icsbe 2012
Second international Conference on Sustainable Built Environment

LIVABLE CITIES IN THE FAST-GROWING COUNTRIES

Proceeding of
the Second International Conference
on Sustainable Built Environment (ICSBE)

Yogyakarta, 10-12th July 2012

LIVABLE CITIES IN THE FAST-GROWING COUNTRIES

Proceeding of the Second International Conference on Sustainable Built Environment (ICSBE)

Yogyakarta, 10-12th July 2012

Faculty of Civil Engineering and Planning
Universitas Islam Indonesia

In collaboration with:

ISBN: 978-602-98397-1-5

ICSBE 2012 Organizing Committee
Faculty of Civil Engineering and Planning
Universitas Islam Indonesia
Jalan Kaliurang Km. 14,5 Sleman
Yogyakarta 55584
Telephone: +62 (274) 898444 ext 3200
Facsimile: +62 (274) 895330
Email: icsbe@uii.ac.id and icsbe@yahoo.co.id
URL: www.icsbe.uii.ac.id

FOREWORD

The international Conference in Sustainable Built Environment (ICSBE) is a forum initiated by the Faculty of Civil Engineering and Planning, Universitas Islam Indonesia (UII), through collaborations with worldwide universities and research institutions. The conference is aimed at nurturing the study, comprehension, and appreciation of the built environment. It provides a venue for exchanging of ideas, sharing of knowledge, and dissemination of information about the study of the built environment in different parts of the world. It seeks to further develop regional and international network of academics, professionals, and policy makers on the management of the built environment.

The first ICSBE was held in May 2010 in Yogyakarta, with the theme 'Enhancing Disaster Prevention and Mitigation', which attracted participants from 8 countries, who presented 74 selected papers. This year, the Second ICSBE presented the theme 'Livable Cities in the Fast-Growing Countries'.

Livability has been regarded as one of the indicators for assessing quality of living in cities around the world. Melbourne was recently selected as the most livable city in the world. The selection was conducted by the Economist Intelligence Unit, who based their selection on a combination of factors related to the environment, health care, culture and infrastructure systems. However, the results of such a survey suggest that none of the top ten most livable cities in the world are the cities of the fast-growing countries in the global south. This leads to the perception that, using the same indicators, cities like Jakarta, Mumbai, and Rio de Janeiro, will never be seen as 'livable cities' – a paradox to the facts that these cities own a much higher population than cities in the north, yet significantly contribute to the stability of the global economy, regardless of the fact that a significant number of residents of these cities inhabit informal settlements.

Therefore, the challenge of making a city livable in such a region is to bridge the gap between formal/informal systems, rich/poor citizens, healthy/unhealthy environment, etc. In the light of Amartya Sen's notion of development, bridging the above gaps means to minimize or eradicate factors that hinder such development, which Sen calls 'unfreedom'. For Amartya Sen, development is seen as a way to achieve freedom by 'removing unfreedom'.

Inspired by the above notion, the conference aims to better understand how livability is perceived in the fast-growing cities of the south. What kinds of 'unfreedom' need to be tackled in the planning and design of the built environment in order to achieve such livability?. This conference is intended to provide a venue for sharing the knowledge and experiences among actors of development in coping with the issues related to livability in the urban built environment, which include issues such as waste management, transportation, disaster mitigation, informal settlement, food security, and accessibility; and to develop instruments for assessing such livability in the urban global south.

The conference committee invited the Mayor of Yogyakarta City, Drs. H. Haryadi Suyuti to provide a keynote speech in this conference based on his experience in managing Yogyakarta as the first rank of livable cities in Indonesia. Five invited speakers consisting of Prof. Colin F. Duffield (University of Melbourne, Australia), Prof. Kohei Komatsu (Kyoto University, Japan), Prof. Hüseyin Gökçekuş (Near East University, Turkish Republic of Northern Cyprus/TRNS), A/Prof. Kazuhiro Toyoda (Hokkaido University, Japan), Prof.

Ibrahim Numan (Fatih Sultan Mehmet University, Turkey) and Dr. Wiryono Raharjo (Islamic University of Indonesia) presented their papers in the area of conference sub-themes.

More than 100 abstracts from 8 countries (Australia, Indonesia, Japan, Brazil, Malaysia, Pakistan, Philippines, Turkish Republic of Northern Cyprus/TRNC, and Turkey) were received by the organizing committee, 56 of them turned to papers, however not all of them met the requirements of publication in this proceeding. The 49 final papers presented in this proceeding are grouped into the following four topics:

- Urban disaster mitigation and conflict management,
- Integrating formal/informal urban systems,
- Urban food security and agriculture, and
- Engineering the public attitude in development.

Four appointed peer reviewers who have qualified and expertized in the area of specified topics reviewed selected all papers. At the beginning reviewing process, the local peer reviewers selected and checked to entire submitted abstracts whether or not the papers matched with the conference themes. To achieve qualified papers for the ICSBE conference proceedings, the committee has provided sufficient time to all authors in revising their abstracts and papers. Final notification of paper acceptance was made after the main reviewers reviewed each paper.

Yogyakarta, Indonesia, July 10, 2012

Editors,

Mochamad Teguh (Universitas Islam Indonesia)
Hüseyin Gökçekuş (Near East University, TRNC)
James Lamoreaux (Editor in Chief, the Springer's Environmental Earth Sciences Journal)
Wiryono Raharjo (Universitas Islam Indonesia)

Conference Committee

Chairman	: Prof. Ir. Mochammad Teguh, MSCE, PhD.
Steering Committee	: Ir. Hanif Budiman, MT.
	: Ir. Suharyatmo, MT.
	: Dr. Ing. Ilya Fajar Maharika, IAI.
	: Luqman Hakim, ST., M.Si.
Conference Coordinator	: Ir. Wiryono Raharjo, MArch., Ph.D.
Deputy Conference Coordinator	: Fitri Nugraheni, ST., MT., Ph.D.
Members	: Miftahul Fauziah, ST., MT., Ph.D.
	: Putu Ayu Agustiananda, ST., MA.
	: Any Juliani, ST., M.Sc.
	: Awaludin Nurmiyanto, ST., MEng
Creative Team	: Atika Ulfah Jamal, ST., MEng, M.T
	: Zainul Musthofa, SPd.I
	: Puji Astuti
	Agus Sulistyo
Graphic Designer	: Sahid Faoji, SST.
Webmaster	: Andwi Valentine

Scientific Board

- Prof. Hüseyin GÖKÇEKUŞ – Near East University, TRNC
- Prof. Colin F. Duffield – University of Melbourne, Australia
- Prof. Kohei Komatsu – Kyoto University, Japan
- Assoc. Prof. Dr. Kazuhiro Toyoda – Hokkaido University, Japan
- Prof. Jim LaMoreaux, Editor, Springer's Environmental Earth Book Series, USA
- Prof. Ir. Eman Satyarno, MEng, Ph.D. – Univesitas Gadjah Mada, Indonesia
- Prof. Ir. Yoyong Arfiadi, MSc, Ph.D. – Universitas Atma Jaya Yogyakarta, Indonesia
- Dr-Ing. Agus Setyo Munthohar, ST, MEng – Universitas Muhammadiyah Yogyakarta, Indonesia
- Ir. Elvira, MT, Ph.D - Universitas Tanjungpura, Indonesia
- Dr. Ing. Ir. Widodo, M.Sc. – Universitas Islam Indonesia

- Dr. Ing Ilya Fajar Maharika, IAI. – Universitas Islam Indonesia
- Ir. Revianto B.S., M.Arch., IAI – Universitas Islam Indonesia

Table of Contents

Panel 3
Urban Food Security And Agriculture

Panel 4
Engineering The Public Attitudes In Development

SPECIAL PANEL

INVITED SPEAKERS

Realistic actions and approaches for sustainable development of major infrastructure

Colin Duffield[1, 2]

Associate Professor, Department of Infrastructure Engineering, The University of Melbourne

Melbourne Sustainable Society Institute, The University of Melbourne

Abstract

This paper candidly considers sustainability as it applies to major infrastructure investment. It reflects on the particular emphasis sustainability takes for both developed and emerging economies and details the current drivers of sustainability in the context of people natural resources and the built environment. It considers a number of scenarios for the sustainability of infrastructure development and outlines its link to economic development and growth in prosperity through timely investment. It considers what is working and what is not working and what might realistically contribute to sustainable infrastructure development. This creates the foundation for postulating a range of measures that technical people can actually positive contribute to the development of a sustainable environment.

The case for sensible infrastructure investment is made that not only adapts to our changing environs but proactively provides a mechanism to transition to a more sustainable and realistic future. The proposed approach requires integration of financing, technology and human desire. A call is made to progress our holistic and integrated thinking.

Keywords: Infrastructure development, sustainability, project management

Introduction

Infrastructure underpins our society both economically and socially and involves long term decision making as the capital cost required for any particular investment is generally large and the facilities last for a long period of time. Thus it is often difficult to conceptualise what infrastructure is required long-term verses what can be afforded today. Further complicating such decisions is the fact that infrastructure is not a means to an end in itself but rather the assets facilitate society achieving its expectations. The long term nature of infrastructure invariably means that the decision to invest is taken with consideration of sustainability.

This paper seeks to understand which parts of sustainability apply to decisions to invest in infrastructure. The method adopted to consider this is to critique of what sustainability means for us today, to candidly reflect on which aspects of sustainability really influence infrastructure, to consider current international techniques for incorporating sustainability into major building and engineering works, and to identify some tangible steps we can take to transition to a more sustainable future.

What we mean by infrastructure is reasonably well understood. Economic infrastructure is typified by the sectors of: transport, water, energy and communications and to some extent by the mining sector that provides essential resources.

- Transport is the supply line that feeds either import or export businesses, local economies, and it doubles as a mechanism to access social activities.
- Water related infrastructure includes storage and distribution networks for potable water, waste water disposal and frequently treatment thereof, stormwater and irrigation.
- The provision of electricity, and to some extent gas supplies, to households and industry underpins productivity.
- Telecommunications, broadband Internet, video, and satellite communication, underpin business and, increasingly, social media and society.

Society also expects good facilities by way of schools, hospitals, community centres, appropriate justice facilities, convention centres and the like. It is therefore essential in the context of the infrastructure to include these so-called social infrastructure assets.

What is not quite so well accepted is the meaning of sustainability and how to integrate sustainability thinking into major infrastructure development.

Sustainability

Sustainability is a widely used but often not well understood term, especially when it comes to infrastructure investment. It is informative to draw the key features of some of the seminal definitions for development sustainability.

In 1987 the Brundtland Report of the United Nations stated that: *" ..humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs…"* [UN 1987].

Meeting the needs of the present without compromising future generations philosophical discussion that brings into play not only current day economics but also social equity and public good matters. There are a number of ways that these dimensions have been depicted but common forms typically include: built, environment and social dimensions. A useful expansion of these concepts was developed by Hawkens et al (1999) in their four capital model of sustainability, refer Figure 1.

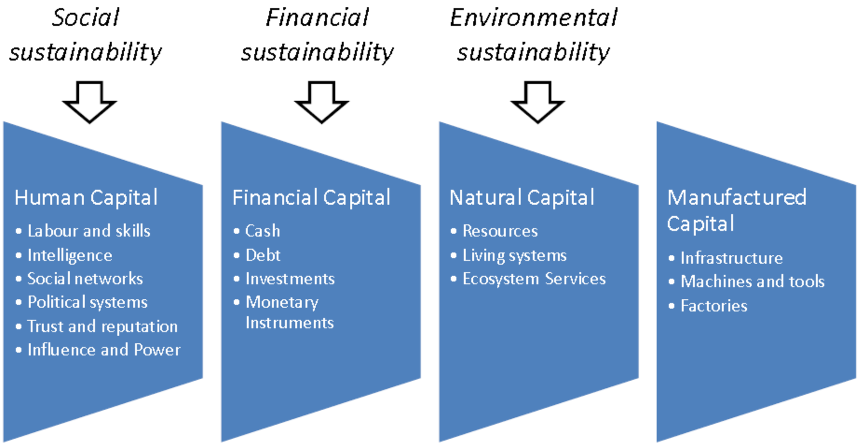


Figure 1: Four Capital Model of Sustainability (Adapted from Hawkens et al 1999)

Further, the inter-generational requirements of sustainability mean that consideration of these matters cannot be static. The UK Roundtable on Sustainable Development (1996) presented a positive way of considering sustainable development as:

> *"...a continuous process –a journey, not a destination. The key requirement is that we should all be moving in the right direction..."* [UK Roundtable on Sustainable Development 1996].

