama* sacred area surrounding the temple.

CONCLUSION

Development of Bali tourism industries which tend to disregarded culture and destroy environment like happened now, is felt disturb Bali traditional custom and society mores. Balinese people have unique cultural values, besides also as a collective which tied by awareness of culture unity, that is culture from Hinduism. According to Prof. Dr.Wayan Ardika, MA. (2004), special fascination of Bali tourism comes from its unique culture and tradition. Balinese's way of life and religion make tourist interest to visit Bali, beside supported also by its natural beauty.

The effort that takes place by approaching tourism accommodation with occupying area surround sacred places, so that hinder and disturbing Balinese people to conducting their religious service, will lessen the cultural value of Balinese society. This will affect tourist attraction, so it is useless to build tourism accommodation, if tourist is not attracting to come to Bali.

In relation with Bali tourism, tourism constrain according to Burn and Holden (1995) expressing *''Tourism is the totally of the relationship and fenomena arising from trevel and stay of strangers (Ortsfremde), provide the stay does not imply the establishment of a permanent resident"* becoming importance. Because, tourism activity cannot be discharged from the encounter of] of demand and offer as economic law. Offer to supply of communications, service, transportation, accommodation, and attraction including culture and it nature followed by request of tourist attraction in that area. That tourism activities thereby have produced economic activity in the form of cultural industry which is has capitalism background.

Like development of Bali tourism, namely tourism development which ought to forwarding ideal aspect (moralities, social, and cultural) in the reality have been knocked over by capitalism system (development of tourism with massive capital, is not labored by local society which have more understanding ability and requirement of their area) so that negative impact of Bali's tourism development will be experienced by their society.

Unlike government regulations, religious regulation (traditionally called *Bhisama*) is sacred, and people can do nothing other than to obey. It is not a subject of change.

In radius five kilometers, such in Pura Luhur Uluwatu with its support temple (called as *prasanak*), it capable to build *dharmasala* and *pasraman*. It also can provide with building as "diorama" which can visualize various life philosophy value contained by existence of Pura Luhur Uluwatu with it support temple. That effort is of course positive, as long as conducted and proceeded with circumstantial study. The study result infused in responsible program, excellent to short-range and in the long term. Thereby today's generation will have spiritual commitment to continue ancestor heritage that very glorify.

Pura Luhur Uluwatu have holy region in radius more or less five kilometer. This regional referred as *kekeran* area, mean holy region. What we should pay attention is to protect that region so-called as *kekeran* area. Shall all sides respect *kekeran* area to take care so that there will not be building which do not related to existence of Pura Luhur Uluwatu.

Kekeran area shall be ensuring so remain greenly with Balinese classic flora. It also can be creative as long its purpose is to develop forest with its indigenous flora, so that *kekeran* area really green as well as holy is not be made to be developing other facilities. More *bhisama* sacred area surrounding the temple of Kahyangan Jagat like this Pura Luhur Uluwatu have to be taken care, so there may not be any building other then temple facility within *apeneleng* radius – around five kilometer - have to sterile from building which there not related with existence of Pura Luhur Uluwatu.

In the future, it is very expect by all of stakeholders when stating policy relate to earlier planning document, or in *bhisama* and *awig-awig* which mean also reckon Balinese and Hinduism custom which was the most entitled group to Bali. What must more concern next is so that development -- specially done by investor -- which disagrees with custom method, Bali environment and religion really can discontinue and damaged environments should be returned like before. These problems don't only momentary roaring afterwards development which is damage to be re-continued, like some occurrences which we witness during the time.

The people who as follower religion in practicing the religion teaching should always attach in their bible as life believe. If they don't comprehend one matter in religion teaching, he earns to ask to *Brahmana Sista* or *Brahmana* which is expert in the bible.

What is expressed in bible and which explained clearly by *Brahmana Sista* that is called *bhisama,* according to Hindu teaching. Statements in bhisama come from Sanskrit of root word of *bhi* with the meaning are fearful.

It mean if what was expressed in bible as well as have been explained by Hindus a skilled holy man (Brahmana Sista) but it not be executed by people, it really very fearful.

Bhisama is a religion norm specified by *Brahmana Sista* is not a law norm, because the sanction depends on confidence of people in the truth of *bhisama*.

Nevertheless *bhisama* can be made as the source of law by institute owning ability to release positive law.

As religious people in Indonesia this adhere religion norm in so many life aspect it is of course an august valuable.

If that can be conducted with high wittingly it is of course as moral investment which very useful in society.

Sabha Pandita PHDI Center has releasing many religious rules and *bhisama* which still not yet so settle the deed of because the less continue socialization.

That is why various traditions which are still digress from Hinduism teaching still many go on. That thing is caused because a person still not familiar to Hinduism teachings is such as expressed in their bible.

In fact there is on the contrary: if there is a person believing in according to bible but not yet being tradition in the society, is often alleged as pervert and bizarre. There is errant tradition because opposing against religion teaching even also positive law.

Although it is never been found a direct effect of *bhisama* collision yet, but because its importance in existence of temple as sacred place, Balinese society should not wait till physical and spiritual disaster occurs. It is said Balinese people well known both as religion and creative. But nowadays they cannot avoid development era. Short-range advantage, like accomplishment goals of earnings genuine area making environment development in Bali meets its critical point. Development of Bali based of religion and custom, so that custom village expected as the base of development in their area. Incoming tourist to Bali is not to see high building which have often they have see, but seeing culture and custom of Bali. It is not that Balinese society and government is opposed to development, but in Bali recognized traditional laws which are peremptory like one of them are *bhisama* radius of sacred area surrounding temple. Problem of it in the society, people which has land possession in radius of sacred area, cannot exploit it, though every year they remain to pay for big state tax because its location which assumed strategic as tourism attraction location. So that then emerge many collision and oppositions. It is regretfull if the writhing of tourism in Bali knocked out their society and land. In the end, it is worried if aura and *taksu* Bali will be lost.

In consequence tradition is that what assumed as the by correct religion. This needs more serious socialization of *bhisama*.

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SOCIAL CAPITAL CONFIGURATION OF MASS DISASTER IN JOGJAKARTA: CASE STUDY BAITUL MAAL DESA, DOMPET DHUAFA REPUBLIKA RECOVERY PROGRAM

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ABSTRACT

There was a big earthquake in Jogjakarta at four years ago that made many public building and houses were collapse and many people died and injured. Most of the actions conducted were focusing on physical such houses or public building were rebuilt. Some actions based on psychological and economic activities in order to recovery of livelihood society has slow due to the damage. Several organizations did some actions for economic recovery included Dompet Dhuafa Republika as Islamic foundation (LAZ) in the form of Baitul Maal Desa programme that implemented in Bantul, Jogjakarta. Baitul Maal Desa (BMD) or also called village trust fund founded at March, 2007 until now still exist had program vision was build local institution model that had roles 'amil institution' and 'empowerment insttitution'. This institution has some strategies by managing cash fund (zakat, infaq, shadaqah), and recruited local human resources as productive manager that will technically manage strategies sector based on local potention like farming and veterinary. This institution has special characteristic, according the resercher's perspective, that is the involvement of this institution in all social elements especially poor society (dhuafa) and also earthquake victims.

In this paper, the researcher want to give description about local dynamics programs in damaged area by social capital and village trust fund (BMD) as institution space. Using social impact analysis, this paper also can give description about another social agent of recovery program by BMD that bring influences in structure and social changes at Bantul, Jogjakarta.The researcher limits the discussion into the first category that will be related to the second one. Basic questions that will be answered are (1) How social capital building between society and islamic foundation actor institutionalized in village trust fund (BMD)?; (2) What is the main factor that contribute in social capital building and what is the certain social capital characteristic between society and islamic foundation actor? and (3) How social capital contribute in survival process of poor society (dhuafa) that can make their life sustainable (being sustainable lifelihood)?.

In closing remarks, it will stress that the recovery from disaster especially is not only on physical actions but also social cultural actions. It is because the contribution to social capital is needed for sustainable livelihood in Bantul society based on local resources. This is because natural disaster cannot be separated from social cultural problems in society as disaster has occurred in different location for different reason and in different forms.

Keywords: *village trust fund (baitul maal desa), social capital, local initiaves, local values and sustainable livelihood*

INTRODUCTION

Natural disaster is an extraordinary case which brings impact on both physical and also non physical aspects. This condition changes the social significant in the location that hit by disaster.

This is experienced by Jogjakarta people especially in Bantul region in this four last years because of the disaster victims, ruined infrastructure and socio-psychological.

The following Table 1 illustrates data of victims after the earthquake in Jogjakarta and Central Java. The number of deaths in the category of injury is far greater than the victim died as an example for the district of Bantul victim died while 89% of injuries by 64%. Meanwhile, data for houses were damaged to the

Bantul area much larger than other regions in the amount of 57% for the category of damaged houses, 33 /% category lightly damaged houses and 54% category of the ground. It is of course if this data seen furthermore gives illustration existence of indication of poorness because no residence besides source of subsistence of family which must be strived again by each victim household to return to normal life.

Table 1. Earthquake disaster victim data in Jogjakarta and Central Java (per 6 June 2006)

REGION	PEOPLE		HOUSE BROKEN		
	DIED	INJURED	AS FLAT AS LAND	HEAVY	LIGHTLY
JOGJAKARTA					
1 Bantul	4.280	12.023	28.939	40.038	30.906
2 Sleman	285	3.792	5.243	16.003	33.233
3 Jogjakarta	185	320	2.164	4.577	2.617
4 Kulon Progo	21	1.508	3.872	5.251	8.888
5 Gunung Kidul	84	1.059	13.543	4.718	16.742
SUB-TOTAL	4.805	18.702	53.761	70.587	92.386
CENTRAL JAVA					
6 Klaten	1.036	18.128	30.298	61.224	93.628
7 Others	16	399	584	3.237	2.220
SUB-TOTAL	1.052	18.527	30.882	64.451	95.848
TOTAL	5.857	37.229	84.643	135.048	188.234

The involvement of various stakeholders including government and private sector from within and outside the country as the reconstruction effort and recovery after the disaster a positive contribution to the survival of the community of Bantul. One contribution to the handling of post-earthquake in Jogjakarta which has been built back home some 278 (two hundred and seventy-eight) by the government in cooperation with other agencies and local communities. Based on the results of the implementation according to Djoko Kirmanto (2008) stated that one of the factors that determine the success of rehabilitation and reconstruction program in Jogjakarta and Central Java is because of the implementation of a development approach based on community empowerment. This is obviously because it involves all elements of the public or stakeholders so as to foster a sense of having a stronger, control modules by the community itself and control the completion of the acceleration of development becomes larger. In other words, the social capacity has an important role in determining the success of disaster management. With social values, trust (mutual trust between the government and society), good relationships (with institutions in the domestic and international), as well as elements of other social capacity of the rehabilitation and reconstruction post-disaster can be moved quickly. Nevertheless the social life of the community recovery after the earthquake in clear needs of post-disaster management strategies is more long-term and sustainable.

One of those studies will be made by the reseacher in his role in disaster response is Dompet Dhuafa Republika as one of the The Institute of National Religious Obligatory Amil (LAZNAS) through its program of Baitul Maal Desa (Village Trust Fund or VTF). The existence of Village Trust Fund (VTF) until now still exist to do programs and activities oriented to meet the needs of local communities, especially those who initially earthquake victims as well as those belonging to categories of 'dhuafa' (the poor). As an institution Amil (community fund managers), which facilitated Dompet Dhuafa Republika have differences with Amil institutions in general. The most fundamental difference is the time collect funds ZIS (zakat, infaq and Sadaqah), VTF-are not recommended-circulate "folder contains the request for funds" to the donors ZIS. In an effort to prepare a replacement is VTF empowerment activities / self-reliance of local 'dhuafa' and the program is offered to Donors ZIS. ZIS a successful fund collected by VTF, very recommended, to be managed productively with the target (1) Opening access to employment opportunities, (2) Facilitating the 'dhuafa' manage their own business, and (3) Managing spontaneous social security for 'dhuafa' program participants. This VTF characteristics that is the interest for the reseachers to conduct further studies on the implementation of skeletal program with social analysis is including social capital study. With study method using quantitative and qualitative analysis of expectations can give the picture / reality which is more empirical, objective and analytic. In the end, it is important to studies related to post-disaster response which more haves the character of self-supporting and orients is long-range for better change for local public especially they which included in disaster victim.

RESEARCH QUESTION AND METHOD

Research Question

Following introduction above that can be arrange research question as follows:

1. How social capital building between society and islamic foundation actor that then institutionalized in village trust fund (VTF)?;
2. What is main factors that contribute in social capital building and it certain social capital characteristic between society and islamic foundation actor?; and
3. How social capital contribute in survival process of poor society (dhuafa) that can make their life sustainable (sustainable lifelihood)?.

Method

This research use qualitative and quantitative research method, which is flexible to permit in-depth elaboration of the topic.

1. Sources of research:
   a. Library research (extensive research on the archival and academic materials)
   b. Previous researches related to the topic
   c. Reports from popular press
   d. Reports from monthly report at VTF Programme
2. Method of Analysis:
   a. Descriptive statistic
   b. Documents analysis
   c. Interviews with practitioners

RESULT AND DISCUSSION

Dimension and Typology of Social Capital in BMD (VTF)

Understanding the social life of the VTF program activities in Bantul becomes representation existence of the role of social capital in the process of strengthening / empowerment for self-reliance and sustainability of life for families of disaster victims / orphans. Context of family life disaster victims / orphans is when viewed from the building values, culture, and perceptions, institutions and mechanisms can be seen from the dimensions of social capital. Dimensions of social capital is what determines the typology / characteristics of the existing social capital in community activities related to the VTF program. In this paper an explanation of social capital component will be viewed in three levels namely the level of values, institutions, and mechanisms that can be scheme as follows:

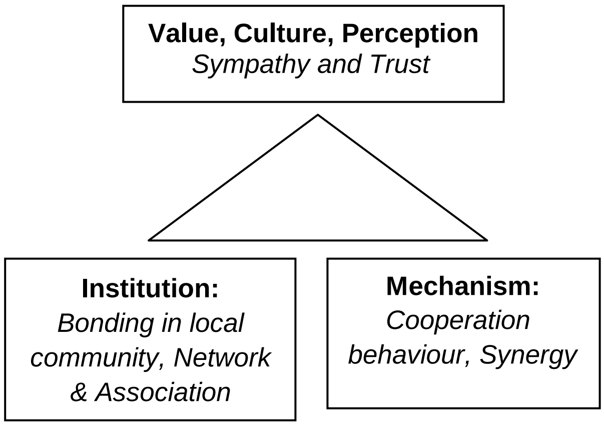

Figure 1. Social capital components
Source: Mefi Hermawanti and Hesti Rinandari (2003).