Putting this statement into sustainable development reality provides the starting point for why there is substantial disagreement in the level of sustainability thinking that can be introduced at any stage without compromising the ability of a society to be healthy in all aspects of the terms, refer Figure 2.

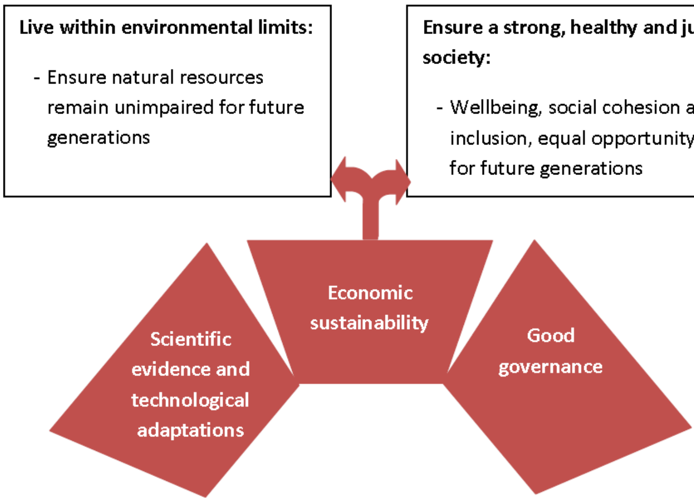


Figure 2: The Five Principles of Sustainable Development (based on the Sustainable Development Commission 2011)

If one takes these models of sustainability, it is important to understand the tradeoffs between the economy, the environment and society (both today and in the future).

Key drivers for the future include:

- **Population**: Forecast increase from 2012 to 2020 of about 25%. (i.e. 7.6 billion people), forecast to 2050 in the order of 9 billion people.

- **Equity**: Overall well being appears strongly linked with prosperity in terms of life expectancy, health, happiness and thus it is reasonable to expect the growth of emerging economies and the expectation of parity with the Western World in terms of resource consumption, refer Fig 3. This growth places an increasing demand on resources.

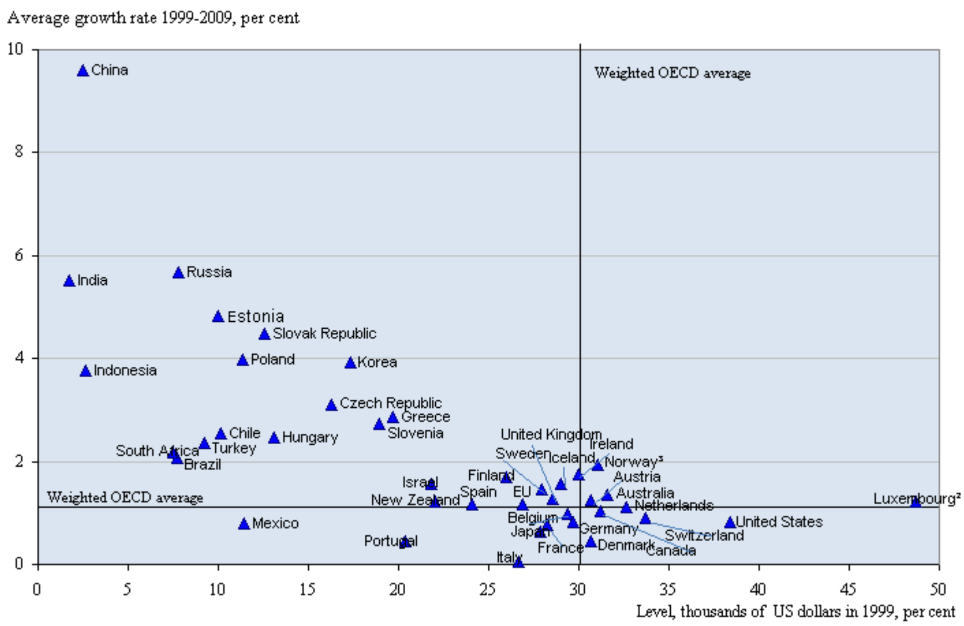


Figure 3: GDP per capita levels and growth rates (Source: OECD (2010), National Accounts Database and OECD (2010), OECD Economic Outlook No. 88: Statistics and Projections Database.)

- **Consumption**: Increased prosperity and increased population will draw down our resources.

- **Energy use**: There may not be sufficient energy available, particularly is emission targets were enforced and world energy was equitably distributed. Major changes to current use will be required, refer Fig 4 (extract from Jackson 2009).

- **Environmental concerns**, including Climate change: At a global level environmental concerns link to the longevity of the earth, concerns include the level of CO_2 and consequential global warming. Environmental changes can increase the exposure of infrastructure to natural hazards that may result in design loading modifications.

Philosophical questions such as: can the world sustain that the lifestyle we expect, must be asked. But to contemplate such questions one has to start with a positional understanding of what the current state is. Considering the relatively short timeframe to 2020, what scenario should be considered in respect to infrastructure? Some suggestions are provided in Table 1.

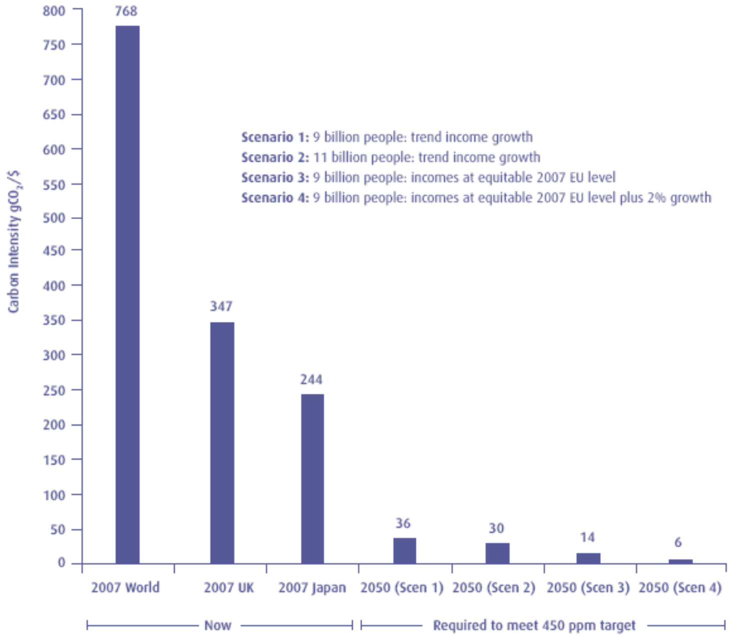


Figure 4: Jackson (2009) Carbon intensities now and required to meet 450 ppm target

Table 1. 2020 infrastructure scenarios

Issue	**2020 scenario**	**Influence on Infrastructure**
Population	Increase from 2012 of about 25%. Forecast 7600 million people.	A massive increase in facilities is required to maintain status quo
Expected growth in prosperity of world	Emerging nations of China, India, Brazil and the former Eastern block countries are already establishing themselves and other Asian nations are building strongly.	Many areas of fastest growth and infrastructure investment will be dominated by the emerging economy and resource rich nations that are supporting this development. Increased use of transport, energy and telecommunications will place accelerating pressure on the environmental balance of the globe.
Global political alignment on global warming	Full alignment of interests is unlikely.	Individual nations will be required to balance their economic needs with competing challenges to address climate changes without overarching global policies and universal support.
Climate change hazards	Accelerating impact of global warming, serve peak events, rising sea levels to impact some communities.	Changes to design standards and technology will be expected by communities.
Use of fossil fuels	There will be growing pressure to reduce reliance on fossil fuels, starting	Pressure to change style of power generation. Also, by products from the petrochemical

	with 'dirty' fuels such as brown coal	industry are main stay materials for roads and thus alternate technologies will be required.
Deteriorating condition of existing assets	Current rich countries will confront increased redundancy of their aging assets.	Pressure to upgrade and replace existing facilities placing a huge financial impost on the developed world.
Radical change in the form of infrastructure expected by communities	Greater use of telecommunication and potentially experiments as to how to live more sustainably.	Early adoption of new ways of functioning in a sustainable manner may result in innovative solutions. Early focus likely to be high speed trains and carbon efficient vehicles.
Financing	General desire to involve private financing and realistic user pay mechanisms.	Clear policy, depth of ability to pay and clear and efficient delivery of infrastructure will be essential.
Project initiation	Detailed consideration of not only project level Value for Money but also inclusion of wider economic and environmental impacts	More centralised planning and strategic focus.

In summary, a likely hypothesis is that nations will seek to improve their quality of life through growth, productivity and modified consumption, accelerated use of resources and energy. For infrastructure by 2020 it appears this will mean significant development with limited radical change to our collective expectations of the level of service provided by the underpinning infrastructure.

To test this hypothesis an investigation of current and planned infrastructure activity has been undertaken.

Current Investment in infrastructure

At good summary of infrastructure activity has been compiled by Urban Land Institute and Ernst & Young (2011) where they detail a range of significant strategies to spend on infrastructure investment. A summary of their findings is paraphrased as Table 2.

It is clear from the information presented in Table 2 that collectively countries have identified infrastructure development as a key strategy for improving their societal wellbeing. Typical infrastructure investment trends are provided as Fig 5.

As an example, since 2009, the UNEDC has been convening workshops to discuss economic plans and strategies to counter the impost of the Global Financial Crisis in Eastern European countries, at the first of these forums, held in Geneva, all country Treasurers spoke and to a person of infrastructure investment (usually with the hope of private sector involvement) being one of the pillar strategies for their country's recovery and long term resilience. It was acknowledged that there were generally significant shortfalls in funds available for investment.

Table 2: Current Infrastructure Investment programs (based on Ernst & Young 2011)

Country	**Program**	**Program**
Australia	Infrastructure Australia	Development of national infrastructure priorities and to provide advice on how to invest a strategic fund of US$20.2 billion infrastructure spend as part of the Building Australia fund (a post GFC initiative).
Brazil	Growth Acceleration Program	A strategic investment program focusing on energy, urban infrastructure, sanitation, and transportation. Launches in 2007 with $349 billion investment and extended 2011-2014 with a further $900 billion.
Canada	Infrastructure Canada	Responsible for a seven year plan for Building Canada, US$33.5 billion plus US$5.1 billion for targeted programs.
China	12th Five year plan	$1 trillion was committed in 2011 for infrastructure spending over five years. Focus areas: high-speed rail, secondary emphasis on water supply, electricity and highways.
India	11th and 12th Five-year plans	Implemented by India's Planning Commission, $5000 billion was committed in 2007 with 1/3rd to be spent on roads and the balance on transit, water, electricity and other infrastructure. The 12th plan runs from 2012 to 2017 and has $1 trillion set aside for infrastructure.
Mexico	National Infrastructure Plan	Launched in 2007, this program has identified over 300 infrastructure projects to invest in. The focus is ports, airports, roads, railways, water and energy with current commitments of over $141 billion.
New Zealand	National Infrastructure plan	A strategic group established in 2009 to develop a 20 year plan for national connectivity via highways.
U.K.	Infrastructure UK	Established in 2010 with a charter to inform investment of $320 billion in energy, transportation and waster over the next five years.