The third level of social capital on terms that provide social capital can contribute to the occurrence of social integration as well as resolving conflicts in society, especially after the disaster. Discussion of the three components of social capital in the VTF program in Bantul as follows:

1. Value Context and Norms

Community consisted of individuals are social beings with characteristics need each other in life. Therefore there is a tendency to cooperate with each other and interact with each other, including at the time of disaster conditions in which all people need to survive / establish their life. In the interaction is not without some values and norms which according to Fukuyama (in writing Djamaludin Ancok, 2003) explained that "*Social capital can be defined simply as the existence of a certain set of informal values or norms shared among members of a group that permit cooperation among them.* This opinion is similar to the explanation Hasbullah (2006:14) that the value of the idea as something that has been considered hereditary right and important by members of community groups. Therefore domination of certain idea in public will form and influences' orders act the society (*the rules of conducts)* and (*the rules of behaviour)* which together form the cultural patterns.

Referring to the explanation above, VTF as Amil institutions and empowerment at the village level has clear rules of conduct that shape cultural patterns among the actors involved in it. As an institution, Amil must have basic values and norms based on Islamic values. Understanding of the social aspects of zakat funds, infaq and Sadaqah (ZIS) makes the activities / programs related to the utilization of funds ZIS is oriented to the needs and interests of the people especially the orphans. This is in accordance with one paragraph explanation of the Qur'an that one important pillar of Islam is zakat, because he was not merely the individual dimension of worship but also social. That is an important instrument of income distribution, if the charity is well managed and professionally. Because of the charity, the property will go and do not accumulate in the hands of rich people (Al-Hashr: 7). Explanation of the Quran sentence clarified opinion one of the religious obligatory figure, Didin Hafidhuddin (2002) states, in religious obligatory/zakat, there are indications that Islam encourages Muslims to work hard to get possession. Therefore, only those who own property can be issued charity. Zakat is well managed will be able to open employment and widespread efforts and control of assets Muslims.

Further examine the ideas and strategies of the VTF programme to decent of rural orphans (disaster victims) will be identified based norms and values. The idea is to manage funds systems program or ZIS (zakat, infaq and Sadaqah) in a systematic, measurable, independent, and sustainable. Following illustration in Figure 2 is showed the picture of VTF program ideas.

From the Figure 2 above derived a slogan / spirit of the BMD program include: (1) decent of dhuafa, (2) braids ukhuwah and (3) inspires job (activity ethos). Spirit of this program is there is a correlation with vision and program mission which are Vision, VTF program is to build a model of local institutions on the scale of the village that serves as an institution and at the same time enableness institute of dhuafa at village scale.

The program's mission is to facilitate the local institutions that can provide access to: (i). Employment, (ii). Integrated micro enterprises, and (iii). Spontaneous social security for orphans program participants, all of it aims to improve the status of dhuafa become prosperous I. Although on the way of strategy options to achieve the vision, mission and goals are adjusted to the capacity and potency that exists in the program target areas.

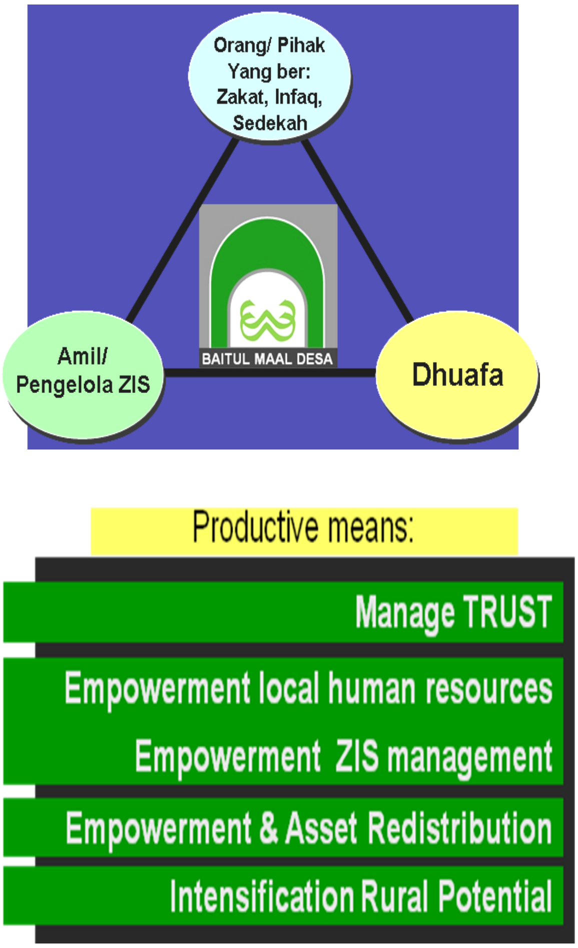

Figure 2. Idea programme of VTF
Source: Progress report of VTF Programme (2008)

In implementation of this BMD program divided to management structure as follows: (1) management team VTF (VTF Center) is the human resources potential assessment activities, including communications with the village local community leaders, assessing the feasibility of productive activities and the choice of monitoring and supervision of all VTF longer and (2) VTF program managers at the village level consisting of 2 (two) local people who have been selected / recommended by community leaders and supervisors. Existence of management structure that makes this VTF program become monitoring through monthly mechanism statement submitted by he manager of VTF at the village level to the management team VTF (VTF Center). This explanation can be illustrated as follows:

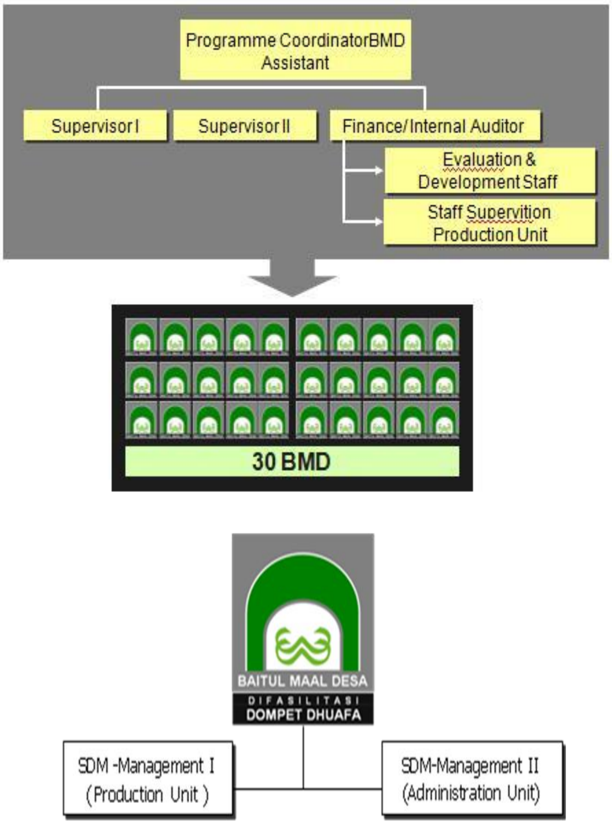

Figure 3. Structure management of VTF programme
Source: Guide Book of VTF Programme (2008)

If seen furthermore value bases and norm at program VTF clearly refers to the Islamic values associated with the review of the concept of poverty. In particular, VTF Program Coordinator explained that the VTF desire to understand poverty not because of 'destiny' but rather on the structural and cultural. He illustrates the following framework as seen in Figure 4. Explanation of Figure 4 is as follows:

1. Normative-theological paradigm, the assumption is the condition of poor-rich, hard-liked, smart-left, success-failure of a person or people being poor is a sign of destiny. They are having paradigm this is not busy thinked of why people to become poor. This opinion sight strenghtened with story such as: When "Fulan" poor life, he was diligent in worship even though the cloth wrapper should alternate between husband and wife, but did not leave the service. But when given a broad wealth, he became forgetful of worship, being busy doing business to add on his property. So Why "Fulan" the poor? Because God wants that way, so he can diligently to worship. That is how normative-theological perspective view of poverty.
2. Cultural Paradigm, argued that poverty is associated with an individual or group of people who greatly influenced by lifestyle, habits of its (life and culture).
3. Structural paradigm, the assumption is the poverty that had befallen the community caused by the system or the political structures that tend to side with certain groups. Economics policy applied by government only oriented to the owners of capital so that the rich become increasingly free to control the market, while the poor increasingly oppressed and downtrodden (economically).

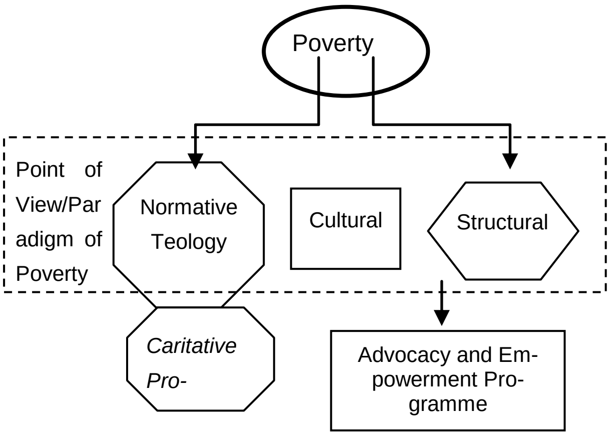

Figure 4. Point of view/paradigm of poverty and out-put VTF programme
Source:Guide Book of VTF Programme, 2008.

From the perspective of the explanation of poverty in particular for providing an understanding of the program initiator of VTF to define poverty is more on cultural aspects and structural elements of empowerment and advocacy. However VTF able to make a program where the value strategy of religiousity can be synchronized with local cultural values are developed in the community. Habits of mutual aid societies and mutual cooperation can be interpreted as a manifestation of collective values especially during the post-disaster that indirectly contribute positively to the implementation of VTF programs. Comprehension about the form of social assistance is not only a form of compensation / something that charity alone, but represented by VTF manager able to come up creative ideas from local communities, especially victims of disasters / dhuafa to harness the local potential in the region.

Based on that explanation, if seen furthermore in the form of derivation spirit of program that is decent of dhuafa, braids ukhuwah and inspires this job (activity ethos) realized in so many activity having the character of economic and non-economically without disregarding capital potency and socio-cultural capital people of Bantul. In a simple explanation can be seen in Table 2.

Table 2. Derivation of spirit VTF programme

No	Spirit Programme Category	Activities Category
1	Helping 'dhuafa'	• Scholarships for orphan's children • Compensation for the elderly / nursing home (there is a form of money and commodities like food-'sembako') • Compensation cost of hospital treatment
2	Establish Ukhuwah	• Meetings between VTF management (BMD Center) with the VTF program managers in each village • Meetings between management BMD (BMD Center) with the BMD program managers in each village with a donor/muzakki. • Meetings between BMD program managers in each village with beneficiaries / dhuafa.
3	Inspiring the work ethos	• Help the business of production equipment • Help business capital

Table 2 above shows the difference ZIS fund management for the benefit and prosperity of dhuafa/poor people. This is based on the contextualization between empiric conditions of the village environment and capacity of local people, especially 'dhuafa'. When dhuafa are still possible to make productive economic activity is a third option that is inspiring job/activity ethos would more given high priority even does not disregard point (1) where there are managers who do VTF at specific moments such as Idul Fitri/ Lebaran and Idul Adha. Thus, at the level of values and norms are built on Islamic religiousity is context with requirement, local potency and is context with requirement, local potency and the future improvement.

2. Context of Trust, Reciprocity and Participation

In this discussion will be seen on the side of the mechanism that formed the relationship between the actors associated with the VTF program. If referring understanding about social capital of this reciprocity aspect according to Hasbullah (2006), social capital is always colored by the tendency of the good exchange between individuals within a group or among the group itself.

The pattern of exchange / reciprocity is not something done in the reciprocal instantaneous but a combination of short-term and long term in the sense of altruism and passion for helping others concerned interests. In conceptioning islam is known as 'sincerity'/' candidness ' in which the spirit of helping others without expecting instant and without a specific deadline. Even the reciprocity concept will not be able to walk in the relationship between individuals or groups in the community when there is no sense of trust.

Trust as described by Putnam in Hasbullah (2006) is a form of willingness to take risks in social relations based on the feeling is sure the others would do something like what is expected and always act in a pattern of mutually supportive actions. This is what later would become social capital continued to build a network among the group / community to conduct mutually beneficial cooperation.

Here, understanding becomes a network of social capital as stated by Fukuyama (2002) the moral relationship of trust that the network on a group of individual agents who share the norms or values beyond informal values or norms is important for common market transactions. This discussion provides an understanding that social capital is not built by one individual but rather lies in the growing trend within a group/community.

In this case, the mechanism between actor related to VTF programs may be seen from the results of questionnaire analysis that the reseacher had done at the time of social analysis in the VTF program in 2008. Discussing the analysis of a program cannot be separated from the determination of indicators that will measure, especially in analyzing the impact of the implementation of a program. In this case, VTF selecting social indicators, based on output indicators are indicators that show immediate results (outputs) or indirectly, or impact (outcome) of a service activity (in this case VTF as an agency fund/ZIS to the public).

Analyssing level of VTF program effectively, VTF program presented indicators: (i) access to employment, (ii) satisfaction of program participants, and (iii) the public response to the existence of VTF. The explanation is to point: (i) access to employment that people look at areas that VTF does not have a job / jobless to work through the productive units and VTF obtained income. For point (ii) the satisfaction of program participants, especially the community look at aspects of the program participant services/ VTF facilitation whether it has appropriate / sufficient what the needs of program participants. As for point (iii) public response to the existence of VTF at the trust aspect / trust and acceptable / acceptance from the public in the role of VTF as a collector and manager of institutional funds locally ZIS empowerment and institutions. These indicators appear to explain the results of monitoring and evaluation can be objective to be used as an ingredient evaluation and recommendation of further development of VTF programs. The results of questionnaire data processing by simple random sampling can be poured in Tables 3.

Table 3 Result of VTF programme effectiveness

INDICATOR	RESULT (%)			
	Very Maximal	Maximal	Less Maximal	No-Answer
Access to Job Opportunity	12	45	33	10
Satisfaction of Beneficiaries	20	40	27	13
Response from society to BMD	23	43	21	10

Source: Final Report VTF Programme, 2008

From Table 3 it can be explained that the existence of VTF in Bantul region got response from public. Response form of its to leave a fund (ZIS) in VTF to be managed productively and also in activities organized by VTF for example fasting open together, cheap bazaar, Idul adha, syawalan or study-‘pengajian’. From the level of satisfaction with the program participants have shown the standard (40%) this is because the match with a choice of productive activities raised by managers are able to involve many participants of the program or just simply managed by a manager. For level of access to employment shows higher level result (45%) this is because of involvement of program participants especially in a organic farming program that is a pioner programme more than in the year 2007. At 2007 the programme participants distribute in some different activity that arranged by VTF management in the local region.

2. Social Capital Model

After discussing the dimensions of social capital thay can be seen form of social capital model of the VTF program in Bantul as post-disaster areas. The reseachers adopted a model of opinion by the Mefi Woolcock (2003) which distinguishes 3 (three) types of social capital are: (1) Social Bounding, in the form of values, culture, perceptions and traditions / customs (custom), social capital characteristics strong ties within a social system which is still the application of kinship system with the clan system which embodies a sense of sympathy, duty, trust reciprocity, and mutual recognition of credible cultural values; (2) Social bridging, in the form of institutions and mechanisms that are the social ties that arise in response to various characteristics of the group; (3) Social linking, form relationships / social networking with the relationship between several levels of social power and social status in society. Thus the relation that exists in the VTF program activities can be illustrated with the model proposed by these figures where doesn't close possibility there will be modifying relationship woke up among actor by VTF program.

This obviously depends on the existing capacity in communities to build their network following a number of associations including the building including the value base of trust for each other and work together as an element of reciprocity. Also located also on the ability of a group of people in an association in involved in a network of social relationships. In this case is the network of relationships to create social order through a local institution with a mission VTF Islamic religiousity and community empowerment. Simply, this explanation described as follows:

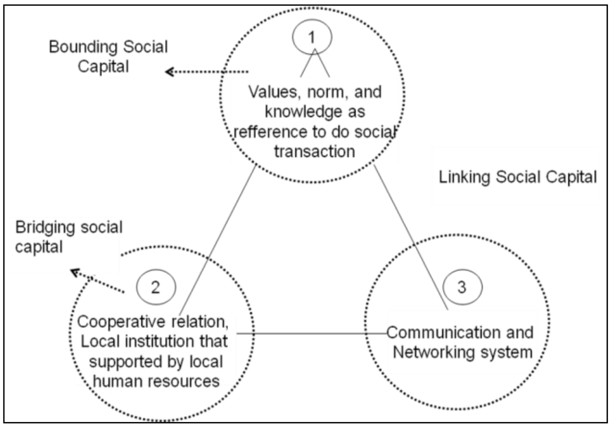

Figure 5. Model of social capital VTF program

Social Capital Contribution and Sustainability of Disaster Victim

The discussion at this point is showing the VTF program aspects considering sustainability life of disaster victim. Therefore, the choice of program implementation strategies pioneered in the second year (2008) is to apply the pattern to facilitate VTF assets in the form of redistribution of land leased fields. In the long term, VTF has a target for waqif (man which communal ownership) area of rice field to be managed by VTF and then used with dhuafa at a local scale in a sustainable way.

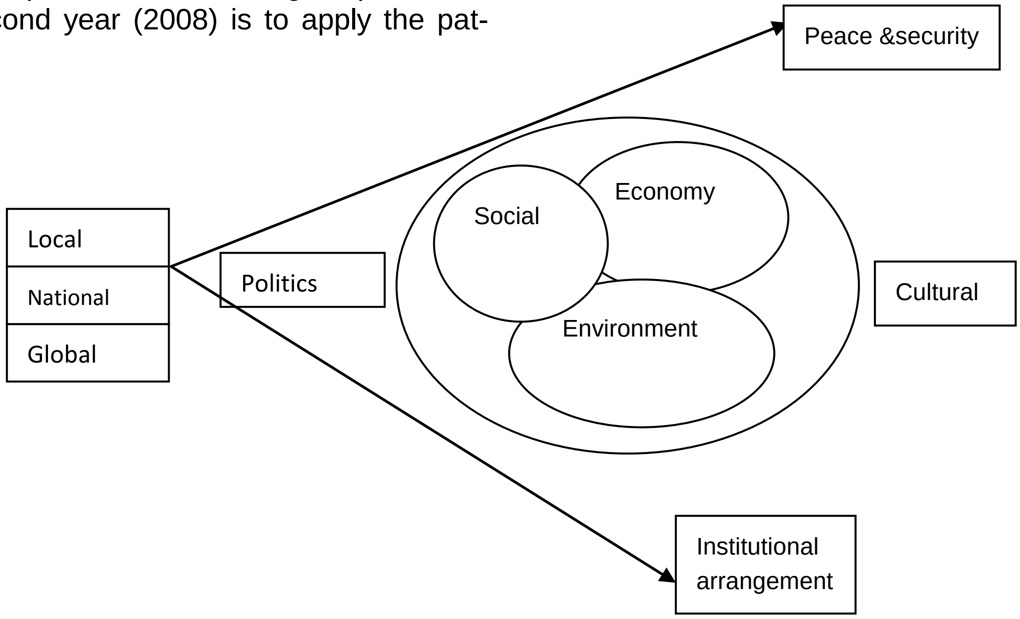

Figure 6. The systems of sustainable development
Source: Barry (2002)

In conducting its mission, VTF takes the concept of sustainable agriculture development to achieve food security, especially the village scale. Because of rice commodity still a basic need for food, so that this prospect made medium to assist improvement of prosperity from farmer especially mini farmer of which is not owned farm (in term VTF that is dhuafa farmworker). In addition, several studies indicate that organic farming is very real effect on the amount of labor compared with conventional agriculture. Especially in organic farming systems through diversification of crops, difference of cropping patterns and planting schedule can distribute labor requirements based on time.

As image of implementation of agriculture program in the year 2008 organic farming activities are carried out in 9 (nine) villages in Bantul, where area of rice fields with land tenure paid by 50% in the beginning and the rest after crop. Each VTF is planned to manage 5 (five) hectares area of rice field, where for farm with a width of 5 (five) hectares may involve 6-7 labour farmworker/dhuafa farmworker. Farmers/ dhuafa who worked for VTF will increase at the time of crop named by 'bawon'. For income received by farmworker/dhuafa adjusted to the crop that will be distributed by the manager of VTF to farmworker/dhuafa according to agreement in the form of money or goods (rice). Choice of this activity ultimately led VTF as a local institution that has a productive unit sale of rice. This is what gives the change in the relationship between the management team at VTF Center with VTF in the implementation of the program. VTF Center team roles other than supervision program, but also as a facilitator to build a network of farmers markets/dhuafa who worked in the VTF program implementation area. In the end at the future will guarantee sustainability of rice production marketing in particular has at least initiated and ongoing effort for the welfare of local orphans/dhuafa.

The above explanation has been illustrated in Figure 6. Figure 6 confirm that the choice of activity/VTF program has adopted a sustainable development system while still in local category. The existence of economic integration between the elements, socio-cultural, environmental sustainability as organic choices and institutional policies supported the pattern of VTF with administrative responsibility for the creation of local food security village. Obtained social security of farmers / farm laborers dhuafa obtained from the production mechanisms adequately supported so that the distribution system can provide input to the household income gradually and continuously in the future. However, VTF remains an institutional form that can not be separated from internal and external influences that arise both from the elements perpetrators / actors and social environment. Therefore, VTF sustainability in the future will be strongly influenced by the capacity of managers VTF (Amil) in generating ideas and activities oriented to the welfare of orphans. Also openness management system or management ZIS funds entrusted by donors / muzakki must be maintained to create a relationship of trust and responsibility in the future.

CONCLUSIONS

Studies on the general has given the impression that the activities of residents in various types of social transactions with the base values and norms including resiproitas can trust and institutionalized in VTF.Many activities implemented by the VTF management team,local VTF village manager and beneficiary/dhuafa become a form of social capital explanation of the configuration which combines religiousity (value aspect), the functioning of institutions to create a widespread network of relationships between VTF and donor/public. Forms of social capital among others manifested in the institutions working to inspire the work ethic, mutual cooperation, harmonization of institutional management functions on a certain level in particular has provided a guarantee to the victims of the disaster/dhuafa.

The process of transition from the institutional cultural ties to the front as the VTF management network can developed it and will foster a more widespread social and institutional facilities and enabling dhuafa. The concept of poverty needs of dhuafa through a strategy of organic farming provides positive implications for the sustainability of livelihoods of disaster victims/orphans. Disaster victims/dhuafa finally get a chance and the right to a decent livelihood is socially and economically. Although there is still a weakness side for a structured management choices made indicate the dependence of local VTF managers with the management team VTF (VTF Center). Therefore, for future development, to accommodate the functioning of VTF social capital will continue to exist followed by maintenance of a synergistic relationship between the parties concerned in it.

ACKNOWLEDGEMENT

This paper is product of experience as a writer staff at the implementation time of program evaluation VTF by Dompet Dhuafa Republika in Bantul, DI Jogjakarta. Although the researcher does not involved in direct intervention program for VTF currently, the researcher's experience in conducting social analysis in 2008 which is the 2nd period of the VTF program makes the study interesting forward to the follow as a process learning in the conduct sustained disaster management activities. Not forgetting the researcher thanks in particular the Coordinator VTF Program along with supervisors and staff who have been providing the opportunity for reasearcher to write the results of studies with different approaches namely social capital. May be useful for all those who read this paper.

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DISASTER PREPAREDNESS IN THE FORM OF MODEL EMERGENCY SCHOOL LEARNING WITH *FUN LEARNING* APPROACH USING RECYCLING HOUSEHOLD WASTE LEARNING MEDIA

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ABSTRACT

Almost all regions in Indonesia, according to the geographical conditions, are including areas prone to natural disasters, so that it's hardly required a disaster-preparedness. One of the consequences is palpable in the field of education where students have difficulty both mentally psychologically and physically with the destruction of learning facilities. For this reason it is deemed absolutely necessary to prepare a model of disaster preparedness in the form of emergency school learning that emphasizes to the approach of fun learning in an effort to rehabilitate the psychological condition of students. Remembering the emergency conditions in which many learning tools are damaged hence the media made of plastic and metal waste are specially implemented for handling education in post-disaster areas. Research method used is Research and Development (R & D) by using the four-D Models (Define, Design, Development, and Disseminate). The results of the research are: (1) a learning tool have been developed through a test in SDN test Wojo (tsunami disaster, Bantul) and SDN Pangukrejo (Mount Merapi disaster, Sleman), (2) study module base on fun learning is yielded by using the media of plastic and metal waste, (3) the increase of mental stamina and motivation of the students to study, and (4) learning about early detection and integrated disaster risk in science subjects in primary schools affected areas can be developed.

Keywords: *disaster preparedness, fun learning, emergency school.*

INTRODUCTION

Almost all regions in Indonesia, according to the geographical conditions, are including areas prone to natural disasters, so that it's hardly required disaster preparedness. One of the consequences is palpable in the field of education where students have difficulty both mentally and physically psychologically destroyed and damaged by learning facilities. Disasters are also often causing a prolonged effect for children. Education infrastructure destruction caused by the disaster make the children lose the opportunity to participate in educational activities. Educational activities then held in emergency schools. In many disaster incidents, this condition lasted for a long time. This situation is clearly less favorable for them who have to learn with limited facilities, and ultimately teaching and learning process cannot take place optimally.

Legal framework to address this case has been mandated in the 1945 Constitution article 31 paragraph one which states that every citizen has equal opportunity to obtain education. Similarly the Law on National Education System Law No. 20 of 2003of the eleventh section of article 32 that states about the government's obligation to conduct special education for those who have difficulty in learning.

For this reason it is deemed absolutely necessary to prepare a model of disaster preparedness in the form of emergency school learning that emphasizes to the approach of *fun learning* in an effort to rehabilitate the psychological condition of students. Remembering the emergency conditions in which many learning tools are damaged hence the media made of plastic and metal waste are specially implemented for handling education in post-disaster areas. Besides that, this research is also introducing to the students about the existing knowledge about disaster, as emphasized by the United Nations International Strategy for Disaster Reduction (UN ISDR) in the form of *Institutionalizing Integrated Disaster Risk Management at School.*

The study involved several experts and practitioners who have been involved in the development of disaster-prone school education either in college involving science experts (Suyoso, M.Sc. and July Astono, M. Si) as well as educational evaluation experts (Dadan Rosana, M.Sc.), or experienced enough teachers in learning science in elementary schools from SDN Wojo Banguntapan Bantul and SDN Pangukrejo Cangkringan Sleman. In relation with that, hence this research activity located in the Science Laboratory of FMIPA UNY, SDN Wojo Banguntapan Bantul and SDN Pangukrejo Cangkringan Sleman Jogjakarta.

Later in the second year it will be held a limited dissemination involving teachers and students around the disaster-prone eight schools in Jogjakarta. Thus it is clear that the subject of this research are the students and teachers from several schools located in areas where the tectonic earthquake in Bantul District, and Mount Merapi volcanic disasters in the district Cangkringan of Sleman regency in the province of Jogjakarta Special Region.

In the first year the number of students involved as a part of limited restricted dissemination stage only about 32 people since the number of students in two most vulnerable schools selected is limited in number. The study also refers to empirical validity by some good teachers who are in one group with the selected schools as a place of trial; those are the district Cangkringan and district Banguntapan. Therefore, beside the students who attend school in disaster-prone area also involved four teachers who taught science at those two schools.

The first year of research results has been able to develop a learning tool as follows: (1) Practicum device special for recycling, (2) Learning Plan, (3) Student Activity Sheet (LKS) and (4) Instrument Evaluation.