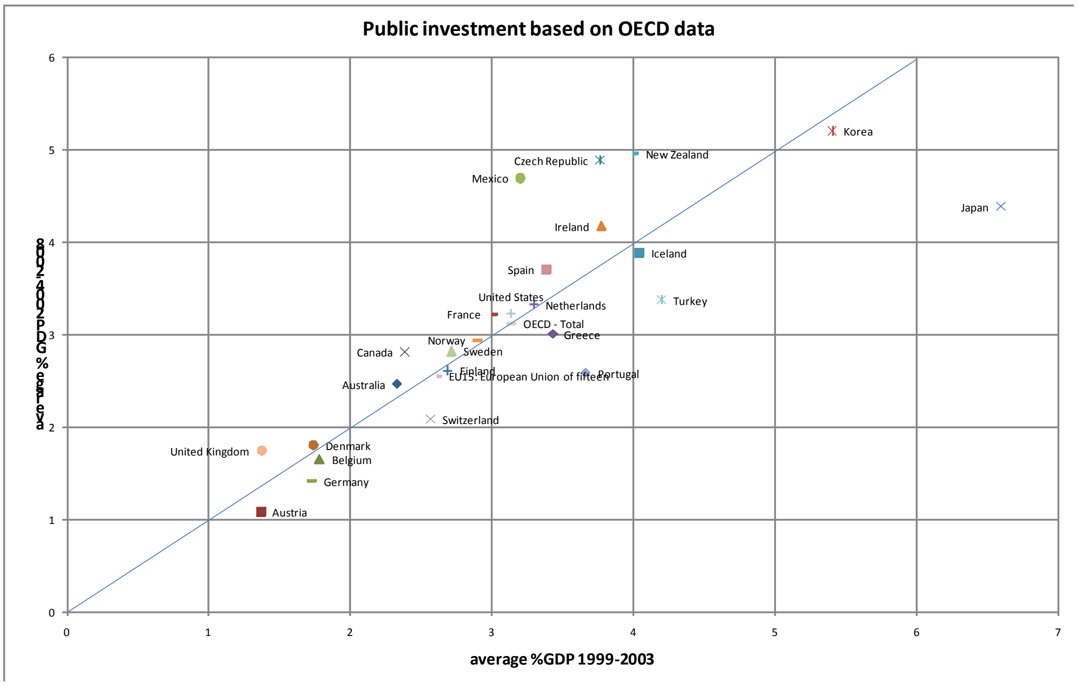


Figure 5: Example of extend of public infrastructure investment, percentage of GDP source of data OECD (2011) stats.oecd.org [accessed 27/10/11]

It is understandable that developing countries recognise infrastructure investment as a critical ingredient to improved prosperity but what drives developed nations to invest. The answer to this lies in the age, condition and appropriateness of the existing infrastructure. Infrastructure typically has a design life of 75 to 100 years. Countries such as Australia, Canada and US have critical infrastructure that far exceeds this and is desperately in need of repair and regeneration. The assets in much of Europe are generally younger as they were reconstructed post damage from the Second World War, however, many of these assets are significantly constrained by the medieval layout European cities and this constraint limits the options for refurbishment and thereby adds to the cost of capital work.

The projected project activity confirms that, at least in the short term, countries are planning to invest heavily in infrastructure regardless of resource and environmental uncertainties. The need to overcome current impediments to productivity, to accommodate growth, and to maintain the standard and condition of infrastructure is overwhelming. So what is the economic imperative and realistic timing for investment?

Sustainable economic reality

Do the benefits of infrastructure investment outweigh the socio-economic costs?

The world continues in transition from nationally based societies to an interconnected global socio-economic system, (Laszlo 1990). The level of infrastructure provision is a major factor in the attractiveness of a country or region for overseas investment. The nature and struggle for market share is dominated by the US, Russia, Japan, the European market, and the emerging Asian nations, including China and India. The level of physical quality of infrastructure assets is significant due to the link between the level of infrastructure provided and a country's output productivity. Global environmental issues are directly affected by infrastructure provision and there is a need to control issues such as global warming and climatic change, attenuation of the ozone layer, excessive land, air and water pollution lead to a strong international push for sustainable development.

On one hand infrastructure is a major consumer of resource to construct facilities and for some classes of assets (such as power generation) the technology adopted may impact the environment to a greater or lesser extent. Further, infrastructure facilitates a life style, e.g. provide major freeways and traffic volumes will increase, and subsequently impact negatively on global warming.

Many of the benefits of infrastructure are difficult to measure and data necessary for the quantification of these benefits is not currently included in national statistics nor are they specifically considered in the evaluation of specific projects. Economists broadly categorise these issues as externalities. Whilst the magnitude of the benefit of infrastructure investment to private industry may range from output elasticity from 0.03 (Hulten and Schwab 1991) to 0.39 (Aschauer 1989) the positive relationship of infrastructure to industrial productivity is undeniable. More recent work by the World Bank (Calderon et al 2011) claims that an output externality from infrastructure investment is between 0.07 and 0.1 regardless of whether a country is rich or poor. Thus under current considerations the benefits of infrastructure investment are deemed to outweigh the negatives of greater CO_2 emissions or resource constraints.

Calderon et al (2011) also suggests that the relationship between infrastructure and GDP can be reduced to consideration of the influence of only transport, energy and communications.

From this analysis it is concluded that infrastructure investment is beneficial. However, positive externalities are not derived from random investment but rather a focus on the costs and value contributed to society from specific investments, which influence the long term outcome.

Constraints and timing for infrastructure investment

The economics of infrastructure investment is seriously constrained by the ability to both fund and finance the scale of investment required. Infrastructure investment is particularly expensive for strategic investments in transport, energy and communications, the very things that drive growth in GDP. It is useful to separate the issues of funding and financing as they both raise different issues for different communities.

Affluent countries have matured their thinking to focus specific project attention around efficiency and value for money. In this respect such countries make firm commitments around their need to invest and resolve the mechanism to be used to fund the initiative prior to engaging with the market to procure the infrastructure. This facilitates a balanced commercial negotiation as governments engage the private sector. If the project lends itself to use of private equity and finance, governments can gain the benefit of cash flow relief and further risk transfer to the private sector.

Emerging economies are in a more difficult situation as they often seek to rely on the private sector's finance as an actual mechanism to facilitate the project and there can be greater uncertainties surrounding funding sources and thus guarantees are almost always sought as a part of any transaction.

The subtle project differences brought about by the balance of funding and financing can be explored by considering commercially driven (market output) projects and public good projects (non market outputs) with a view to understanding where the returns and benefits are derived.

At a project level, the ADB's (1997) guidelines for evaluating the economic justification for of projects provides a useful starting point for reflecting on what may be impacted when considering economic sustainability. Projects are considered in two broad categories, those that have direct market outputs (like many economic infrastructure projects) and those that have non-marketed outputs (like social infrastructure projects). Matters considered when appraising such projects are detailed in Table 3 and this analysis leads to the financial plan for specific investment decisions. It is evident that sustainability influences impact the majority of considerations regardless of the type of project.

Table 3: Scope of economic analysis of projects (based on ADB 1997)

Direct market projects	**Non-marketed outputs**	**Sustainability influence**
Demand forecasts, price	Demand forecasts, need	✓
Cost of preferred option	Cost of preferred option	✓
Economic return	Benefit valuation	✓
Financial incentives	Funding options	
Charges and affordability	Charges and affordability	✓
Environmental effects	Environmental effects	✓
Distribution of net	Distribution of costs	✓
benefits:	Distribution of benefits	✓
winners and losers	(+ve + -ve)	
Sensitivity and risk	Sensitivity and risk	✓
analysis	analysis	
Policy conditions, laws	Policy conditions, laws	✓
Financial plan	Financial plan	

The differences come in terms of availability of revenue, versus the benefits gained from strategic investment. Graphically, and in economic language, the conceptual supply demand curve for the above project evaluation is depicted in Figure 6.

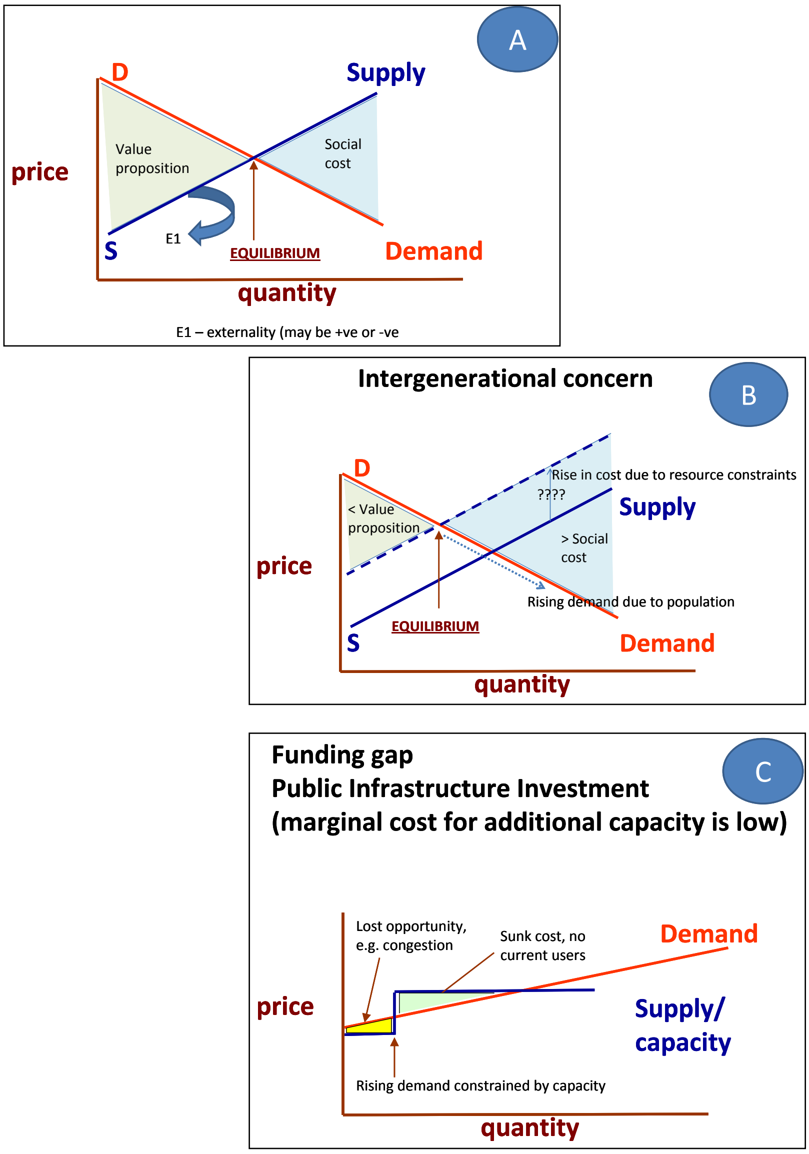


Figure 6. Economic consideration of sustainable infrastructure development

Figure 6A depicts a simplistic supply and demand curve for a 'Direct Market' project. From a neoclassical economic point of view one would only consider the value proposition component of this curve, i.e. to the left of the equilibrium point (price at which quantity demanded just equals quantity supplied – market). In this section of the graph an investor supplies a product and the market pays a price such that there is scope for a positive return on investment. In infrastructure terms the investor finances the deal and the market funds the investment. Prior to the Global Financial Crisis there were numerous such infrastructure projects, e.g. City Link, Eastlink, Cross City Tunnel and the Clem 7 tunnel. Figure 6A also demonstrates the example where for social reasons a government may choose to cross subsidise the project (i.e. a non-market output project). Worthy of note is that neoclassical economic considerations do not include equity or social factors.

Matters of sustainability cloud the simple appraisal denoted in Figure 6A. Figure 6B identifies the impact of aspects of sustainability, a growing scarcity of resources may increase the cost base for supply, without a commensurate increase in general wealth this will mean greater pressure on the amount of social cost required to provide the infrastructure. Compounding this is that increasing population will likely increase demand. This discussion may suffice for energy or communications projects where staged development can mirror demand. Unfortunately for transport projects, the requirement to access large tracks of land and the limited opportunity to develop parallel facilities means one needs to consider growth in the initial investment decision. This scenario if outlined in Figure 6C.

Figure 6C depicts the situation for a public good investment, like a road. Such investments are dominated by the capital cost and the marginal cost associated with increased demand is minimal until a capacity limit is reached. Planning for future growth invariable impacts economic sustainability by:

- Delaying the initial investment until such time as the economics of deferring investment is untenable, e.g. road congestion.

- Creating a funding gap as users and demand may not be immediately available.

It is suggested that sustainable economic investment in infrastructure invariably involves a mixture of sound investment decision making, social considerations, equity and such decisions by necessity are (or become) political. Forward thinking communities assess projects inclusively and thus consider (to some extent) the broader sustainability concepts.

It seems self evident that to encapsulate all these factors a mixture of sound business principles along with a social conscience is required. Further, the skills and thinking are aligned with the overall need for funding and financing and thus even if project finance is not sought the approach and diligence is appropriate. But considering finance, how do we attract investors?