The Learning device has been tested on students at SDN Wojo and SDN Pangukrejo. This is in accordance with the specific purpose of the research relating to the objectives of the *third* and *fifth* that is; developing learning media by using waste materials or waste plastics and metals that be easily obtained in the post-disaster areas, and producing *fun learning* based module using the media learning from plastic and metal waste. Thus, this design can be applied in accordance with the *second* goal that is, developing teaching and learning strategies with *fun learning* approach, in an effort to improve mental resilience and motivation to study further after the disaster that comes with the realization of the *first* research objective that is; to develop learning about early detection and disaster risk integrated in science subjects in elementary schools disaster areas. In accordance with the original study design has been obtained, the results of this study are divided into three main sections:

1. The result in the form of real product
   a. Media learning utilizing waste materials or waste plastics and metals that can be easily obtained in the post-disaster areas
   b. *Fun learning* based learning module using the media of plastic and metal waste
   c. Observation sheet of limited activity dissemination
   d. Observation sheet of teacher training activities
   e. Student Activity Sheet associated with the media developed
   f. Profile of students' skills in using the media
   g. Assessment of the learning process
   h. Product Assessment, student learning outcomes (cognitive tests and portfolio)
   i. Articles and Proceeding/Journal of Sciences in the submission stage of the manuscript to the editor of Education Journal Research Institute of Yogyakarta State University

2. The results in the form of recording process of the activities
   a. Instruments Analysis
   b. *Need assessment* (analysis of the needs of disaster-prone school students)
   c. *Performance assessment* (performance of disaster-prone-school-students of science teachers)
   d. Observation sheet and questionnaire of attitude
   e. Cognitive test
   f. Portfolio
   g. Learning assessment tool
   h. Recording Photos
   i. Videotape

3. The results in the form of Partnership

This first year of activities carried out cooperation with SDN Wojo Bantul and SDN Pangukrejo Sleman in teacher training activities for a group of work and one trial learning tool and the evaluation instruments at those two schools. This cooperation is conducted within the framework of limited testing, consulting of learning implementation and media development. Besides that, it has explored the possibility of cooperation with several schools that are also located in disaster-prone areas of tectonic earthquake and Mount Merapi in Jogjakarta Special Region.

RESEARCH FINDINGS

This research uses several methods in the framework of research and development (R & D) those are; descriptive, evaluative, and experimental. Descriptive research methods used in early studies were to collect data on existing conditions. Evaluative research method is used to evaluate the testing process of product development. And experimental research method uses to test the efficacy of the product produced. While the model testing phase was conducted *collaboration action research* strategies involving teachers directly in primary schools and disaster-prone students in the bottom of school concerned.

Moved from the consideration of approaching systems that the development of practical tools for students at the school vulnerable to disasters will not be quit of management and organizational context of learning, hence the spiral model is selected as referenced by Cennamo and Kalk (2005). In this spiral model there are 5 (five) development phases, those are: (1) definition (define), (2) design (design), (3) show (demonstrate), (4) development (develop), and (5) presentation (deliver).

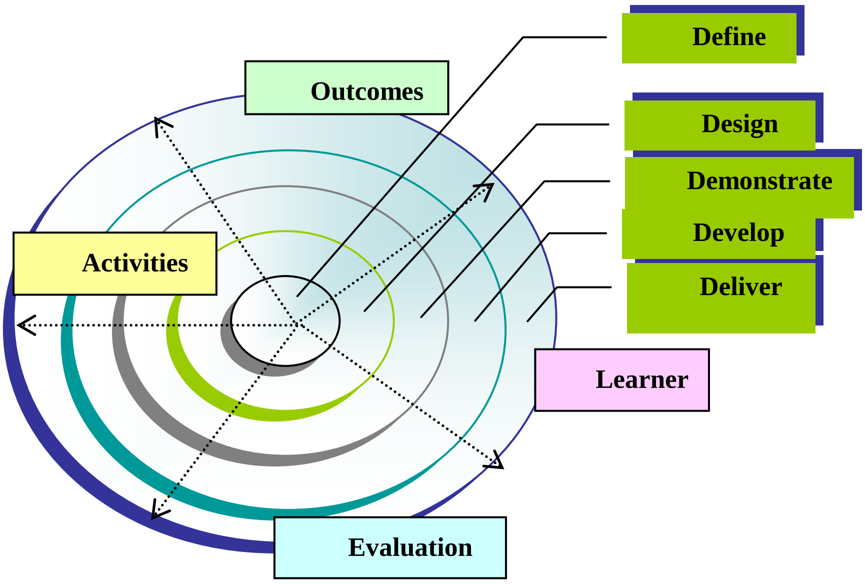

Figure 1 Five phase spiral model of teaching design
Source: Cennamo and Kalk (2005)

A research in the first year begins with a need analysis in the schools potentially affected both by the volcanic Mount Merapi disaster and tectonic earthquake. Analysis is done to determine the basic needs related to the continuity of teaching and learning process after disasters. Simply research stage that has been successfully conducted in the first year of this study can be viewed on the diagram below. Learning tool development activities which adopt the development model of Kemp et al. (1994) has successfully developed the necessary learning tool in science teaching and learning process for students of disaster victims in the secondary school level. The learning device that successfully developed are: (1) Practicum device special for recycling, (2) Learning Plan, (3) Student Activity Sheet (LKS) and (4) Instrument Evaluation. Learning device has been tested on students at SDN Wojo and SDN Pangukrejo.

Conducting research of the application of learning tools in science courses held on the two partner schools SDN Wojo and SDN Pangukrejo, which the teachers followed the training. These implementation activities have been held from 18th July 2006 to 20th September 2008 with duration of 2 sessions per week. Each time meeting or forwarding of RP, it observed: (1) the ability of teachers to manage teaching and learning activities with teachers' competency evaluation instruments, (2) teacher and student activity in learning, (3) Profile of student abilities, and (4) performance and attitudes of the students during the teaching and learning activities with the corresponding instrument. Observations of each activity are presented in Figure 2 below.

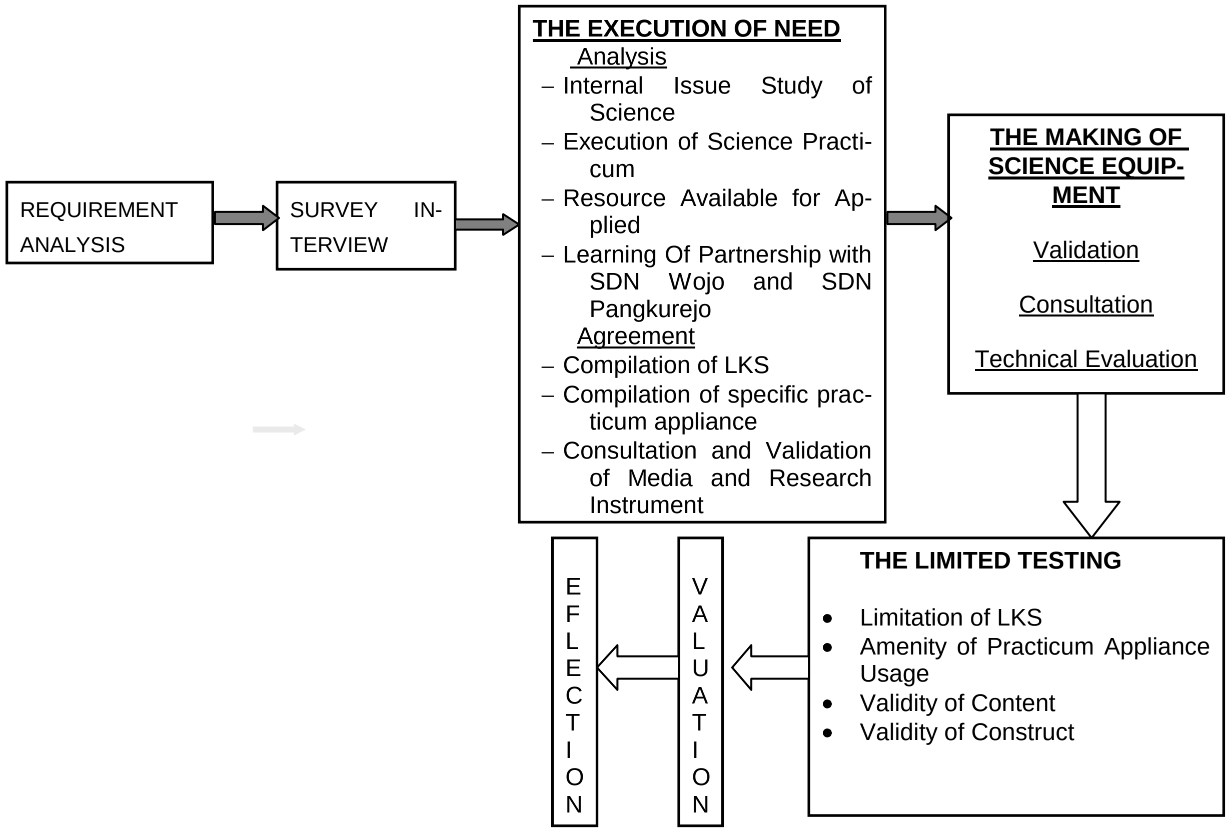

Figure 2 The step diagram execution of research

1. Teachers Ability in Managing Learning

Partner teacher's ability in managing cooperative learning focuses on the ability of activities: Learning Preparation, Introduction, core activities, Closing, Time Management, and the ability of teachers to control classroom atmosphere.

2. Teacher and Student Activities in Education

Teacher and student activities during teaching and learning activities are expressed in percentage of teacher and student activities occurred during the learning process. Percentage of teachers' activities ranged from 7.5% to 35.8%. Activity of the most dominant teachers are explaining teaching materials, that is 35.5% and seek additional examples 21.5 % whereas the least activity a teacher is providing feedback 8% and stimulating to considering the concept 8.5%. While the students' activities are dominated by listening / paying attention to the teacher's explanation or other students 32.1% and the least was asking questions 11.4% and writing down important things that 12.4%.

3. Evaluation Response Against Students Learning

Based on data from the response of students' attitudes towards learning using the learning tool created specifically for disaster emergency handling, it is clear that there is a positive improvement of student attitudes. This is of course a very significant capital to develop further learning, because the attitude that one of them associated with the motivation to be critical success factors of the program.

4. Implementation Evaluation Discussion of Student

The students' discussion activity getting better, this leads to higher activity. This can be seen from the increasing percentage of the activity on next meeting which 1, 2 and 3 values decreased, and the value of 4 and 5 increased.

5. Cognitive Test

This test is used to see students' cognitively level after learning activities were carried out, besides that this test is important to see the correlation between performance and cognitive. This cognitive test consists of 4 formative testing devices and 3 structured tasks based on empirical testing it fit to be used. The average difficulty levels of tasks are medium, which is only about 6 tasks with high difficulty levels and three tasks with low difficulty levels. The complete results of tests of cognitive instruments can be found in the appendix.

The test results of the product are used to determine the student mastery level of subject matter which is measured by assessing the cognitive abilities in learning. Then the cognitive ability will be reviewed individually that called as the individual's exhaustiveness, and viewed as a whole class of students attending class from beginning to end that called as classical exhaustiveness.

The average proportion of correct answers to the first students' formative test 1 is 0.26, and the average proportion of correct answers after they learned using the devices made with the next three formative tests (formative test 2, 3, and 4) is 0.72. Thus, the average proportion of students' correct answers increased amount 0:46. The results of students' exhaustiveness analysis prove that, 23 students or 88.64% of the students have completed their study, of 26 students who follow the field practice of teaching and learning activities and discussions. Thus, classically the students have completed their study, because the percentages of students who have completed their studies exceed the standards set forth in exhaustiveness syllabi. According to the science syllabi, the class is complete if 85% of the students have completed their study, or 85% of the students had p ³ 0.65

There is increasing in cognitively levels between before and after treatment that can be viewed with different test, t test. This indicates that the treatment provided significant enough to increase the level of student cognitively.

6. Correlation between Performance and Cognitively

It can be shown an interesting thing about the correlation between performance and cognitively in this research. By using the Bivariat Kuder-Richardson correlation using the SPSS program, it showed that there is a strong correlation between performance and cognitively.

One important thing that needs to be analyzed for this study is the correlation coefficient between the variables of cognitive tests, and performance assessment in the form of teacher observation sheet. Testing with the bivariate correlation showed that with a significance level of 0.01 obtained:

a. Descriptive Statistic Correlation
   Pearson Correlation between performance and cognitive value 0.791
b. Nonparametric Statistical Correlation
   Kendal's Correlation between performance and cognitive value 0.668
c. Spearman's Correlation between performance and cognitive value 0.807

From the data above, it is clear that the correlation coefficient between performance and cognitive value was above 0.500. Thus there is a strong correlation between the three variables; it means that the students who have high performance values tend to better cognitive value.

CONCLUSIONS

The first year of research results has been able to develop a learning tool as follows: (1) Practicum device special for recycling, (2) Learning Plan, (3) Student Activity Sheet (LKS) and (4) Instrument Evaluation. Those learning device has been tested on students at SDN Wojo and SDN Pangukrejo. This is in accordance with the specific aim of the research relating to the *third* and *fifth* objectives, developing learning media by using waste materials or waste plastics and metals that be easily obtained in the post-disaster areas, and producing *fun learning* based module using the media learning from plastic and metal waste. Thus, this design can be applied in accordance with the *second* goal that is, developing teaching and learning strategies with *fun learning* approach, in an effort to improve mental resilience and motivation to study further after the disaster that comes with the realization of the *first* research objective that is; to develop learning about early detection and disaster risk integrated in science subjects in elementary schools disaster areas. Then, to be realized in second year of the research are:
(1). Developing process evaluation models and science learning products for elementary school students after the disaster, (2). Integrated analysis involving many variables that affect the success of learning both in the form of the manifest variables and latent variables using Structural Equation Modeling (SEM). Therefore, this research is explanatory so that it's carried out an analysis line for several study variables. And in order to develop models of research methods, it used *Research and*

Development (R & D) using *the four-D Models (Define, Design, Development, and Disseminate*). While the statistical analysis to see whether the relationship between variables that is *measurable* and that *latent* in this study used structural equation models with line analysis and confirmatory analysis, using structural equation modeling.

Some of the results achieved in the first year of this study are:

1. The learning device has been successfully developed and supported the quality processes and the quality of science teaching and learning process
2. Teachers are able to do all aspects of learning syntax as it has been designed together with the research team
3. Teacher activity is dominated by KBM manage activities in accordance with the study design, encourage or train the students to active independence
4. Students Activities are dominated by using the learning activities, practice field, and relevant discussion, and practice activities to do active independence. Active independent practice activity increases with the high percentage of teachers' activities in these skills to train students
5. The dominant active independence done by students is a skill to observe and share tasks in groups to complete group assignments.
6. In general, students expressed pleasure and new to learning tools and learning models that have been developed by researchers, so students interested to attend the next science learning as they have followed
7. Science teachers think that teaching media researchers that has been developed quite helpful and very useful in teaching and learning science
8. Teaching and learning processes that apply learning tool made specifically for post disaster situation can increase the proportion of students' correct answers. For formative tests is amount 0:46 and the processes increased by 0.78. However, it still took quite a long time to gain the mature achievement of that goal because the main concept that is *fun learning* can be achieved through continuous development and improved next year.

SUGGESTIONS

Based on the above conclusions, there are still several weaknesses found in this research. Therefore it needs a reflection as the feedback of research action plan next year. Variations of learning media that have successfully created are still not able to fulfill schools need yet, because there are so many science concepts that require tools or instruments for demonstration experiments. However, the limited funds and time led researchers in the first year to be more focused on the tools that easier to make.

It needs the involvement of the Education Department at the district / city in coaching and the Ministry of National Education, who really desperately need development in such this research. Publication of the tools available and socialization planned by researchers' team in subsequent years are expected could be more intensive.

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INVOLVING COMMUNITIES IN DISSEMINATING EDUCATION ON SUSTAINABLE SETTLEMENTS

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ABSTRACT

The meaning of social comfort, cultural ethics, social symbols and identity, will dominate life styles of the communities. Accordingly, cultural issues become significant during people's lifespan, and the cues of the social system through cognitive process will facilitate the mutual interaction between individuals in the community and their everyday environment. However, the complete knowledge of particular environment is constructed through the whole cognitive processes of the users' experiences in that environment. The gradual process of cognitive development and environmental adaptability as well as cyclical process of present environmental interaction will develop the structure of mental power to provide future projections. The people's cognitive imagery process starts from being able to express relative location or movement in the environment by reference to their own body, and then gradually begin to coordinate perspectives and to adopt a general reference framework until people reach the fully integrated cognitive picture of their surrounding environment. This human cognitive development is greatly associated with the construction of sustainable framework of thinking. As cognition is a basis for understanding the world, the way people interact with their environment also provides a psychological weaning, a secure preparation for their self-confidence. Therefore, people's wider worldview and sustainable concept of life are also constructed from their basic environmental perception during the childhood, and then influenced by their improved cognitive ability and structure of intellect over their lifespan. In terms of achieving sustainable environment, the need of involving communities in preventing environmental destruction,- whether due to natural disasters or human-made devastation -, is very essential to generate a more continuous and pleasurable settlement. Consequently, environmental adaptability is important for future survival. Hence, spreading out knowledge throughout the whole communities in practical ways will be more advantageous, and continuing education for the community during their lifespan is also crucial.

Keywords*: community involvement, environmental experience, sustainable settlement*

INTRODUCTION

Community capital is essential in human life. Hence, all social and cultural potentials and community's characteristics will greatly generate a future perspective of the environment where they settle. Community's cultural and social lifestyles play important roles on how they utilize their everyday environment, whether or not they are aware of their roles and functions.

Social communication among people in the community, and mutual interaction between people and their physical setting, also affect on how the environment can continue to exist. The environmental experiences of people, who live in, will be very significant to support and then reconstruct their setting to be more adaptable and enjoyable.

This paper explores the roles of communities in the context of delivering knowledge to shape a more sustainable settlement. First, it sees the sights of how specific community experiences their lifespan. After that, it looks at the interaction between physical setting and people's behaviours, of how environmental perception is based on. Then, it discovers how people's participation shall be empowered to deal with the continuation of the environment. Finally, it resumes some conclusions and sets up recommendations.

CONTINUING PEOPLES' LIFESPAN

Developmental psychology, also known as human development, is the scientific study of systematic psychological changes that occur in human beings over the course of their life span (http://en.wikipedia.org/wiki/Developmental-psychology). Life cycle of human being includes: baby born/ infant – childhood – teenagers – adolescence – older adults – elderly people – died. Among those classifications, they interact and communicate, and sometimes interdependence each other.

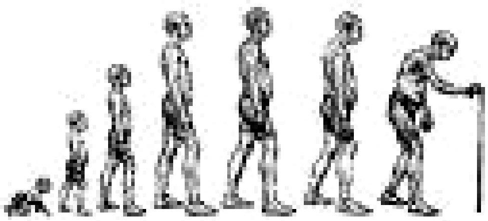

Figure 1: Human Lifespan.
Source:http://breakthroughgod.wordpress.com/category/human-lifespan

During their lifespan, people grow and even change, both physically and psychologically. The different abilities incorporate with a broad range of topics including psycho-physiological processes, cognitive development and self-concept and identity formation. Whilst the stages of cognitive development identified by Piaget are associated with characteristic age spans, they vary for every individual. Furthermore, each stage has many detailed structural forms (http://tip.psychology.org/piaget.html).

As children grow up, their cognitive ability also develops. This childhood step is the basic knowledge for children to develop their learning ability to adapt the changes in order to view the wider world and to construct the framework of intellectual thinking. Its cognitive development is greatly associated with the construction of sustainable framework of thinking. The development occurs through gradual accumulation of knowledge versus stage-like development, or the extent to which children are born with innate mental structures versus learning through experience (http://en.wikipedia.org/wiki/Developmentalpsychology).

Surrounding environment where they live in will support the continuation of people's lifespan. Therefore, views of sustainable settlement need to be disseminated among all generations in the community to stay survive. Environmental knowledge itself can be acquired by interacting with or experiencing different environments, as Golledge (1991) noted that the interaction between users and environment could be direct and active, as would be the case when a person lives in, travels through, or otherwise physically experiences a particular environment.

Principles and theories in formal education might be useful to transfer knowledge and information about sustainable settlement. Nevertheless, informal communication amongst people is also quite beneficial and in some cases very practical in maintaining the existence of the environment.

Physical design and organisational structure of the setting, the characteristics of individual involved, and the quality of people's interpersonal relationships will perform the environmental system (Moos and Lemke, 1984). Therefore, settlement living space and environment should also regard the transformation of socio-cultural values in order to meet the need and preferences of the whole system towards a more sustainable settlement, including preventing from environmental destructions.

Achieving a more comfortable place needs to understand the transformation of friendly spatial information from image into preferable behaviour which actually the characteristic of the environmental perception process. Concerning the interrelationship between person and environment, a person may seek, choose, or create an environment in order to satisfy his/her needs and preferences (Lawton, 1990). A visual representation of environmental attributes plays an important role in ability to cope with diversity of the environment itself. Similarly, as Kitchin (1994) emphasises, a cognitive ability is a mental ability to construct or to enable a person to predict the environment which is too large to be perceived at once, and to establish a matrix of environmental experiences into which a new experience can be integrated. Consequently, the continuation of people's environmental experiences will be synergically in harmony.

ENVIRONMENTAL EXPERIENCES

People-environment relations will include the subjective experience of environments which connotes action or behaviour within the environment (Bechtel, 1997). According to Golant (1984), every individual will produce different environmental experiences due to various reasons, and the environmental information generated by the behaviour is also processed and perceived in different ways. The person, who has lived longer in the same environment and community is more likely to have been experiencing the environmental influence and adaptation level in his/her behaviour style and activity pattern (op. cit.). Perceiving and interpreting the physical environment is a complex process involving the interaction of human physiology, development, experience, and cultural sets and values with outside stimuli (Sanoff, 1991). However, the process of reactions will be influenced by the first sense such as visual, auditory, tactile, that people receive from the stimuli (Hesselgren, 1975; Canter, 1977; Garling and Evans, 1991).

As the perceptual process relates to human senses, and is always influenced by psychological aspects such as emotion, awareness, and attitude, environmental perception is thus also closely related to environmental psychology. Cassidy (1997) defines environmental psychology as *'the study of the transactions between individuals and their socio-physical environments'* (p.4). He also offered another definition, i.e. *'the application of psychological knowledge and method to understanding the process and implications of the human-environment transaction and applying the insight attained to improving the quality of the experience'* (p.240). Environmental psychology has to consider its past, present and future relationship to these disciplines: psychology, other behavioural or social sciences, design and physical science (Proshansky, 1987). Therefore, environmental psychology should be concerned with the way in which people construct their world individually and through shared perceptions, cognition and discourse over time.

Environmental psychology should address the people-environment relation as an integrated concept of interdisciplinary sciences, and the methodological foundation to theoretical constructs and processes will contribute to the qualitative improvement of future environments (Sime, 1999).

The meaning of 'place' is also concerned with the relationship between individual and the surrounding environment. Different environments may reveal different identity and meanings. As a consequence, the complete knowledge of the environment could be constructed through the whole cognitive processes of the users' experiences in that particular environment. Accordingly, a particular daily living (human settlement) environment may also be perceived as having specific implication values of the community.

Furthermore, Gustafson (2001) indicates that a place is not only a physical environment, but also as a symbolic, historical, institutional and geographical environment. A meaningful place, therefore, appears as a process, where various individual projects converge and/or compete with other projects, with external events and with the course of time. In addition, a place may not mean the same things to everybody and meanings of place may even emerge from conflicts about how places should be defined. Such conflicts will involve different valuations of meanings and places.

As human settlement environment is a part of everyday life, it will set in place the cues of the social system through cognitive process, and will also facilitate the mutual interaction between individuals and their everyday environment. The visual cues influence people in terms of the cognitive imagery and wayfinding within the environment, where people deal with their survival context of life.

Many aspects can influence the perceptual process, including a matter of subjectivity. Nevertheless, it can be understood if people have already known their daily living environment well, and they might also have a strong place attachment on it, so that the adaptation effort to handle the stability and changes of the situation would be easier. As Moos and Lemke (1984) assert, *"…Cognitive appraisal processes mediate some person-environment transactions, and they influence efforts to adapt (coping) and the results of such efforts (outcome). An individual's appraisal is affected to varying degrees by both personal and environmental characteristics…" (p.163).* Moreover, in order to sustain the environmental experiences, the need of a prosthetic approach to the design is also important. Carstens (1985) emphasises, *"…a prosthetic environment is one that permits the optimal functioning of the individual by offering support when needed, but allows for independence, challenge and learning…"* (p.15). Challenge and support should be available for the practice of skills and independence for all levels of ability. The challenges offered and the supports provided should be balanced, to avoid frustration and anxiety due to the exceeded challenges, and to prevent the loss of skills and abilities because of the absent of learning opportunities.

The fact that environmental experiences during childhood period are important, and are always remembered, until they are grown up to become adults. In addition, cognitive structures change through the process of adaptation, which are assimilation and accommodation (http://tip.psychology.org/piaget.html).

Assimilation occurs when new information is introduced to a person. It involves the interpretation of events in terms of existing cognitive structure, whilst, accommodation refers to changing cognitive structure to make sense of the environment. In other words, it occurs when the person recognizes schema to accommodate himself / herself with the environment (http://facultyweb.cortland.edu/andersmd/PIAGET/5.html).

The pressure of living environment can be a source of environmental stress. The dimensions of stress ranging from high to low, the number of eople affected is also varied from individual to community, and the duration effect can also be temporary to chronic. The continuation process and improvement quality of environmental experiences will support the ease of environmental adaptation process to reduce environmental stress and to cope with all kind of dramatic environmental changes.

Hence, wider worldview and sustainable concept of life are also constructed from a basic environmental experience during the childhood, and developed by the improved cognitive ability and structure of intellect over the lifespan.

Maintaining a peaceful, comfortable, and unstressful environmental circumstances needs to have to do with the roles of all residents, regardless the age and background. So that every one can contribute to,- and participate in -, educating each other, learning from one to another, and sharing knowledge about the sustainable future settlement environment.

COMMUNITY INVOLVEMENT

Community involvement emphasises on participation of individual, community organization and in self-help and political incorporation in the community development tradition.

Basically, in some areas, there is an enormous demand by native communities to take part in the process of planning and management of their own environment. Actually it is now widely understood that such involvement in some cases will lead to more appropriate development strategy. Nevertheless, lack of knowledge and experience of the participants may also cause such constraints, both during the process and the decision of solutions.

The most substantial is to involve all parts of community who will be affected by the policy as early as possible, and to ensure them that their roles and participation initiatives are vital.

General Principles for Participation and Involvement

Referring to a report of Urban Design Group's Public Participation Programme (1998), there are a number of general principles that may also be adopted by local communities in some urban contexts in developing countries, including Jogjakarta. Some of the principles are summarised below:

1. Involve all parts of those affected. This means that community planning will work well if all parts commit to it.
2. Local community should take responsibility for the overall process. Local residents are to organise the activities where possible, eventhough they are given such advices by the professionals.
3. Any participaton is better than none, and the quality of participation is more important than the numbers involved.
4. Involve full spectrum of community, with regards of different ages, backgrounds, and social-cultural aspects.
5. The participation activities should be effective, not just wasting time and cost.
6. Accept different agendas. This regards to a varied reasons of involbement.
7. Accept various commitment, in order to accomodate different priorities.
8. Transparent and honest.
9. Accept limitation and learn from others, including outsiders who can share the experiences.
10. Use experts and facilitators .
11. Follow up and maintain continuity.
12. Getting involve is not seen as a chore, but meeting people and having an opportunity to have fun throught all simulation and games during the process.
13. To make easier to grasp what is intended, such visual presentation is more effective rather than words.

In order to attract people to take part in such public involvement, and to give opportunities to all parts of the community to get involved, there are different levels of participation (Arnstein, 1969). It does not mean that any one is better than any other, since these differences are appropriate at different times to meet the expectations of different interests.

According to Sherry Arnstein (1969), there are eight steps ladder of participation:

Table 1 Eight steps ladder of participation

1. Citizen control	Degree of citizen power
2. Delegated power	
3. Partnership	
4. Placation	Degree of tokenism
5. Consultation	
6. Informing	
7. Therapy	Non participation, No power
8. Manipulation	

Sources: Arnstein (1969) in Wilcox (1994)

Both manipulation and therapy are non participative. The aim is to educate participants and to achieve public support by public relations. Whereas informing, consultation, and placation, are legitimate steps to enquire participants' advices but no channel for feedback. The power holders still have the right to judge the legitimacy. Citizens' power spreads out into three degrees, i.e. partnership, delegated power, and citizen control. Wilcox (1994) simplified the levels of participation as follows:

1. Information
2. Consultation
3. Deciding together
4. Acting together
5. Supporting independent community interests.

Besides level of participation, there are two other dimensions: i.e. steps of participation and different interests/ stakeholders. Steps of participation consist of initiation, preparation, participation, and continuation, whereas, stakeholders include local groups, business, residents, activists, officers, politicians.

The Roles of Community

The roles of community will be influenced by different groups, attitudes, as well as initiatives, in which they are classified. It will also be affected by where they stand in the participation level.

In the case of the ways to disseminate knowledge and education in Jogjakarta urban settlement context, the community can be take part in what they are interested in, which level they will stand, whether indicidually or in a group. Each individual can play the roles to disseminate the knowledge.