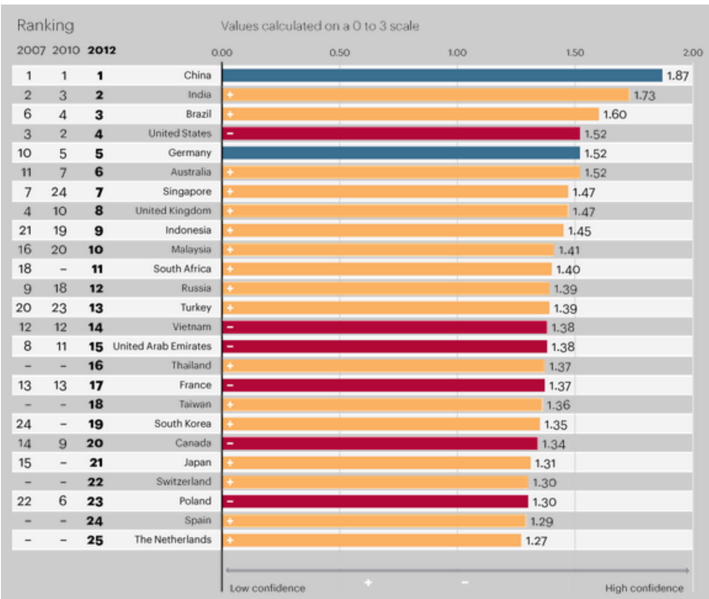


Figure 7 AT Kearney Foreign Direct Investment (FDI) Confidence Index (AT Kearney 2012)

Clarity in funding is the first step in attracting the private finance sector. Done robustly this considers the full consequences of the sustainability framework detailed in Figure 1. It also requires appropriate governance, technology and commercial risk allocation. Attracting finance commences with the development of a robust financial plan, refer Table 3 and a realisation that investors are always seeking to maximise their value proposition, refer Fig 6A, within an acceptable risk profile.

Given the growth forecasts for various countries and potential market opportunities, companies like AT Kearney (2012) produce investment attractiveness indicators, refer Figure 7 to assist the market. Such indices provide an insight into the competitive nature for finance. The scale of finance required for infrastructure developments invariably means involvement in the global financial market and competing with other countries (and investment sectors) in relation to investment attractiveness (return for a given risk profile).

If consideration of sustainability means increased capital cost, the pressures on raising finance and for that matter ultimately funding projects is self-evident. This brings into play technical expectations, directions and necessary skills.

Separating the noise around sustainability from action

Integration of sustainability thinking into infrastructure decisions is changing the fabric of our profession, governments, companies and education institutions. By way of example at the University of Melbourne interdisciplinary research institutes have been initiated to integrate professional skills. An example of this is the Melbourne Sustainable Society Institute, http://www.sustainable.unimelb.edu.au/ where a range of themes cut across traditional boundaries.

For engineering and building projects a range of guidance materials emerging like: The International Code for a Sustainable Built Environment; BREEAM, refer Fig 8, CEEQUAL: Sustainability Assessment and Awards for Civil Engineering, Infrastructure, Landscaping and the Public Realm, six star greenstar.

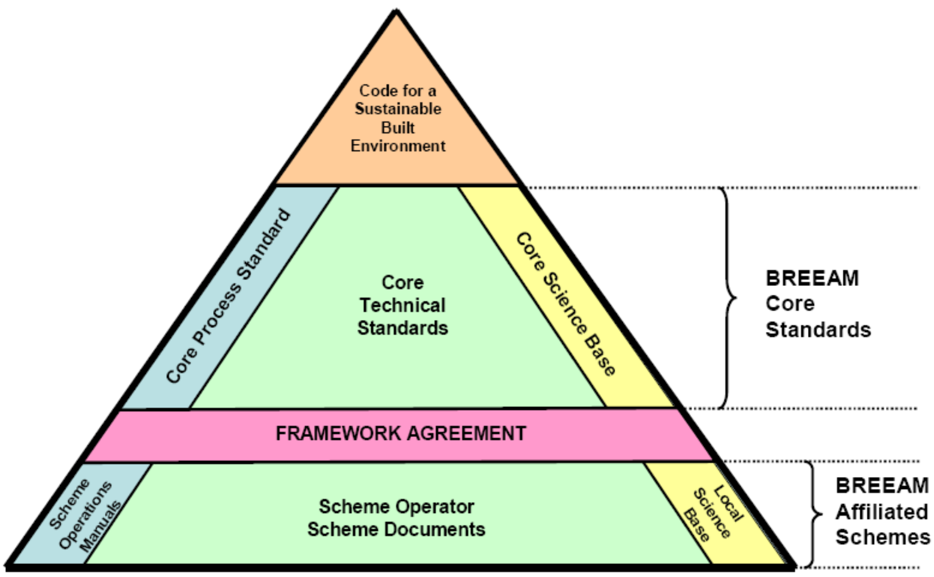


Figure 8. Code for a Sustainable Built Environment framework

Adequacy of current infrastructure to protect and function in light of sustainability changes

A further question can be asked as to whether the infrastructure we currently have (and are still constructing) is adequate for the task at hand and fit for purpose to withstand natural and man made hazards. Anecdotally, there appears to be greater intensity in natural events and an increased frequency of such events.

Our existing infrastructure has been designed for the predicted risks with a view to minimising the consequence to lives and damage should such events occur. Typical engineering design levels to be accommodated are a 1 in 500 year or 1 in 1000 year events. Reflection on the last few years has cyclones and hurricanes of large magnitudes reaching further inland than previously, with devastating loss, long duration droughts that have nations on their knees, floods that are appearing all too frequently and previous barrier such as levies simply not doing their job, nuclear power station disasters, tsunamis and earthquakes.

It would appear our design standards need to be made more robust to such hazards but the cost of retrofitting is colossal and sometimes simply non-practical.

Levers for change, action, decisions – Options for contributing

The long term nature of infrastructure creates difficulties for decision makers as they anguish over how to make 'the best' decision for investment of scarce resources and capital. This section considers what we now know and then considers what can be done to achieve improved sustainable development.
It has been established:

1. Growth and development will continue and probably do so at an increased pace.

2. Whist there is ongoing discussion about the extent of physical changes caused by global warming; we would be remiss to ignore the impact human development is having on the environment.

3. Something has to change as there are insufficient global resources to meet everyone's needs in an equitable manner.

4. Infrastructure investment provides an opportunity to make a quantum change yet there remains uncertainty as to which specific projects should be prioritised.

5. Societies expect improving wellbeing, safety, and economic sustainability.

6. Funding and financing are a major constraint for investment.

There are actions that can be taken, given that this discussion on infrastructure has centred on public infrastructure, thus central governments can, if they choose, influence the outcome and once good decisions are taken the infrastructure will be used. The actions are not constrained to our political leaders but also involve studious professional engagement. Specific technical actions include:

1. Planning for projects with a holistic view to sustainability, growth and resilience. This requires significant early project appraisal, business development and economic consideration. This is outworked as

appropriate forward planning and prudent project selection. Australian examples of this concept include: water pipeline projects to expand areas of water reticulation and thus make communities more resilient to droughts; desalination projects that enable new clean water to be sourced (this of course bring an energy burden that must be balanced); Gold Coast Rapid transit project that will modify transport in the Gold Coast area from congestion on a linear strip of roads to an integrated system of light rail and road that will reduce congestion, reduce pollution and create growth opportunities.

2. Governments have the power to impose regulation on infrastructure. Such regulation can take the form of rules and regulations, oversight of pricing, rate/return regulation, establishment of the level of service, taxes and charges, and consumer pricing. Regulation, particularly taxation is considered to be a dead hand to productive development and thus whilst the planning angle is positive, regulation can be an impediment. Institutional structuring and clear positive governance arrangements can guide the market to achieve positive outcomes. Such approaches are generally driven by policy (strong vision), guidance and education. Local political unity for the developed policy and potentially global unity would of course strengthen to possibility of success.

3. Consideration of the options for funding and financing projects such that equity, governance, productivity and efficiency are considered. E.g. Private financing, public private partnerships and efficient procurement mechanisms. This goes beyond the simplistic economic approach of focussing only on the current value proposition but extends to consideration of equity and social choice.

4. Seek opportunities to keep the capital and operating costs for projects low. Drivers for this include:

    a. Efficient procurement mechanism

    b. Use of new technologies

    c. Whole of life thinking

5. Pre-emptive modification of design requirements to accommodate changing hazards such that expensive retrofitting (and the associated waste) is avoided.

6. Seek opportunities to drive behavioural change through new infrastructure. This can reduce the costs for utilities, waste and provide operational efficiencies with being detrimental to service outcomes. Management tools for such include:

    a. Key result area targets

    b. Performance based contract

As an aside to the main thrust of the paper some outworking of these matters from a research perspective include:

- General sustainability research, Pearson (2012)

- Specific project focussed research:
    - Comparison of procurement approaches, Raisbeck et al (2010), Duffield (2010)
    - Assessment of climate change impact on physical infrastructure, Stevens (2008)
    - Value for money through relationship contracts, Wood and Duffield (2009)
    - Improved mid project decisions, Xu et al (2011)
    - Optimised road maintenance, Mandiartha et al (2011)
    - Power station investment decisions in Indonesia, Atmo et al (2012)
    - Integrated sustainable precinct design, MUTopia (http://www.mutopia.com.au/)

Reflection on some Australian projects

Public Private Partnerships (PPPs) are complex organisational structures involving a multitude of actors with very different objectives; and in a sense they provide examples of the most complex project considerations. PPPs combine the best and latest thinking and practice in the engineering, finance, legal and governance disciplines (Grimsey and Lewis, 2007 and Asenova and Beck, 2009). Some PPPs are successful by any engineering, financial or social measure but some can fail as is evidenced by several road projects in Australia becoming insolvent. The gain a glimpse of what some projects are achieving the following projects have been considered. The projects focus on transport but a hospital has been included to amplify the potential for operational savings.

Background of case study projects

A summary of PPP projects considered is presented in Table 3. Projects are located in their respective capital cities of Sydney, Melbourne, Brisbane and Adelaide in Australia.

Table 3. A Selection of Australian PPP projects

Project	Construction completion date	Capital Cost	Description	Procurement
Cross City Tunnel (NSW)	2005	$680 million	Twin two-lane tunnels under the Sydney CBD between the Kings Cross Tunnel and the Western Distributor, with connections to the Eastern Distributor. **Outcome**: Not economically sustainable	DCFOM

CityLink (VIC)	2000	$2 billion	34 year concession involving 22km of toll road, elevated roadworks, 2 tunnels and electronic tolling. **Outcome**: Very successful functionally and economically	BOOT
EastLink (VIC)	2008	$2.5 billion	39km of tollroad, low tolls. **Outcome**: Marginal economically but limited risk exposure to public, excellent functional outcome	DBFO
Peninsula Link (Vic)	Under construction	$849 million (NPV June 2009)	27 km four lane road, travel time savings 40 min **Outcome**: Potentially expensive	DBFO Availability based toll road
Clem 7 tunnel (Qld) BrisConnect	2010	$2.89 billion	4.8km tunnel **Outcome**: Economically unsustainable for investors but limited risk exposure to public, excellent functional outcome.	DBFO
Royal Adelaide Hospital	Under construction	$2.33 billion	State of the Art 800 bed hospital **Outcome**: Appears excellent and sustainable	DBFO
Gold Coast Rapid Transit	Under construction	$949 million	13km light rail passing through major tourist business centre. **Outcome**: Appears excellent and sustainable	DBFO Finance mix from Queensland Government, the Australian Government, Gold Coast City Council and private sector

Observations and reflections:

The following generalisations have been drawn from the case studies:

- Sustainable outcomes appear associated with the selection of a Special Purpose Vehicle provider on the basis of the long term provisions for the public rather than simply for governmental convenience.
- Demand risk is a critical factor in the structuring of a PPP deal. Skewed traffic forecasts frequently result in failure of the deal and this has led to reluctance by the finance market to participate.
- The arrangement of PPP deals is far smoother where governments have clear and mature policies, guidelines and commitment and clarity in decision processes.
- Success of a PPP deals does not appear constrained to any particular risk allocation or payment regime.
- Great engineering, financial and operational innovations have been achieved. Also, successful project outcomes are consistently achieved in terms of delivery time, whole of life costs, quality, functionality, and ongoing operational and maintenance standards.
- The direct linking of large value capital projects to the finance market exposes these projects to financial opportunism, manipulation, and market machinations that sometimes occur around major financial transactions and markets.
- There appears to be a ceiling on the number of co-located PPP facilities based on social equity considerations and the affordability of tolls.

Concluding remarks

This paper sought to articulate the relationship between sustainability and major infrastructure investment decisions. In the discussion it is clear that sustainability impacts on most components of infrastructure as both sustainability and infrastructure consider the long term consequence of societal needs.

Key aspects of sustainability, as outlined by Hawkins et al (1999), require consideration of social, financial and environmental aspects of sustainability whilst being mindful that society seeks strong, healthy and just outcomes. The position has been put that drivers of population, equity, consumption, energy use and environmental concerns will significantly influence decision making but such considerations will not deter ongoing (and potentially increased) investment in infrastructure around the globe.

A major constraint to infrastructure development remains economic sustainability in terms of funding and financing. It has been confirmed that once infrastructure is successfully procured that on balance its benefits outweigh the lingering uncertainties surrounding the drivers for sustainability.

From an economic perspective it is evident that there is no magic solution but rather a range of alternatives that emerge on the basis of sound investigation. This leads to the conclusion that sound investment decisions will rely on a multidisciplinary approach to project evaluation and structuring that incorporates technical solutions with sound commercial and financial input.

There are a number of strategic contributions that professionals can make to realistically integrate sustainability thinking into their projects. Specific considerations include: holistic planning for sustainability, growth and resilience; appropriate legislation and policy; in depth leverage off opportunities brought by financing structures; mechanisms to contain and reduce costs; modifications to design philosophy to make solutions more robust for the future; and the commercial structuring of projects.

The reflection on Australian PPP projects highlighted that sustainable solutions are often difficult to pre-empt but from a functional and environmental perspective consistently good outcomes have been achieved through the integration of public and private participants in projects. There is clearly room for further development in the area of economic sustainability.

References

Aschauer, D. (1989). Is Public Expenditure Productive? *Journal of Monetary Economics* **23**, 177-200.

Asenova, D. and Beck M. (2009) “Obstacles to Accountability in PFI Projects” in Akintoye A., and Beck M. Ed. (2009) Policy, Finance & Management for Public-Private Partnerships, Wiley Blackwell.

Asian Development Bank (1997). Guidelines for the economic analysis of projects. Economics and Development Resource Center. Manila.

AT Kearney (2012) Foreign Direct Investment Confidence Index, http://www.atkearney.com/index.php/Publications/foreign-direct-investment-confidence-index.html, [accessed 6.7.12]

Atmo, G., Duffield C.F. and Zhang, L. (2012) A Framework for clean power station projects based on Public-Private Partnerships in Asia developing economies, the Second International Conference on Sustainable Built Environment, Yogyakarta.

Calderon, C., Moral-Benito, E. and Serven, L (2011) Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach, Policy Research Working Paper 5682, The World Bank, http://econ.worldbank.org/external/default/main?pagePK=64165259&theSitePK=469372&piPK=64165421&menuPK=64166093&entityID=000158349_20110615103058, [accessed 19.1.12].

Duffield, CF (2010), Chapter 9: Different Delivery Models. In: G.A. Hodge, C. Greve and A. Boardman (Editors), International Handbook on Public-Private Partnerships. Edgar Elgar Publishing Pty, Cheltenham, pp187-215.

Grimsey, D. and Lewis, M.K. (2007) Public Private Partnerships; the Worldwide Revolution in Infrastructure Provision and Project Finance, Edward Elgar.

Hawkins, P., A. Lovins, L. Lovins and L. Hunter (1999). Natural Capitalism: Creating the Next Industrial Revolution. Boston, Little, Brown and Company.

Hulten, C. and Schwab, R. (1991). *Is there too little public capital?* Infrastructure needs and policy options for the 1990's, February, American Enterprise Institute.

Jackson, T (2009) Prosperity without growth? The transition to a sustainable economy, Sustainable Development Commission, London, http://www.sd-commission.org.uk/publications.php?id=914.
Laszlo, E. (1990). Responsible (Project) - Management in an Unstable World. In R. Gareis. *Handbook of Management by Projects*. Vienna, MANZsche Verlags - und Universitatsbuchhandlung.

Mandiartha, IP, Duffield CF and Thompson, RG and Wigan MR, (2011) Developing a transition probability matrix as a measure of road network maintenance effectiveness, Transport Research Board congress, Washington DC, January 2011, 17 pages.

Pearson, C.J. (Ed)(2012). 2020: Vision for a Sustainable Society, University of Melbourne, Melbourne Sustainable Society Institute, http://www.2020sustainablesociety.com.au/the-book/.

Raisbeck, P, Duffield, CF and Xu, M (2010) 'Comparative performance of PPPs and traditional procurement in Australia', Construction Management and Economics, 28: 4, 345-359.

Stevens, L.K. (2008) Assessment of impacts of climate change on Australia's physical infrastructure, The Australian Academy of Technology Sciences and Engineering (ASTE).
Sustainable Development Commission (2011). Governing for the Future: The opportunities for mainstream sustainable development. London.

UK Round Table on Sustainable Development (1996). First Annual Report, Sustainable Development Commission.

United Nations (1987). Our Common Future: Report of the World Commission on Environment and Development, www.un-documents.net/ocf-cf.htm, [accessed 2.7.12].
Urban Land Institute and Ernst & Young (2011) Infrastructure 2011: A strategic priority, Washington, D.C.: Urban Land Institute, http://www.ey.com/GL/en/Industries/Real-Estate/2011-infrastructure-report--setting-strategic-priorities, [accessed 19.1.12].

Wood, P. and Duffield, CF (2009), In Pursuit of Additional Value: A benchmarking study into alliancing in the Australian Public Sector. Melbourne, Department of Treasury and Finance, State of Victoria.

Xu, M, Duffield, CF and Ma, J. (2011) Performance of Mid-Project Reviews (MPRs): Quantification based on Fuzzy Recognition, *Journal of Built Environment Project and Asset Management,* Vol 1:2, pp137-155.

Role of Timber Structures for Establishing Sustainable Built Environment and Connection Techniques Supporting those Timber Structures

Kohei Komatsu[*1]

*1 *Professor & Ph.D, Laboratory of Structural Function, Research Institute for Sustainable Humanosphere, Kyoto University, Gokasyo, Uji, Kyoto, 611-0011, Japan*

Abstracts

In this paper, role of timber structures as carbon stoker and recent trends surrounding timber structures both in European countries and Japan were first reviewed briefly. Then two important engineered timber joint techniques which support relatively large scale timber structures in Japan were introduced. Drift-pinned joint assembled with steel insert gusset plate was first introduced as most popular and widely used connection system for relatively large scale glulam structures. The second one was Lagscrewbolt (LSB) system. Pull-out characteristics of LSB was first reviewed then R&D of innovative LSB jointing method was introduced, and its ductile performance was showed off by experiments on full-scale glulam portal frame specimens.

Introduction

Constructing buildings using wood or wooden materials is now getting worldwide consensus[1)] as one of the preferable and effective solutions for restricting or reducing CO_2 emission in this world, because wooden buildings can not only stock CO_2 in their structural element for long period but also wooden structural material itself can be made of CO_2 and H_2O by using sustainable clean solar energy with supplying fresh O_2 for all living creature on this earth as shown in Figure 1[2)] This action is well known as “Photosynthesis” that only timber has this noble function among other such currently dominating structural materials as steel, aluminum and concrete.

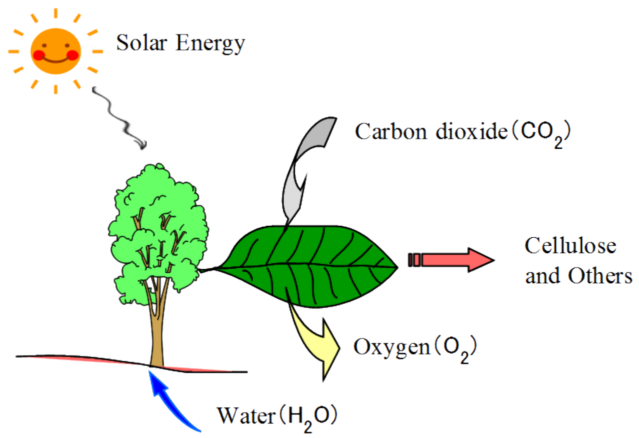


Figure 1. Photosynthesis based on sustainable clean solar energy[2)] (revised by the author).

The consensus, that carbon stock and CO_2 reducing system based on wood and wooden materials will bring better built environment, is now gradually spreading into various countries as a realistic solution for creating most clean and sustainable relationship among all living creatures, built environment and structural materials.

Hereafter, the author would like to show some examples, how timber structure has been coming back to this world as one of the preferable structures, and of recent technologies on engineered timber joints which can support medium and large scale timber structures as the reliable carbon storage buildings.

Recent Trends Surrounding Wooden Buildings

Countries other than Japan are likely to prefer to construct so-called multi-story buildings using wooden materials[3)]. For example, in UK, a wooden 9-story building called as “Stadthouse” (exactly, ground story is made of reinforced concrete and upper 8 story is wooden structure) has constructed at London in 2009 as shown in Figures 2-a), b) and c)[4)]. In this medium raise multi-story wooden building, relatively new wooden materials called as “Cross Laminated Timber (CLT)” shown in Figure 2-a),b) were used for all structural elements such as floors, walls, and others and those were assembled together using long screws as shown in Figure 2-b).

a) On site assembly of wall element made of CLT panels having openings already processed in the factory.(Courtesy of Mr. Matti Linegar)

b) Cross Laminated Timber (CLT) and long screw used for constructing 9-storey building at London.

c) Completed building.

Figure 2. “Stadthouse” a wooden 9-storey building at London, UK. The structural design of “Stadthouse” was taken part by *Teckniker* Ltd, and photos b) and c) were taken by the author when he visited UK.

Figures 3-a), b) and c) show another example of glulam 6-story building being constructed, using the technology of Nordic company, at Quebec, Canada so as to add to an existing 6-story RC building. As the author took these photos in winter of 2009, this building is thought to have been completed already.

a) whole view of frame structure

b) column, floor and girders

c) details of beam-column joint

Figure 3. Six-story glulam building being constructed at Quebec, Canada (photo was taken in 2009)

Next examples are not the real buildings actually constructed on ground but were buildings just evaluated their earthquake resisting performance by using the world largest shaking table facility called as “E-defense” located at Miki-city, Hyogo prefecture, Japan, where more than 15 years ago a devastating earthquake called as “Hyogo-Ken Nanbu Earthquake” occurred and killed more than 6000 peoples due to collapse of mainly wooden dwelling houses. Since this devastating earthquake, a lot of shaking table tests were carried out using this huge facility mainly for making earthquake resisting performance of wooden dwelling houses clear as shown in Figures 4-a), b) and c). Then foreign research groups also stated their efforts to make sure the possibilities of construction of “multi-story wooden structures” using “E-defense”. For example,. Figure 5 shows 7-story building made of CLT panels tested by Italian research team, while Figure 6 shows 7-story building made of OSB panels and specially designed light timber framings conducted by US research team.

a) Three story wooden post & beam house on shaking table facility. Two specimens were put on the table and Kobe earthquake record was given to them at the same time.

b) Specimen anticipated to be survival was first collapsed out of prediction. While that anticipated to be collapsed remained without fatal collapse.

c) Close-up view of collapsed specimen. It was shown through this sensational experiment that the prediction of collapse on full scale wooden dwelling house was not so straightforward.

Figure 4. Destructive tests on wooden dwelling house using the shaking table test facility of E-defense.

Figure 5。 Story CLT test specimen on the shaking table of E-defense.

Figure 6. Steel ground + 6 story light timber framing test specimen on the shaking table of E-defense.

While in the case of current Japan, the Building Standards Act restricts the maximum height and the story of timber buildings so as not to exceed 13m and three story (except for light timber framing structure; 4 story is admitted), respectively. In current Japan, therefore, multi-story timber structure will not be target at this moment, but low-raise and wide area timber buildings are rather having good wind as the target of "low-raise wooden public buildings". In fact in Japan, a new bylaw, which aims to promote more positively low-raise public timber structures, such as school class rooms, public assembly hall, kindergarten, public library, railway building and so on, has been enforced on 2010[5)]. One of the reasons why this noble bylaw was issued are to achieve the international promise, that was done by a former Japanese Prime Minister who declared to reduce the CO_2 foot print by 25% by 2010 compared to the level of 1990 at the United Nations Summit on Climate Change in 2009[6)]. Figures7-a), b) and c) show typical example of school classrooms constructed using glulam. Although these school class rooms were constructed before the above mentioned bylaw has been enforced, but this kind of low-raise public timber structures will increase more in Japan due to promotion of the bylaw. Figures 8-a), b) and c) show another example of low-raise but rather wide area glulam building for kindergarten.

c) Completed school class room

a) Glulam school class room under construction

b) Details of beam-column joint

Figure 7. Two-story glulam school class rooms being constructed or completed in recent Japan

a) Glulam frame structure under construction

b) Details of beam-column joint

c) Completed building

Figure 8. Single-story glulam kindergarten being constructed and completed in recent Japan

Steps of Japanese Glulam Construction

a) Overview of the building under construction.

b) Details of glulam arch structures.