The cultural ethic of respecting others, and the principle of mutual benefits among family members to take care of each other, would be very practical to support all members and wider society. This means that every one can share the environmental experience he/she holds to each other, discussing, and thinking a more qualitative improvement to the environment.

The regular and occasional neighbourhood or community forum can be a communication medium for sharing social problems and discussing the solutions. In this forum, individual or group can be involved in, and distribute the solution initiatives to other participants.

Formal as well as informal public information notice boards can also be very useful to spread the information out to the people in the surrounding area/ environment.

The existence of some informal community groups or organisations in each subneighbourhood was very much beneficial for people to have chances to get together, or to do social activities with their group members. Other informal community organisations that would give special services and are beneficial to take care of the community life should be supported.

Furthermore, another benefit for Jogjakarta cultural context is the social system. Social capital of harmony and principle of conflict avoidance in the Javanese cultural context (Magnis-Suseno, 1997) also psychologically contribute to the peaceful life of the community. With minimum conflict and in a peaceful environment, people could be encouraged to be more active in the society, and then to improve their own ability in many aspects. This is also very beneficial for their private life. They can improve the quality of life, whether in a family scope or in a wider social context. Therefore, it is essential to set up the interrelated organisations with those statutory basic principles, to be more supportive for the continuing lifespan.

In general, social community can be splited up based on different types of users of environment. The types include classifications by gender, age, and different needs and interests. Children, adults, and elderly people, can take part in the participation, whether individually or in specific groups. They will be able to deliver and disseminate such knowledge, information, and other environ-mental policies.

Methods of participation are varied (Wates, 2000). In the context of dissemination, it can be in the form of action planning events, roundtable workshop, interactive workshop, interactive display, roadshow, participatory appraisal, focus group discussion, simulations and games, and written information.

Mutual support between children and elderly are possible, and are the subjects of empowerment of every generation. While, mutual benefits amongst community groups, professional experts and other stakeholders are also very promising. Therefore, community social network is essential to be set up.

Here is the summary of opportunities, chances, and possibilities of each individual to get involved in participation process:

Table 2 The opportunities and roles to participation process

What stage of lifespan	What roles	Which level of participation?
Infants	-	-
Childhood – individual	Learning	Manipulation, therapy, receive information
Childhood – groups	Learning, sharing experience and knowledge	Manipulation, therapy, receive information, informing
Teenagers – individual	Learning, Discussing, Sharing.	Manipulation, therapy, receive information, informing
Teenagers – youth groups	Learning, Discussing, Sharing, Simulation process	Manipulation, therapy, receive information, informing, consultation
Adolescence – invidual	Learning, Discussing, Sharing, Educating, Simulation process, Deciding together, Acting together	Therapy, information, consultation, placation, partnership, delegated power
Adolescence – groups	Learning, Discussing, Sharing, Educating, Simulation process, deciding together, acting together	Therapy, information, consultation, placation, partnership, delegated power
Elderly, individual	Learning, Discussing, Sharing, Educating, Simulation process, Deciding together, acting together	Therapy, information, consultation, placation, partnership, delegated power
Elderly – groups	Learning, Discussing, Sharing, Educating, Simulation process, Deciding together, acting together	Therapy, information, consultation, placation, partnership, delegated power
Experts / professionals	Discussing, Sharing, Educating, Simulation process, Making decisions	Partnership, delegated power, controller
Outsiders	Learning, Discussing, Sharing, Simulation process	Therapy, information, consultation, placation, partnership, delegated power, partnership
Other stakeholders	Learning, Discussing, Sharing, Educating, Simulation process, Deciding together, acting together	Partnership, delegated power, controller, supporting donation

CONCLUSIONS

The contents of environment will reveal the prospective quality of the community, and include what are the actual things as well as the on-going events. People's activities within the everyday living environment and their behaviour pattern and experiences are also part of those contents.

As human beings age, a weakening in sensory-motor abilities occurs and chronic health problems tend to accumulate, reducing the competence of the individual in efforts to cope with the environment (Carp 1991). Modification of such design in the physical environment seems to be essential to support and to accommodate people's needs. In other words, the urban form elements should be robust enough to accommodate those changing needs, in order to guarantee that the environment will be long lasting.

The roles of individuals and groups in the community need to be enhanced qualitatively to achieve a more effective public involvement. Empowerment of community in maintaining and sustaining their own environment is mainly indispensable.

Methods of participation used depend upon who will participate, and what results are intended. Information of new good practices and guidance to achieve a more sustainable environment to the whole community should be added regularly.

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SUSTAINABLE LIVELIHOOD COMMUNITY DEVELOPMENT AS THE RESPOND OF THE EARTHQUAKE DISASTER

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ABSTRACT

Hazardous of natural disaster at the usually can't be predicted. Specialize earthquake disaster although can't be predicted in exactly time, it depend on the geographic position in the world when the earthquake will be come true. The zone of the tectonic earthquake disaster means ring of fire zone. The event records show that the almost the disaster victims, be caused hit by their house ruin.

The concept for disaster problem solution should be separated into three periods of time: pre disaster, during disaster, and post disaster periods. Every period needs specific problem solving. During disaster period, quick activity response is needed for evacuation and save the victims. At the period of post disaster the main actions are physical reconstruction and psychological rehabilitation, due to traumatic of disaster event. Then at the pre disaster period several activities need to be conducted for quite along time duration. The pre disaster period is also known as a disaster mitigation period. The goal of the mitigation period is how to prepare community toward disaster. It means how to create sustainable livelihood community which be supported by local inhabitant and local natural resources to reduce their vulnerability when disasters hit. Therefore, the development of sustainable livelihood must be taken into account the environment carrying capacity to support inhabitant population.

There are three expectations of sustainable livelihood community development. First, saving house after reconstructed as an engineered building, second, sustainable livelihood improvement in sufficient condition, and third, to be a disaster prepared community.

Keywords: *pre disaster mitigation, building reconstruction, sustainable livelihood improvement, disaster prepared community*

INTRODUCTION

May 27th, 2006 the great tragedy had been happened in Yogyakarta because of tectonic earthquake disaster event. More than 6.000 victims were dead and more than 180.000 houses unit were ruined. The Yogyakarta's earthquake disaster with large victims had been followed by two big earthquake disasters in 2009 which are Tasikmalaya, and Padang. These events proved more that Indonesia vulnerable with earthquake disaster. More than 60% of Indonesia territory is vulnerable with earthquake. Naturally earthquake cannot eliminate. The effort can be done is to reduce number of the victims and vulnerability level by Disaster Risk Reduction (DRR) program. The content of DRR program are to reduce vulnerability and to support inhabitant capability in responding earthquake disaster. This program works by improving inhabitant capacity to respond when the disaster event hit.

The guidance of disaster mitigation program had been regulated at the National Disaster Prevention Law Number: 24 – 2007. The program is separated into three periods of time:

1. Firstly when there is no disaster it means a pre disaster period. The program includes plan, prevent, risk reduction, education, training, research, and spatial arrangement
2. Secondly when the disaster happened it means during disaster. The program is rapid evaluation, emergency activities, save and evacuation, fulfill a basic need, and rehabilitation.

3. Thirdly when there is a disaster hazards potential. The program is mitigation, early warning system and preparation. When the disaster hit, the program is reconstruction of building, infrastructure, also social and economic; and rehabilitation of healthy life, law enforcement and environment conservation.

A model of disaster cycle is shown at Figure 1.

Note of the figure means:
Pra bencana = pre disaster
Pencegahan = prevention
Bencana = during disaster Mi-
tigasi = mitigation
Tanggap darurat = emergency respond
Kesiapsiagaan = preparedness
Pemulihan = rehabilitation
Rekonstruksi = reconstruction

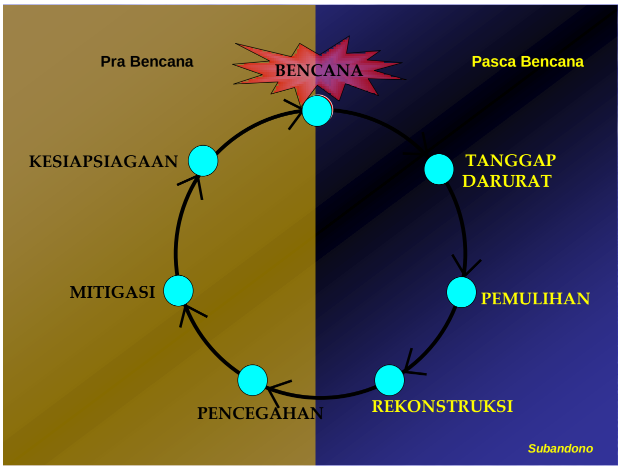

Figure 1 Model of disaster cycle
Source: Subandhono, 2008

Natural and culture consideration

Natural consideration means the result evaluation about level of hazardous for human settlement because of natural factor. For example, earthquake and volcanic eruption are a part of natural factor. The hard problem is the dangerous area had been used for human settlement for a long time. The habitant at the rural zone is usually lack of education, lack of knowledge, and lack of information about disaster hazardous. They obey more to spiritual leader include as culture of literary figure.

The attractive case about it is a culture of a sloping land community in Merapi Volcanic. Their settlement had been declared as a dangerous zone by government since 1992. Government was conducted local migration program that the community has to move to the other safe location. Since for five years no Merapi's eruption event over there, then the community come back to their native settlement. The people believe there will be no dangerous eruption more because their spiritual leader, Mr. Marijan, still stay there. Mr. Marijan refused to move from there because he said that he received message from the Sultan of Yogyakarta, His Majesty Hamengkubuwana IX. The message stated that Mr. Marijan had be promoted as Merapi constable, so nobody can order him to move from his home, except His Majesty Hamengkubuwana IX, including the present Sultan, His Majesty Hamengkubuwana X. A case of Mr. Marijan shows the natural and culture consideration for DRR program.

Another example is a traditional communication tool called "kentong". A kentong is a things made from bamboo or wood. Java people have been used kentong as an early warning system since along time ago. Thus, a kentong can be used to support early warning system for DRR program, especial for inhabitant at rural zone. It also can be used to respond when the disaster come true. A problem is a code to hit kentong to make sound for early warning system has not been yet establish.

A. Human resource consideration factor

Human resource consideration factor mean the ability of human potent to create and to improve the need for DRR program, e.g. a need to build an engineered building, a need of skill to avoid from disaster, a need of skill to manage the natural resources for their living and the importance one, a need of skill to created sustainable livelihood community as an effort for improvement capacity to reduce the risk when the disaster hit.

The first priority DRR program is a rural community by giving them a skill to support their life soon after disaster hit, or to reduce their vulnerability because of a disaster. The model of sustainable livelihood cycle is shown at Figure 2. The problems at every stage of the cycle are (1) how to increased quality and quantity product by avoiding pesticide and herbicide, and how to manage water resources efficiently, (2) how to store product by appreciate technology (3) how to sell food as a product of home industry (4) how to distribute home industrial product by business partner, and (5) how to earn more money by increasing value of food.

The big problem is a process to sell a product. As usual, rural inhabitant is lack of experience and lack information to distribute their food product. So human resources empowerment program is needed to improve capacity power of the habitant.

Goal of human resources empowerment program is to create sustainable livelihood community at the zone with vulnerability of disaster. The living cycle model of sustainable livelihood at rural life as an agro eco system is showed in Figure 2. The detail of the DRR program is showed in Table 1.

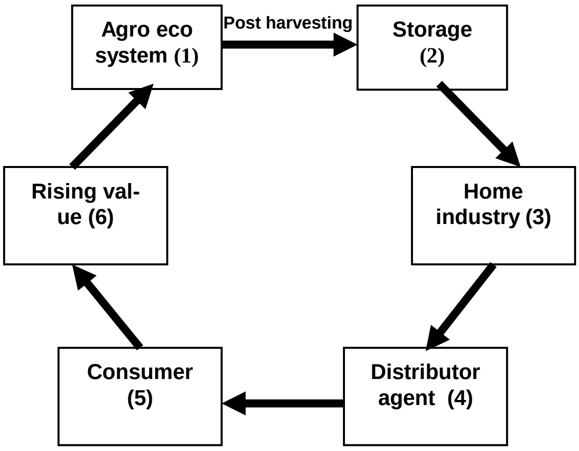

Figure 2 The cycle living model of sustainable livelihood at rural life as an agro eco system
Source: Suhardjo, 2009

Table 1 Matrix of human resources empowerment program

Program \ Level	Children	Teenagers	Adult
Individual	Self help	Participative	Initiator
Communal	• Game of during disaster simulation • Disaster early warning system introduction • Saving and comfort house with game facilitation	• First evacuation of the victims of the disaster • Disaster early warning system socialitation • Conducive environment by sport, art gallery and auditorium facility	• Empowerment of evacuation, reconstruction, rehabilitation. • Early warning system information building • Creation of sustainable livelihood

Source: Suhardjo, 2009

Economic consideration factor

Economic factor to be come strategic factor, quality and quantity product of rural zone were nothing without followed by marketing effectiveness. The marketing agent net working must be created, firstly at local scope, secondly at regional scope, thirdly at national scope.

The other handicapper, the farmer has no finance capital for product processing. Using of banking system not yet common, because of bureaucracy and accessibility factors. A microfinance institution is then become importance for problem solving. An example micro finance institution: finance cooperation, Islamic syari'ah finance institution Baitul Maal wat Tamwil (BMT) can be used for the problem solving.

Figure 3 Micro finance institution Baitul Mal wat Tamwil (BMT)
Source: Suhardjo, 2007

The BMT conception is based on Islamic economist. The concept of profit earning distributed between BMT and investor. The distribution is disposed after money circulation over by ratio conception. The ratio profit distribution to be disposed first when investor submitted their capital to BMT institution. The ratio of profit distribution means profit comparative between investor and BMT institution.

SUSTAINABLE DISASTER RISK REDUCTION PROGRAM

The DRR Program must be done continuously. Socialize about preparedness of disaster respond become a way of live. So it must be formulated by attractive event to avoid boredom. The socialized program shows the negative impact when the disaster strikes. As an example, a figure in Figure 4 shows sadness after an earthquake.

Focus Group Discussion (FGD) is an example of activity to improve community capacity. By doing FGD, many problems can be discussed to get an optimal solution to create sustainable livelihood community. The role of instructor and facilitator in FGD is very importance as a supporting person until the goal which is sustainable livelihood community can be reached. Figure 5 is showed a situation of FGD to train construction worker about earthquake resistance building (barrataga).