Figure 9. The memorial first glulam structure built in Tokyo, Japan on 1951 (Courtesy of Dr. Tomoyuki Hyashi, Forestry & Forest Products Research Institute, Tuskuba, Japan)

Japanese glulam structure started on 1951 half century behind Europe, and the memorial first glulam structure was built in Tokyo using so-called "arch structure form" for "Shinrin Kaikan" which means "Forest Hall" as shown in Fig.9-a), b). Since that time, Japanese glulam manufacturing industry and number of buildings using domestic glulam have been developing until today; of course although their progress was not so straightforward but accompanying with some ups and down as shown in Figure10.

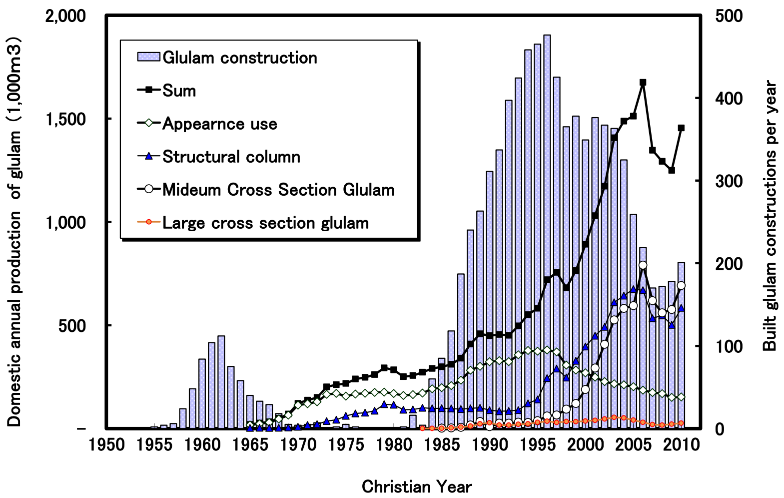


Figure 10. Progress of Japanese Glulam Production and Constructions of Glulam Structures (Courtesy of Dr. A. Miyatake, Forestry & Forest Products Research Institute, Tuskuba, Japan)

As can be seen from Figure 10, substantial progress of Japanese glulam manufacturing industry and constructions of glulam structures started from 1965, therefore the substantial experience of Japanese glulam production and construct of glulam structures is about 50 years. In this 50 years period, I have been sharing my research activities on glulam structures for about 30 years since 1985 when the Japanese glulam production and constructions of glulam structures have actually started their remarkable progress.

Research & Development on Engineered Timber Joints

Drift-Pinned Joint Assembled with Steel Gusset Plate

As the first type of engineered timber joint introduced here is “Drift-pinned joint assembled with steel gusset plate” as shown in Figure 11. I developed this joint method for glulam moment-resisting joint so as to enable easy assemble and quick election on-site as shown in Figure 11, where each glulam joint has been completed preliminary using steel insert gusset plate and drift-pins at well-equipped glulam factory. Hence, by only connecting some high tension bolts between two separate steel gusset plates at construction site, glulam portal frames could be quickly elected. Figures 12-a), b) and c) show examples of construction process and completed three story glulam building using this new moment-resisting joint system for “Obihiro Forest Service Branch Office”.

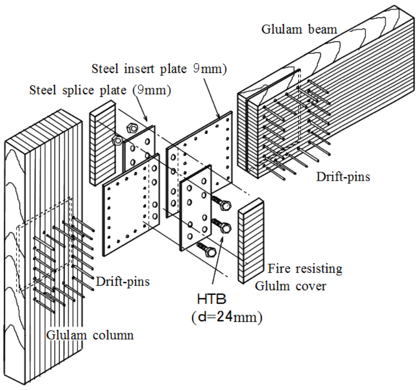


Figure 11. Moment resisting joint composed of drift-pins assembled with steel gusset plates

a) Prefabricated beam with concealed steel gusset plate and drift pins.

b) On-site assembly of glulam three story portal frame.

c) Completed building for "Obihiro Forest Service".

Figure 12. Glulam portal frames under construction and completed building.

a) Prefabricated column

b) Prefabricated beam

c) Assembled beam-column joint

d) Portal frames

Figure 13. Glulam portal frames under construction using drift pinned joint system.

Figures 13–a), b), c) and d) show another example in which drift-pinned with steel insert gusset plate joint system was applied for "Laboratory for Earthquake Resistance Wooden Structures" in Forestry and Forest Products Research Institute, Tsukuba, Japan.

Figures 14-a), b) and c) show a little bit different form of application in which two ways modified drift-pined with steel insert gusset plate joint system was applied as a lattice girder of roof structure for "Gymnasium" in Notre Dame Women's College, Kyoto, Japan. Since those previous successes, the drift-pinned joint with steel gusset plate has been using up to date as most standard and stable technique for composing of glulam moment-resisting joints in Japan.

a) Two ways joint before completion

c) Whole inside view

b) Roof girder after completion

Figure 14. Glulam lattice girder under construction using drift pinned joint and completed one.

Lagscrewbolt® for new moment-resisting connection system

Although on-site assembly, initial stiffness and ultimate strength are ensured on drift-pinned with insert steel gusset plate joint, but precise drilling process on steel gusset plate push up production cost, and also, two ways column-beams moment-resisting join was required. From these reasons, a relatively low cost and new moment-resisting joint system which is appropriate for realizing two-ways moment-resisting joint system was developed as shown in Figures 15-a) in 1997 called as "Lagscrewbolt® (denote as LSB)"[7].

a) First invented LSB

b) Type -MK.

c) Type-GW

d) Type-HK

Figure 15. Various type of LSB developed by the members of Japan LSB Society[7]

The term of "Lagscrewbolt®" was named as a serial combination of "Lag-screw" and "Bolt", namely outer part of LSB has threaded same as "Lag-screw" while at both or single end(s) of LSB, the same thread as "Bolt" was introduced to connect with other structural members. In 2005, Japan LSB Society was established and basic three different LSB system in which thread pitch, thread depth location and type of bolt thread are deferent, were developed as shown in Figures 15-b), c) and d).

Fabrication and Assembly Methods of LSB Connection System

LSB should be used as a pull-out or push-in resisting fastener on glulam frame structures. In order to obtain as satisfactory stiffness and strength properties as intended in design, LSB should be inserted correctly into a leading hall processed in glulam member as precisely as possible using specially designed bowling machine and power torque wrench as shown in Figures.14 or/and Figures.15 Use of impact wrench, however, is not recommended recently as it may give initial damages to glulam side.

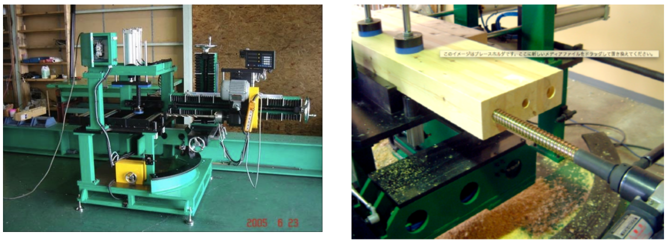
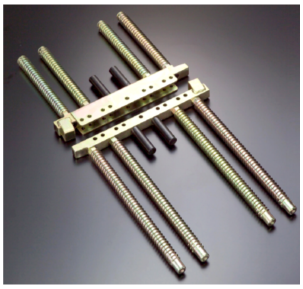


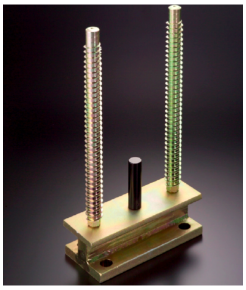
Figure16. Specially designed bowling machine and high power torque wrench for LSB. (Courtesy of Gradworks Co. Ltd.)

Figure 17. Universal CAD-CAM machine and multi-purpose impact wrench.

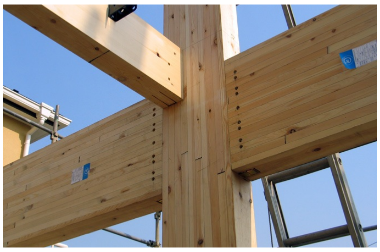
Figures 18 to 20-a), b) and c) show various types of assembly method for LSB.



a) Beam-column assembly

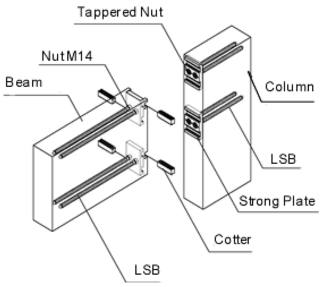


b) Column-base assembly

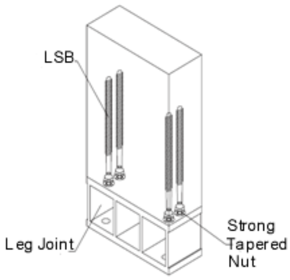


c) Completed joint.

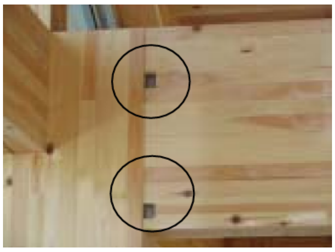
Figure 18. GW system (Courtesy of Gradworks Co. Ltd.)



a) Beam-column assembly

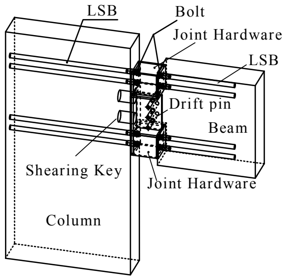


b) Column-base assembly

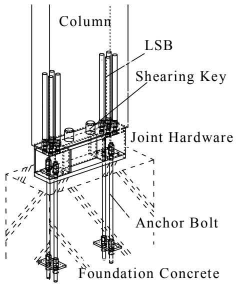


c) Complete joint

Figure 19. H-K System (Courtesy of Hara-tech Co. Ltd.)



a) Beam-column assembly



b) Column-base assembly

c) Completed joint

Figure 20. MK-System (Courtesy of Meiken Co. Ltd.)

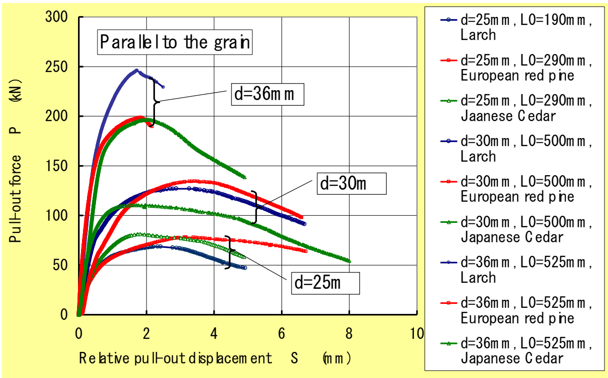
Basic tensile properties of LSB

We have been carrying out various fundamental experiments for evaluating basic tensile properties of pull-out performance of LSBs by using test set-up shown in Figures 21 and 22.

Figure 21. Pull-out strength experiment of single LSB joint penetrated parallel to the grain of glulam.

Figure 22. Pull-out strength experiment of single LSB penetrated perpendicular to the grain of glulam.

Figures 23 and 24 show typical load-relative slip relationship of single LSB joint parallel to the grain pull-out loading and perpendicular to the grain pull-out loading, respectively.



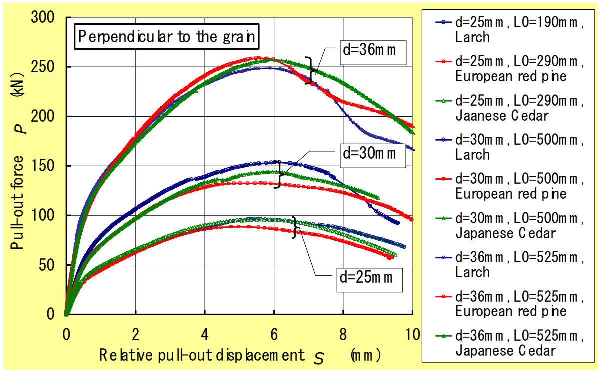
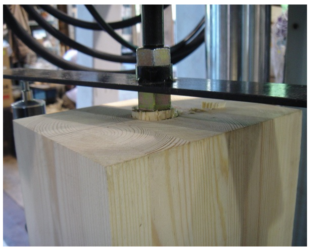


Figure 23. Examples of load-relative slip relationship of single LSB joint loaded parallel to the grain direction with variations of species of glulam, inserted depth (L_0), and top-thread diameter of LSB (d).