Figure 4 Save my soul from the ruin

Figure 5 FGD activity be continued by training program about engineered building to respond earth quake disaster
Source: Sarwidi, 2006

In this training program, the output was the trainees expected to be a skilled worker and socialized agent about resistant building for disaster risk reduction when the earthquake strikes. The other case of FGD is an environmental education forum. Thousands illegal house at urban zone had occupied conservation zone at the bank of the river. This case has been happened because the government failed to implement spatial arrangement conception. It is also an impact of law enforcement weakness.

The ideal solution of this case is the government has capability to move the habitant to the other place, with saver condition. In fact, live at the river conservation zone is high risk for flood and landslides disaster. The NGO (Non Government Organization) take over a part of the problem solution by conducting education approach using FGD forum and to support education fee aid for the children.

Figure 6 FGD forum and followed by education fee aid for the children
Source: Suhardjo, 2005.

The activity has been done since 2004 until present. The future NGO problem is they have no enough funding to support the activity. The NGO expected that the government take over this activity.

CONCLUSION

There will be no safer communities from disaster hazard without supported by sustainable livelihood condition. It means role of human resource and natural resource for community's lives is very importance factor. This paper was presenting the problem especially for rural inhabitant community as they are usually represents a vulnerable community. The vulnerability is caused by lack of education, lack of life skilled, lack of information, and under poverty line.

The serious government problem, how to improve farmer live condition until their live on upper poverty line. Purpose of solution for the problem:

1. Carrying capacity evaluation of the agro ecosystem potential, and calculate how many people can be live in sufficiency condition at the system. The firstly priority to build saving house by engineer building it needing for disaster risk reduction
2. Human resources empowerment program how to manage sustainable livelihood cycle at their community. The community will be able to manage their settlement at the agro ecological system by improving their skilled managing sixth apart of the cyclic of sustainable livelihood it had be showed at Figure 2.
3. To effort that sustainable mitigation and disaster risk reduction program to become as way of life their community. Its must by followed ability improvement how to become disaster prepared community by sustainable program it had be showed at Table 1.

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FARMER'S KNOWLEDGE ON SOIL EROSION AND CONSERVATION

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ABSTRACT

Most of Indonesia has a moist tropical climate, with abundant rains and high temperatures. December, January, and February are normally the months with highest rainfall, which leads to high possibility of flooding with soil erosion. Soil conservation works in conservation agriculture are certainly capable of greatly reducing run-off, soil loss rates and sediment yield. Farmers are the central players in the promotion of conservation agriculture and the choice of the conservation agriculture level seems to be influenced by education level and land size tenure, therefore the objectives of the research are to study many aspects of community related to the understanding of conservation agriculture especially soil conservation. The research will focus on the community of Serayu watershed of Banjarnegara District, Central Java Province because the watershed causes heavy sedimentation of Mrica reservoir. The research was carried out in two step processes i.e. the determination of research area and socio-economic study. To determine the research area, geographical study was carried out. Basic methodology that is used in social economic study was descriptive analytic. Purposive sampling is exploited to determine survey area in term of sub-district and village. Fifteen respondents are selected randomly from every village. It could be concluded that most of farmers in the water catchment area of Serayu watershed (1) know that soil erosion has been occurred in their land based physical river condition but such soil erosion was not influenced by agricultural activities, (2) don't understand conservation agriculture, but they practiced soil conservation both vegetative and mechanical methods. They realized that soil conservation could prevent soil erosion, landslide and loss of soil fertility.

Keywords: *soil erosion, soil conservation, conservation agriculture, Serayu watershed*

INTRODUCTION

The Indonesian archipelago extends from 6° N to 11° S latitude and from 95° to 141° E longitude, and characterized as warm humid tropics. Most of Indonesia has a moist tropical climate, with abundant rains and high temperatures. Annual rainfall ranges from 1000 to more than 5000 mm/yr, with more than 90% of the country receiving average rainfall of more than 1500 mm. December, January, and February are normally the months with highest rainfall. With such high rainfall, there is physically a high possibility of flooding with soil erosion, especially when community behaviours are changed in term of land use (anonym, 2002).

Soil erosion is a physical natural process and generally aggravated by human intervention. Soil erosion occurs normally when the soil lacks protective vegetative covers (Pimentel and Kounang, 1998). Soil erosion leads to a range of detrimental effects including reservoir sedimentation, siltation of irrigation canals, waterways and harbours (Xinbao and Walking, 2005) and even water quality degradation (Lal, 2001). Soil erosion is the most widely recognised and most common form of land degradation and a major cause of falling productivity (Stocking and Murnaghan, 2001). Soil erosion is an insidious and slow process, farmers need to perceive it's severely and the associated yield loss before they can consider implementing soil and water conservation practices (Chizana et al., 2007). Soil conservation works in conservation agriculture are certainly capable of greatly reducing run-off, soil loss rates and sediment yield (Erskine and Soynor, 1996).

Conservation agriculture is an application of modern agriculture technology to improve production while concurrently protecting and enhancing land resource on which production depends (Dumanski et al., 2006). Conservation agriculture including agro-forestry promoted value added production through improves crop and animal production. Conservation agriculture is best achieved through community driven development process whereby local farmers and their associations identify and implement the best option of conservation agriculture. Farmers are the central players in the promotion of conservation agriculture (Mckell and Peiretti, 2004). The choice of the conservation agriculture level seems to be influenced by education level and land size tenure (Bandara and Theruchewam, 2007). Personal characteristics of farmers, institution factors such as local group membership, knowledge in conservation agriculture, income per capita and size of farm influence conservation agriculture adoption (Bayard et al., 2006), therefore the objectives of the research are to study many aspects of community related to the understanding of conservation agriculture especially soil conservation. The research will focus on the community of Serayu watershed of Banjarnegara District, Central Java Province because the watershed causes heavy sedimentation of Mrica reservoir.

RESEARCH METHODOLOGY

The research was carried out in two step processes i.e. the determination of research area and socio-economic study. To determine the research area, geographical study based on (1) topography, (2) accessibility, (3) land use, (4) socio-economic, and (5) local government agreement was carried out. To provide all information about above aspects, some steps need to be done such as (1) overlaying topographical, administrative, land use and landslide maps, (2) discussion with local government, (3) area orientation, and (4) focus group discussion.

Basic methodology that is used in social economic study was descriptive analytic with 3 main activities i.e. survey area determination, socio economic survey and focus group discussion. Purposive sampling is exploited to determine survey area in term of sub-district and village. There are several considerations to choose survey area such as (1) part of the Serayu riverbank, (2) relative wide-open area, and (3) similar to result of determination of research area based on physical parameters.

Socio-economic survey is conducted at selected villages and landowner will be used as target population. Survey is carried out by structural question in the form of questioner. Fifteen respondents are selected randomly from every village. At the end of the survey, community characteristics and motivation on conservation agriculture are collected through focus group in 20 – 30 members' discussion.

RESULTS AND DISCUSSIONS

The result of this research can be divided in two parts i.e. research area description, and socio-economic study.

Research Area Description

Banjarnegara district is located in west of central Java Province and on 7° 12' - 7° 31' S latitude and 109° 29' - 109° 45'50" E longitude. The area is 106.970,997 ha in size or 3,10 % from central Java Province total area. At the north, Banjarnegara is closed to Pekalongan and Batang Provinces, at the east, it is closed to Wonosobo, while at the south is closed to Kebumen. Though Banjarnegara is located at the west of central Java, but there is one district which is closed to it and situated at the west border of central Java, i.e. Banyumas and Purbalingga (Figure 1).

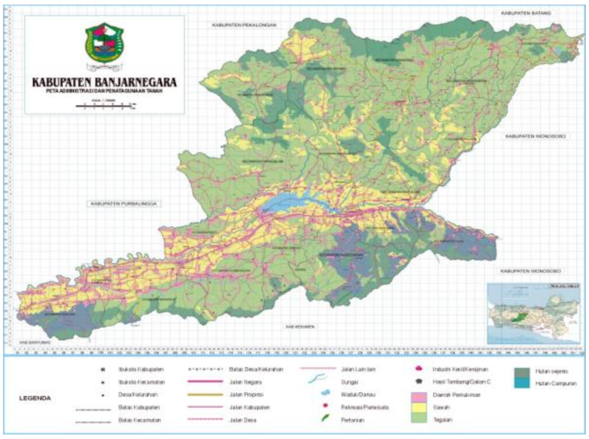

Figure 1 Banjarnegara district

Based on geographical distribution, the area of Banjarnegara can be divided on three zones, i.e. north, central and south. North zone includes mountainous area and part of Dieng High Mountain. North zone covers Kalibening, Pandanarum, Wanayasa, Pagentan, Pejawaran, Batur, Karangkobar and part of Madukara sub-districts. This area can be considered as the biggest water catchment area of Mrica reservoir.

Central zone is Serayu watershed valley region that is relatively flat and fertile. This zone covers part of Banjarnegara, part of Madukara, part of Bawang, Purwanegara, part of Mandiraja, Purworejo Klampok, part of Susukan, Wanadadi, Banjarmangu and Rakit. Mrica reservoir is located at this area. South region can be categorized as Lime Mountain. This area is considered as mountainous hilly and steeply area, therefore secondary crops are very dominant. South zone include Pagedongan, part of Banjarnegara, Sigaluh, part of Mandiraja, part of Bawang and Susukan.

Based on topographical information, big part of Banjarnegara (>50%) is located 500 metres above sea level (m asl). Pejawaran, Batur, Wanayasa, Kalibening, Pandanarum, Karangkobar and Pagentan sub-districts are situated at 1000 m asl. Non-paddy field is the most dominant land use of Banjarnegara (86,32%). Upland area is considered to be the dominant land use at the mountainous area. Secondary and vegetable annual crops are grown very intensively in this area, therefore such area has a very important role in causing sedimentation of Mrica reservoir.

With geographical and topographical analyses, Pagentan sub-district was selected to be the most appropriate research area. This area fulfills some requirements such as (1) there are 2 important Serayu sub-watersheds i.e. Mrawu and Tulis, (2) there is wide open area, (3) there is no similar activity run by local government. With similar criteria, 5 villages have been selected, i.e. Babadan, Tegal Jeruk, Majasari, Gumingsir and Plumbungan. These 5 villages are located at > 1200 m asl with slope > 15%, and tended to landslide (Figures 2 – 4).

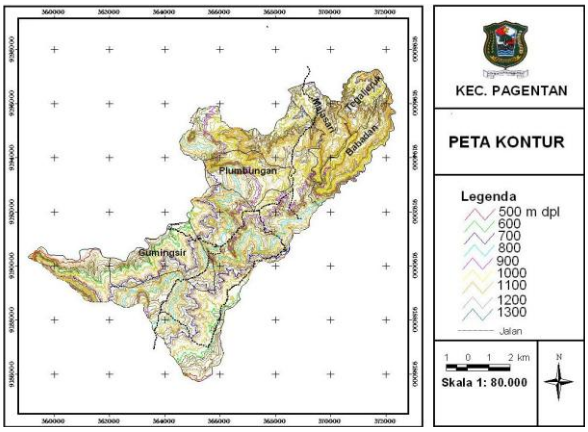

Figure 2 Contour map of Pagentan sub-district

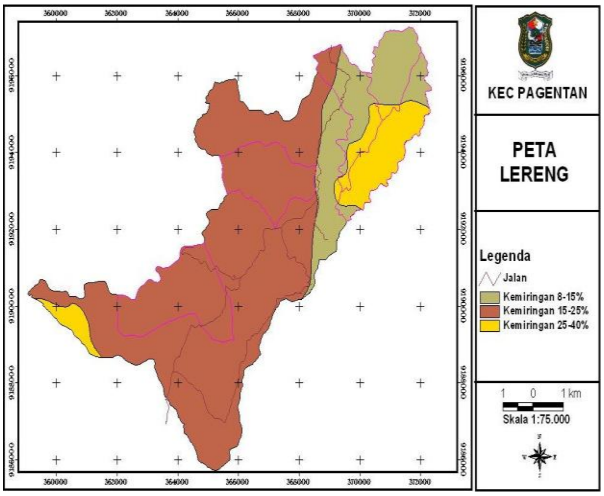

Figure 3 Slope map of Pagentan sub-district

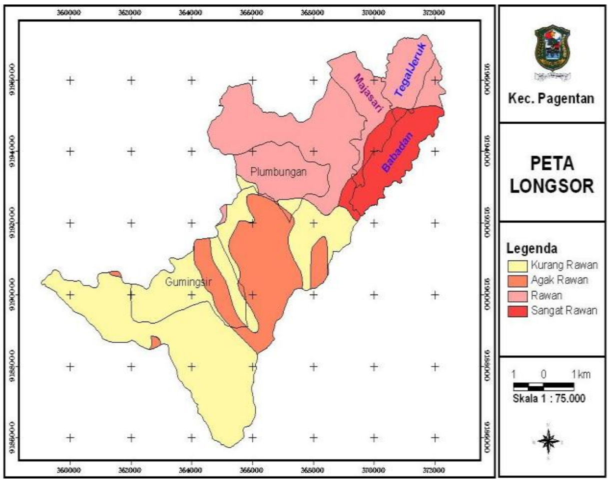

Figure 4 Landslide map of Pagentan sub-district

Socio-Economic Study

The socio-economic study identifies farmer characteristic, household income, and farmer's knowledge on sedimentation and the way to cope with.

1. Respondent Characteristics

The respondent characteristics included age, education level, main job, and side job will be observed because personal characteristics of farmers and size of farm influence soil conservation adoption (Bayard et al., 2006). Bandara and Theruchewan (2007) mentioned that the choice of soil conservation level is influenced by education level and land size tenure. Table 1 showed age distribution of the respondent in every village. From this table, it could be concluded that more than 50% respondents are in productive age, which is between 15 – 64 years old.

Table 1 Age distribution

Village	Number of samples	15-64 years (%)	> 64 years (%)
Babadan	15	93	7
Tegal Jeruk	15	93	7
Majasari	15	87	13
Gumingsir	15	80	20
Plumbungan	15	93	7

Source: Primary data analysis, 2010

Respondents' education level varied among villages from non-educate (no school) until bachelor graduated. Almost all respondents in all villages graduated from elementary school (Table 2). Respondents, who graduate from college, were only being found in Majasari. With higher education level and productive age, the transfer of knowledge and new concept of conservation agriculture could probably be accelerated.

Table 2 Education level

Village	No. of samples	*Percentage (%)*				
		No school	*SD*	*SMP*	*SMA*	*S1*
Babadan	15	*7*	*87*	*0*	*7*	*0*
Tegal Jeruk	15	*0*	*60*	*40*	*0*	*0*
Majasari	15	*0*	*40*	*7*	*40*	*13*
Gumingsir	15	*33*	*60*	*7*	*0*	*0*
Plumbungan	15	*13*	*74*	*13*	*0*	*0*

Source: Primary data analysis, 2010
Remarks:
SD : Elementary school SMP : Junior high school
SMA : Senior high school S1 : Bachelor degree

Table 3 showed main job distribution at every village. Most people are farmers, moreover civil officer could only be found in Majasari. With this condition, it could be considered that almost all communities used crop cultivation as their main job, and other jobs such as trader, civil officer and key person at the community were their side job.

Table 3 Main job distribution

Village	No. of samples	*Percentage (%)*			
		Farmer	*Trader*	*Civil officer*	*Village official*
Babadan	15	*87*	*13*	*0*	*0*
Tegal Jeruk	15	*93*	*0*	*0*	*7*
Majasari	15	*73*	*7*	*13*	*7*
Gumingsir	15	*100*	*0*	*0*	*0*
Plumbungan	15	*100*	*0*	*0*	*0*

Source: Primary data analysis, 2010

The side job was sometimes important to gain more income for the household. The side job income was sometimes even higher than main job income. Even so, not all respondent have side job. Most people in Gumingsir, worked as trader for their side job, while at Plumbungan were more dominating as labor in agriculture (Table 4).

Table 4 Side job distribution

Village	Number (person)			
	Farmer	Trader	Labor in Agriculture	Carpenter
Babadan	2	1	0	2
Tegal Jeruk	2	5	0	1
Majasari	4	3	1	0
Gumingsir	0	14	0	0
Plumbungan	0	0	13	1

Source: Primary data analysis, 2010

2. Farming Activity

Because every village has different geographical characteristic, it has a different type of agricultural area. Land in Babadan, Tegal Jeruk, and Majasari village had a high hilly topography and they could be categorized as the highest part of Pagentan sub-district, there were therefore no paddy fields. There were some plain area found in Gumingsir and Plumbungan. In such area, farmers tended to grow rice when there was enough water. Secondary crops were cultivated at the hilly part especially when water was limited. Home garden was only being observed at Gumingsir and Plumbungan. Due to round village settlement type, it was very difficult to find home garden in Babadan, Tegal Jeruk and Majasari. At such kind of settlement, houses were gathered in one suitable site, while agricultural area located outside the settlement.

Tabel 5 Ownership of agricultural land

Village	Self-own			Total (ha)	Rent	
	Rice field (ha)	Dry field (ha)	Home garden (ha)		Dry field	Total (ha)
Babadan		0,34		0,34		
Tegal Jeruk		0,91		0,91	0,5	0,5
Majasari		1,03		1,03		
Gumingsir	0,18	0,11	0,001	0,29		
Plumbungan	0,06	0,30	0,003	0,37		

Source: Primary data analysis, 2010

Land fragmentation is a common issue to agricultural area in Java. Land fragmentation could also be found in studied villages, although the land was only fragmented into two plots. Table 5 showed that the land ownership could be divided into two categories such as self-own and rent, though rent land was very limited. There was no share cropping system. The size of agricultural land ownership in most villages is tended to be very narrow. It was only between around 0,29 until 0,54 hectare. Only at Tegal Jeruk and Majasari, the size of land ownership was still wide enough 0,91 and 1,03 hectare respectively.

Table 6 Crop types

Village	Annual crop		Perennial crop	Animal production	Fishery
	Rice field	Dry field			
Babadan	-	Maize, cassava, chili pepper	Salaca, albizia, calliandra, patchouli	Cattle, goat, chicken	-
Tegal Jeruk	-	Chili pepper, maize, long bean, tobacco, potato, tomato, cabbage	Pines	Cattle, goat, chicken	-
Majasari	-	Chili pepper, maize, tobacco, long bean, tomato, carrot, cabbage	-	Cattle, goat, chicken	-
Gumingsir	Paddy, maize	Maize, cassava	Salaca, albizia, calliandra, coffee, king-grass	Cattle, goat, buffalo, chicken, duck	-
Plumbungan	Paddy, maize, peanut	Maize, cassava, chili pepper	Salaca, albizia, banana, calliandra, king-grass	Cattle, goat, chicken	Gold fish, tilapia fish

Source: Primary data analysis, 2010

Farmers cultivated different kinds of crop. Every village had its own types of crop, as well as its farming activity. Except crops, communities also kept animal and fish. The annual crop planted in rice and dry field were food crops, not only paddy, maize, and cassava, but also vegetables, tobacco, and medicinal plants. Paddy and maize were cultivated for self-consumption, especially for staple food. Tobacco was cultivated only at Tegal Jeruk, Majasari, and Babadan villages, and commercialized as grate tobacco or "*garangan tobacco*". Now days, potato was only found in Tegal Jeruk. The introduction of potato in this area would be able to change the land preparation system due to very intensive agriculture without considering the sustainability. The perennial crops planted in the studied area were wood trees such as albizia and pines, fruit tree mainly salaca, and also calliandra for feeder. The common animals were cattle, goat, and chicken. Lastly, fishpond was only found in Plumbungan (Table 6).

The household income can be obtained from farming and non-farming activities, both by household head and also members. Besides that, family sometimes also received remittances from children or relatives living outside the village. Table 7 showed an estimate household income of every farmer. The income of household head and members were estimated in 1 year. Other non-farming job income could not be included such as credit, gift and gain from cooperation.

Household income presented in Table 7 was total income from crops, animal, and fish. Then, household total income was calculated by adding income estimation of household head and members from extra activities. Table 7 showed that average income in Majasari and Gumingsir have already reached more than Rp 1 million per month, while in the other villages were still lower. Thus, it could be concluded that Babadan, Tegal Jeruk, and Plumbungan required more productive economic activity to increase their household income.

Table 7 Household income

Village	Household income (Rp/year)	Household total income (Rp/year)	Household total income (Rp/month)
Babadan	1.392.23	1.872.23	156.02
Tegal Jeruk	3.754.08	8.310.36	692.53
Majasari	16.151.93	17.365.27	1.447.11
Gumingsir	15.262.24	20.871.73	1.739.31
Plumbungan	5.418.70	5.348.70	445.72

Source: Primary data analysis, 2010

3. Knowledge About Sedimentation

Intensive agriculture impacts significantly on the environment such as sedimentation (McKill and Peiretti, 2004). Physical characteristic of sedimentation were river siltation and the formation of river delta along its stream. In the long term, sedimentation was severe due to silting up of the dam along its stream, reducing electricity production, and even drought on the river watershed area during dry season.

Table 8 showed the distribution of Farmers' knowledge on sedimentation. It could be concluded that the Farmers' knowledge about sedimentation was still very limited. The Farmers argued that agricultural practice doesn't cause sedimentation. There was no effort to decrease the river sedimentation.

Table 8 Farmer's knowledge on sedimentation

Village	Nearest river with the area	Number of sample	Knowledge of sedimentation (%)
Babadan	Sikopel	15	*27*
Tegal Jeruk	Dolok	15	*27*
Majasari	Dolok, Jawar	15	*40*
Gumingsir	Mrawu, Peneng, Kutukan	15	*33*
Plumbungan	Mrawu	15	*7*

Source: Primary data analysis, 2010
Remark: -) no data

Table 9 Physical river condition within last 5 years

Village	More muddy (%)	More shallow (%)	Delta formation (%)
Babadan	73	40	13
Tegal Jeruk	67	20	7
Majasari	33	100	60
Gumingsir	27	20	27
Plumbungan	100	7	0

Source: Primary data analysis, 2010
Remark: -) no data

Table 9 showed the Farmer's opinion about the physical changes of the nearest river located within their agricultural area within last 5 years. More than 60% Farmers in Babadan, Tegal Jeruk, and Plumbungan clarified that the river is muddier, especially in the rainy season. Farmers in Majasari recognized that the nearest rivers, i.e. Dolok and Jawar, were shallower and formed delta within last 5 years. Only farmers in Gumingsir argued that Mrawu River show no change within last 5 years.

Even though they argued that sedimentation was unrelated with the agricultural activity, they all absolutely agreed that the conservation agriculture must be implemented. Nevertheless, they desired participating only part of their land, by the reason that they still need to grow annual crops that economically can give short term income. There were a lot of motivations to participate in conservation agriculture. Most people want to participate to prevent erosion and landslide, or also to obtain more income from annual crops. Almost all people also declared their ability to implement proper planting principle and do the composting for conservation agriculture.

4. Soil Conservation Practice

Farmers are central players in the promoting soil conservation and conservation agriculture (McKell and Peiretti 2004). Soil conservation is one of conservation agricultural practices. Principally conservation agriculture aims to conserve, improve, and make more efficient use of natural resources through integrated management of available soil and water, and biological resources combined with external inputs (Hobbs et al., 2008). Conservation agriculture is more sustainable, economically and environmentally management system for cultivating crops. Conservation agriculture provides direct benefits to environmental issue of global importance, including control and mitigation of soil degradation, mitigation of climate changes, improve air quality, enhancing biodiversity and improve water (Dumanski et al., 2006). Because conservation agriculture promotes the concept of optimizing yield and profit, while ensuring provision of local and global environment benefits and service, therefore conservation agriculture is very similar to conservation agriculture. Conservation agriculture defined as agriculture which create productive, competitive, profitable, resources conservative, keep the environment, and improve the health, food quality, and safety in the future.

There are 3 types of soil conservation methods, i.e. vegetative, mechanical, and chemical method (El-Swaify et al., 1982). The vegetative method means using of plant and its residue in such a way to decrease the erosion, because rainfall erosion from vegetated soil is determined by crop types, planting density, canopy characteristics, growth habits and quality of stand, combination with other crops in space and time, contribution and management of ground-covering residue, and achieved growth stages development by time rainfall arrives. Soil conservation in this method includes planting covered plant, planting in contour line for steep area, doing the crop rotation, or also using the plant residue as fertilizer. Vegetative method is the key to the prevention of soil erosion (El-Swaify et al., 1982). Mechanical method includes using of cultivation techniques that can maintain the land preservation and decrease erosion such as making terrace, cultivating by contour line (*nyabuk gunung*), making sedimentation pond (*rorak)*. Lastly, the chemical method using chemical compounds was used to preserve soil and its fertility. It was applied to conditioned soil.

Table 10 showed that most people know nothing about conservation agriculture practices. In all villages, more than 50% people declared that they don't know about conservation agriculture. Only in Tegal Jeruk and Gumingsir, people have enough knowledge about conservation agriculture (40%), however, the knowledge was only in term of preservative agriculture or agriculture for next generation.

Table 10 Knowledge on conservation agriculture and soil conservation

Village	Know conservation agriculture (%)	Soil conservation practice	
		Vegetative method (%)	Mechanic method (%)
Babadan	13	65	90
Tegal Jeruk	40	80	73
Majasari	33	53	62
Gumingsir	40	48	53
Plumbungan	13	64	77

Source: Primary data analysis, 2010
Remark: -) no data

Eventhough most people declared they know nothing about conservation agriculture, but many of them have practiced soil conservation, both vegetative and mechanical methods. More than 50% communities in Babadan, Tegal Jeruk, Majasari, and Plumbungan clarified that they have practiced vegetative conservation method. Meanwhile, more than 50% communities have also practiced mechanical method.

The vegetative method which is practiced by farmers included 1) planting cover crop in terrace; 2) planting crop in contour line for steep area; 3) crop rotation; 4) using crop/plant residue as organic fertilizer and reducing the application of chemical fertilizer; and 5) application of manure. There were also mechanical method, which is practiced such as 1) making terrace; 2) contouring; and 3) maintaining water canal (Table 12).

Table 11 showed in detail common soil conservation practice. In Babadan, planting crop in terrace by perennial feeder plant, planting in contour line, and application of manure were the most common conservation practice. In Tegal Jeruk, it is found that farmers practiced more variable conservation. The common conservation practices in Majasari were crop rotation, using crop/plant residue as fertilizer, and application of manure. Planting in contour has not yet applied though the land could be categorized as hilly area.

Table 11 Vegetative method of soil conservation practice

Village	Planting perennial feeder plant in the terrace (%)	Planting in contour (%)	Crop rotation (%)	Intercropping with Legume (%)	Using plant residue as fertilizer (%)	Manure application (%)
Babadan	87	80	60	53	47	100
Tegal Jeruk	87	80	93	73	67	100
Majasari	67		100		100	100
Gumingsir	27	33	80	13	87	80
Plumbungan	47	73	73	60	67	93

Source: Primary data analysis, 2010
Remark: -) no data

Different findings were observed in Gumingsir and Plumbungan. The common vegetative method of conservation, which practiced in Gumingsir, was crop rotation, and using crop/plant residue and compost as fertilizer. Meanwhile, in Plumbungan common practice were planting in contour, crop rotation, intercropping with legume, and using crop/plant residue and manure as fertilizer.

Instead of vegetative method, farmers applied also some mechanical practices such as terracing, contouring and maintaining water canal. Table 12 showed some mechanical methods that were practiced by farmers. It could be found that terracing and contouring have become common mechanical practices, except in Majasari. Nevertheless, based on field observation, the terrace was still improper. The applications of manure as well as water canal maintenance were common practice, except in Gumingsir.

Table 12 Mechanical method of soil conservation practice

Village	Terracing (%)	Contouring (%)	Water canal maintenance (%)
Babadan	93	80	87
Tegal Jeruk	100	93	
Majasari	47		100
Gumingsir	67	53	13
Plumbungan	73	87	53

Source: Primary data analysis, 2010
Remark: -) no data

Basically almost all farmers agreed that soil conservation need to be practiced continuously. Farmers discovered that shaping their lands in certain ways such as contour planting and terracing was necessary to sustain agricultural production (El-Swaify et al., 1982). Farmers realized that the sustainability of their livelihood depended on the agricultural land. Except to maintain their livelihood, practicing soil conservation could be also for better community as a whole. They realized that soil conservation could prevent erosion, landslide, and loss of soil fertility.

CONCLUSIONS

From such research work, it could be concluded that most of farmers in the water catchment area of Serayu watershed (1) know that soil erosion has been occurred in their land based physical river condition but such soil erosion was not influenced by agricultural activities, (2) don't understand conservation agriculture, but they practiced soil conservation both vegetative and mechanic methods. They realized that soil conservation could prevent soil erosion, landslide and loss of soil fertility.

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Author Index