Figure 24. Examples of load-relative slip relationship of single LSB joint loaded perpendicular to the grain direction with variations of species of glulam, inserted depth (L_0), and top-thread diameter of LSB (d).

As can be seen from these load-relative slip relationships, initial stiffness of LSB joint tend to be higher in the case of parallel to the grain than the case of perpendicular to the grain. While for the ultimate strength, both loading cases give almost same values although parallel to the grain seems to be a little bit lower than the case of perpendicular to the grain. Most different features of both loading cases are deformability. Parallel to the grain loading invites rather brittle failure by simple pull-out of LSB as shown in Figure 25-a) or splitting as in Figure 25-b), while perpendicular to the grain loading accompanies with relatively ductile failure manner by making side surface raised-up as shown in Figure 26.



a) pull-out

b) split

Figure 25. Failure phenomenon of LSB joint loaded parallel to the grain of glulam.

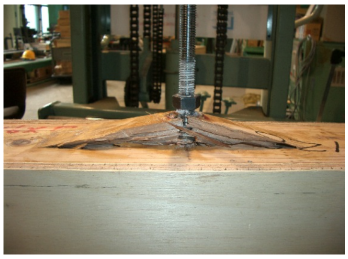


Figure 26 Failure phenomenon of LSB joint loaded penetrated perpendicular to the grain of glulam

Innovation for Giving Ductility[8)]

In order to survive from devastating earthquakes, moment-resisting joints in glulam portal frames should have sufficient ductility, which can give enough energy dissipation performance. For making this scenario realized, a new innovated steel splice joint was invented by the author as shown in Figure 27[8)]. In this special splice joint, special shaped slotted-hole bolted joint[9)] which has neck-down part of "*d*" adjusted to be slightly smaller than the lead hole "*D*" of HTB, hence HTB will slip with expanding narrow pass by consuming a lot of energy as shown in the right hand side of Figure 27.

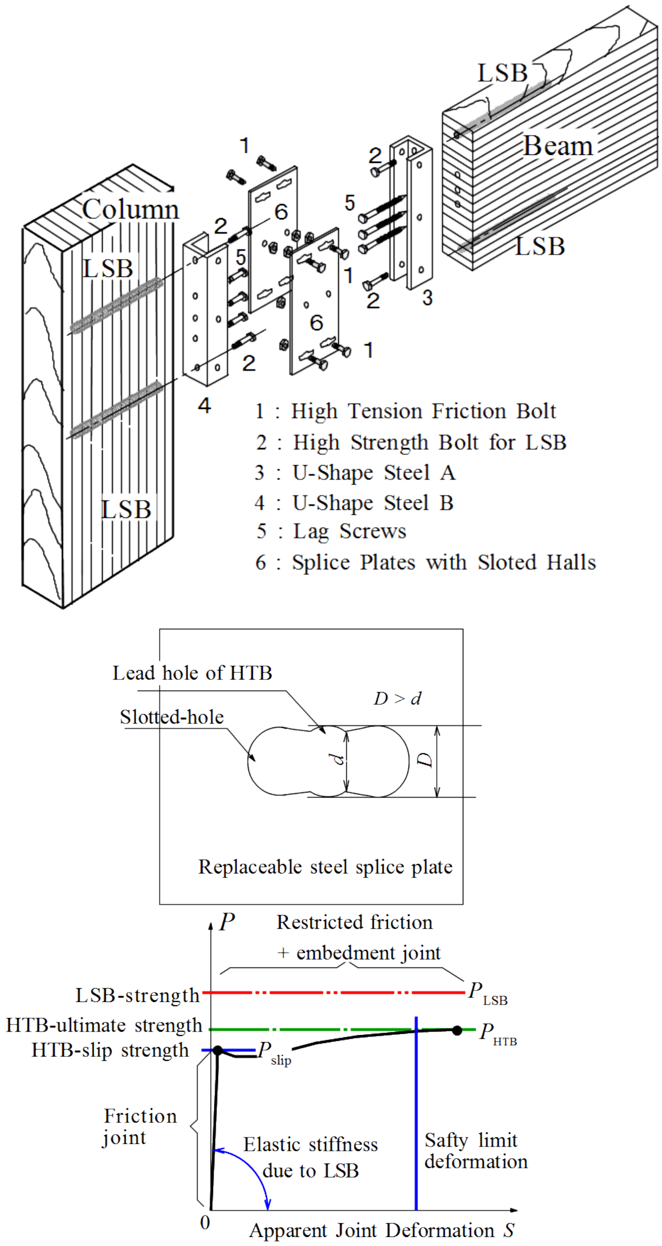


Figure 27 Newly invented LSB connection system[8)] by learning the idea[9)] on slotted-hole bolted friction joint. Idealized ductile load-deformation relationship is shown as a solid black line in right sub-Figure

If the above mentioned scenario could be realized, the apparent load-deformation curve of new LSB joint system will behave like a solid-line in sub-figure of Figure 27, subjected to the condition that ultimate tensile strength of LSB, i.e P_{LSB} should be always higher than the ultimate strength of HTB, i.e P_{HTB}.

Experiments on Column-Leg Joint and Beam-Column Joints[10)]

Figure 28 shows test set-up for beam-column joint specimen and Figure 29 shows actual situation of the experiment carried out at RISH, Kyoto University. Beam and column members used were made of European red-pine glulam whose modulus of elastic was 10.3 kN/mm^2 and modulus of rapture (characteristic value of bending strength) was 29.4 N/mm^2 and produced in a Japanese glulam company.

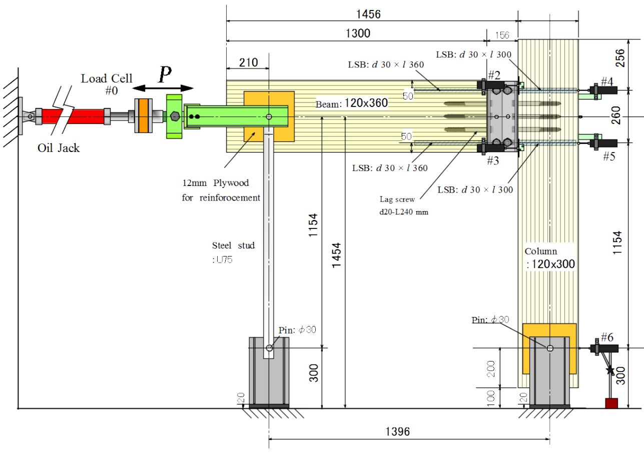


Figure 28. Test set-up for beam-column joint.

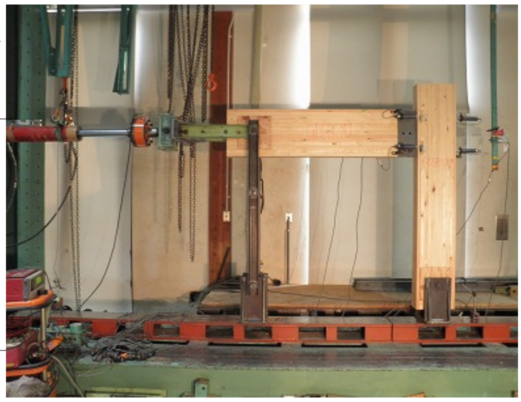


Figure 29. Actual situation of experiment.

Figure 30 show test set-up of column-leg joint, and Figure 31 indicates details of leg-joint. All parts of steel connection jigs were processed using laser boring machine and hand-welding. The lead hall of HTB "*D*" in Figure 27 was 17 mm, while width of neck-down part "*d*" was 15 mm intending this narrow pass can prevent from sudden steep load drop and give a lot of energy dissipation as shown in the right hand side graph in Figure 27.

Figures 32 and Figure 33 show examples of Moment-Rotation relationship of beam-column joint and column-leg joint, respectively. In these figures, red-lines indicate simulated results obtained by non-linear 3-D FEM program called as SNAP-ver.5 by employing hysteresis model of Normalized Characteristic Loop (NCL-model) originally proposed by Tani and Nomura et al.[11)] for RC constructions and recently re-arranged by Matsunaga et al.[12)] for applying to wooden shear walls. Figure 34 shows typical feature of NCL-hysteresis loop defined in equation - (1)[12)].

$$
\begin{aligned}
L(x) &= P/P_{\max} = \left\{B \cdot |x|^{n} + 1 - B\right\} \cdot x \mp A(x^{4} - 1) \\
x &= \gamma / \gamma_{\max}
\end{aligned}
\qquad \ldots(1)
$$

Where A, B and n are parameters which dominate shape of hysteresis loop.

Finally, applicability of this NCL model to the full-scale glulam frame structures were examined by employing full-scale glulam portal frame specimens whose span length was 4.5m and height was 2.73m as shown in Figure 35.

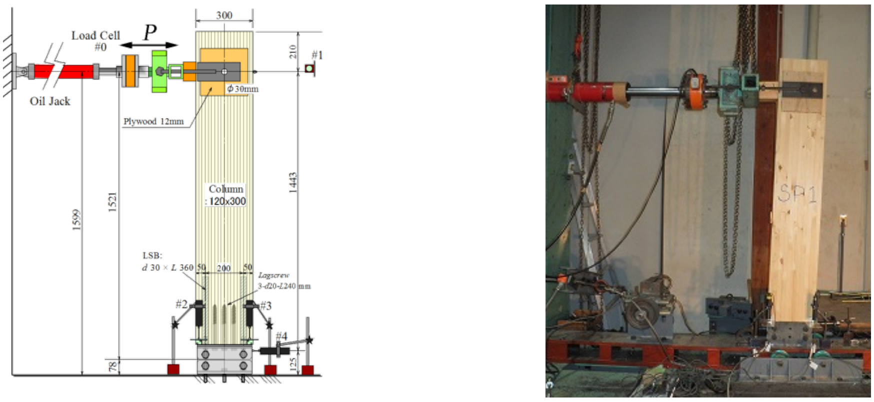


Figure 30. Test set-up and actual situation of column-leg joint.

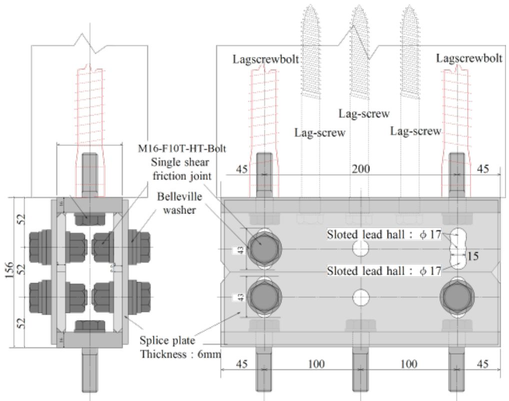


Figure 31. Details of column-leg joint experiment.

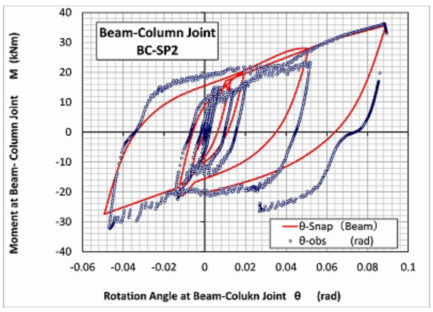


Figure 32. M-θresult of beam-column joint specimen.

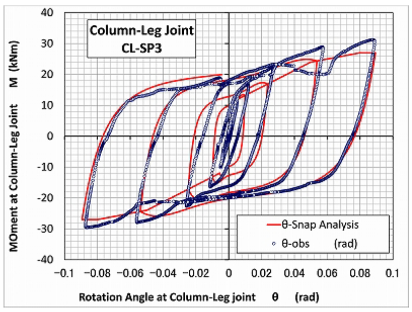


Figure 33. M-θresult of column-leg joint specimen.

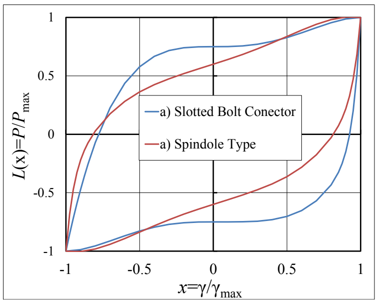


Figure 34 Typical features of NCL hysteresis loop used for simulating timber joint

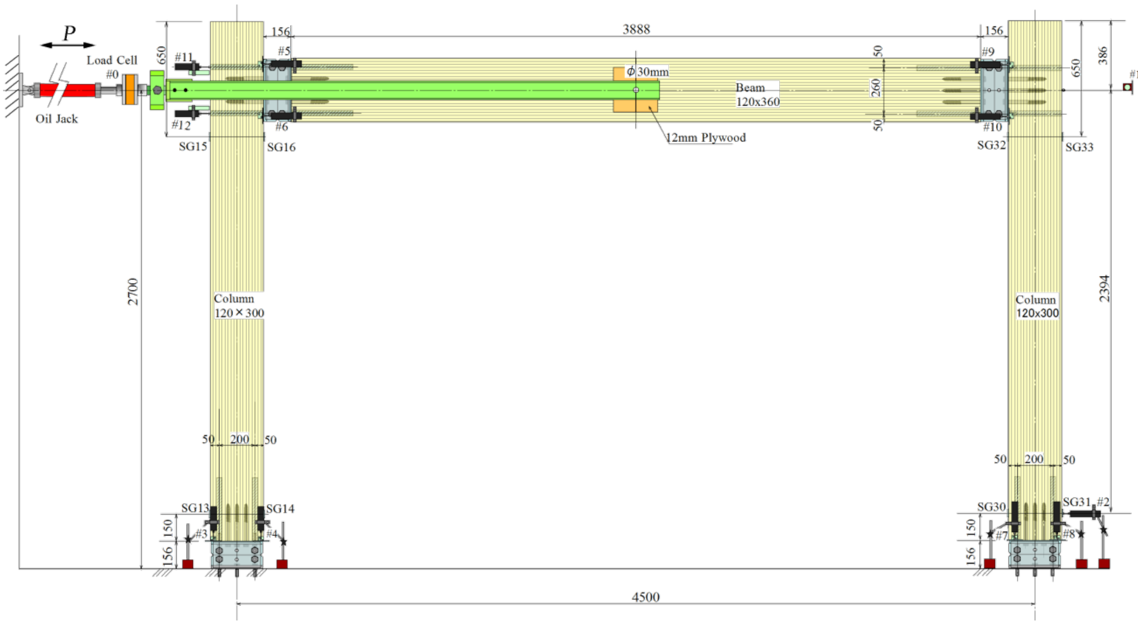


Figure 35 Test set-up for a full-scale glulam portal frame specimen composed of the same LSB joint system as beam-column or column-leg joint specimens.

Figure 36 shows comparison between observed load-shear deformation angle relationship (Blue plots: γ_{obs}) and predicted one by non-linear 3D FEM program (Red-line : γ_{-Snap}).

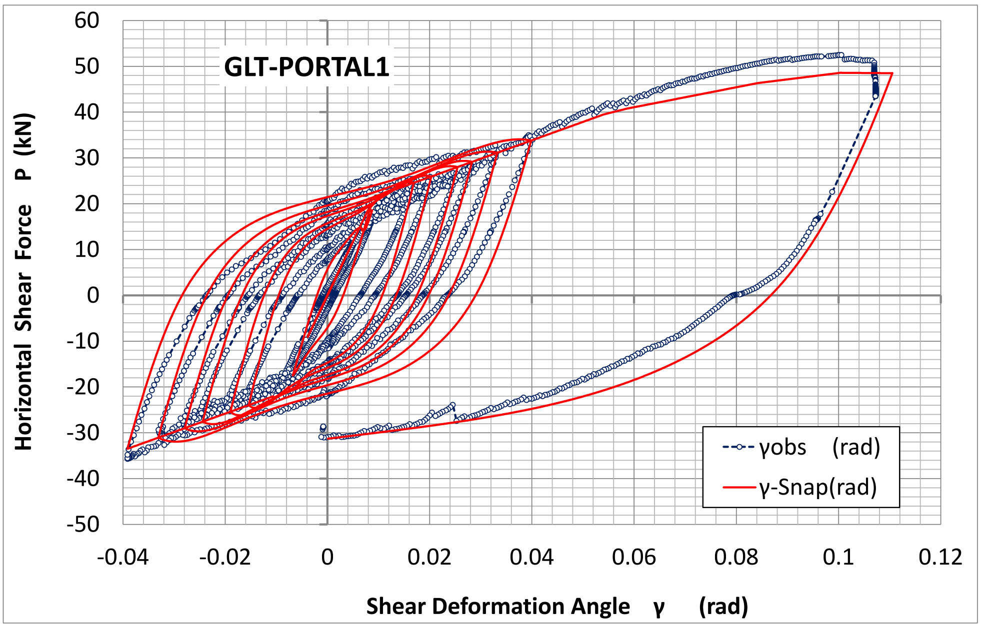


Figure 36 Comparison between observed load-shear deformation angle relationship (Blue plots: γ_{obs}) and predicted one by non-linear 3D FEM program (Red-line : γ_{-Snap}).

As can be seen from above mentioned experimental results, innovation on ductile LSB jointing system actually showed quite better performance not only for the initial stiffness but also for ductile characteristics up to 1/10 rad deformation without any damages on glulam members nor LSB joints themselves.

Summary

In this paper, the role of timber structures as carbon stoker and current trends surrounding timber structures both in European countries and Japan were briefly reviewed.

Then two important joint techniques, which support timber structures, were introduced. First one was drift-pinned joint assembled with steel insert gusset plate, which is now being used most widely for relatively large-scale glulam structures.

The second one was Lagscrewbolt (LSB) system. Pull-out characteristics of LSB was very brittle, therefore innovative LSB jointing method was developed by introducing friction damper concept using specially shaped slotted friction bolted joint system, and the actual ductile performance of the developed innovative jointing system was confirmed by full-scale experiments on full-scale glulam portal frame specimens.

References

For example, Stephen John, Nicolas Perez and Andrew H. Buchanan : The Carbon Footprint of Multi-Storey Timber Buildings Compared with Conventional Materials, Proceedings of WCTE2010, CD-ROM, 2010.

Y. Kurimoto : “75. Chemical components of wood”, in Concise Wood Encyclopedia, p.158, published by Research Institute for Wood Science and Technology, Akita Prefectural University, 2002.

For example, Martin Teibinger, Johann Charwat-Pessler: "Multi-storey Timber Houses in Urban Regions in Austria", Proceedings of WCTE2010, CD-ROM, 2010.

Megan Yates, Matti Linegar and Bruno Dujic "Design of an 8 storey Residential Tower from KLH", Proceedings of WCTE2008, CD-ROM, 2008.

http://www.rinya.maff.go.jp/j/riyou/koukyou/index.html (in Japanese)
Statement by Prime Minister Y. Hatoyama at the United Nations Summit on Climate Change, 22nd September 2009.

Japan Lagscrewbolt Society: "Design and Construction Guideline on Glulam Joints by Lagscrewbolts", 2007. (in Japanese)

Japanese Patent Application No.2011-148503, "Engineered Timber Joints for Wooden Structure", Inventor : Kohei Komatsu, Applicant : Kyoto University, July 4th, 2011.

For example; C.E.Grigorian, T.S. Yang and E.P.Popov : "Slotted Bolted Connection Energy Dissipators", Earthquake Spectra, Vol.9, No.3, 491-504, 1993.

Kohei Komatsu, Shouichi Nakashima and Akihisa Kitamori : "Development of Ductile Moment-Resisting Joint Based on a New Idea for Glulam Portal Frame Structures.", Proceedings of WCTE2012, to be held at Auckland in July, NZ, 2012.

Tani, S. Nomura, T. Nagasawa and A.Hiramatsu: Restoring Force Characteristics of Reinforced Concrete Aseismatic Elements (Part 1) –Restoring Force Characteristics and Metallization-, Transactions of Architectural Institute of Japan, 202, 11-19, 1972. (in Japanese)

H. Matsunaga, S. Soda and Y. Miyazu : Modeling of Restoring Force Characteristics of Wooden Structures and Its Application to Dynamic Analyses, Proceeding of the 78th Architectural Research Meetings, 2007, Kanto Chapter, Architectural Institute of Japan, 201-204, 2008. (in lapanese)

Will, Human and Waqf: A Solution for a Sustainable Environment

İbrahim Numan

Fatih Sultan Mehmet Wakf University, Istanbul, Turkey

Whenever we start to say something, start an argument on the natural or built environment, often the fact is stated that systems that manage and guide these areas are inadequate.[1] But, although both these environmental dimensions are defined within legal systems, they often only remain nominal and are not reflected in practice.[2] Although law reflects our world-view and expresses society's basic values and how they are to be implemented, more often than not we encounter a system that can be transgressed. And more often than not, especially with Enlightenment thought and after the industrial revolution, legal systems have developed aiming to control and dominate nature. Even though a promising new constitutional understanding that aims to repair this point is emerging, especially with examples such as the constitutions of Ecuador and Bolivia, not to mention the movement for the Universal Declaration of the Rights of Mother Earth, are we going to be able to assure these rights simply within a legal framework?[3] All things considered, as much as this is an issue regarding law, more importantly, it is one that regards culture.[4]

Carrying regard for nature beyond legal systems, turning it into a living culture, undoubtedly comes through a comprehension of the relationship between man and nature, through understanding man's place and role within this system. 'Advanced' societies, and especially the West thought of nature as something exterior to society, they could not unite or identify with it. They saw it as a commodity from which its owners will benefit the utmost, and would buy and sell it.[5]

Such a world-view never accepted itself as part of nature. A discourse that saw one in unity with the creator and the whole of creature was not developed, unlike the 14th Century Turkish Sufi Yunus Emre, who says

> "With the mountains, with the stones / Will I call thee, Lord, O Lord!
> With the birds in the early dawn / Will I call thee, Lord, O Lord!
> With the fishes in the sea / With the gazelles in the desert free
> With the mystic's call "O He!" / Will I call thee, Lord, O Lord!",[6]

Among elements that will allow a sustainable environment possible, alongside a comprehensive belief in unity as the principal factor, there are also important ethical points such as welfare, solidarity, loyalty, sacrifice, and dedication. Furthermore, there are also institutions that are built specifically on the culture.

[1] See: R. C. Foltz, F. M. Denny, A. Baharuddin: Islam and Echology A Bestowed Trust, (trns) Nurettin Elhuseyni, Istanbul 2003
[2] Ömer Madra: "Speach" in *Ekolojık Anayasa*, (edt) Mahmut Boynudelik, Istanbul,2011,p. 28.
[3] Ömer Madra: "Speach" in *Ekolojık Anayasa*, (edt) Mahmut Boynudelik, Istanbul,2011,p. 28.
[4] C. Cullinman: *The Rights of Nature.* n.p., 2011. http//www.canadians.org/rightsofnature
[5] Ömer Madra: "Speach" in *Ekolojık Anayasa*, (edt) Mahmut Boynudelik, Istanbul,2011,p. 28.
[6] Yunus Emre: *Yunus Emre and his Mystical Poetry* (ed.: Talât S. Halman). Bloomington,IN: Indiana University, c1981. p. 66.

Before going on to consider the *waqf* pious foundations institution, we should consider the cultural environment that laid the foundations and supported it.

"Did we create the universes just as a game? We create to realize a higher divine aim"[7]

It may be appropriate to pose a question at onset. What existed before the environment, or more precisely the Earth, or the universe exited? May be, the issue over which science and faith approach one another the most is revealed in this question. Nonentity. "He himself was at blindness, meaning at nonentity"[8] When the hadith **"Kana allahu wa kana mahu shay"** (There was God, and there was nothing) was asked the Sufi Junayd al-Baghdadi, his response was "Al'an kama kan" (It is still so). That which existed when nothing else did, wanted to be seen and be loved, "He reflected with his own light into nonentity". [9] He said "kun" (be) and existence came into manifestation.[10] "It is He who created all things, and ordered them in due proportions."[11] The order is one that is continuous, that renews itself. It is set upon a new creation and a new existence every moment. **"Kull yawm huwa fi shen "** says Kur'an.

Allow me to concentrate on two subjects among this continuous being, and with the complementary factor these two present, raise the issue of an institution that is fundamental to a sustainable relationship with nature. First is the will that creates the natural environment; second is the human being, which in partial possession of this will, manipulates the environment.

In the Kur'an, it is written that God established his creation and established authority over what is his, sustained the order he established, and that the created submitted to the will of its creator; that there are signs to this sense for those who consider.[12]

In the story of creation, in various verses of the Kur'an, such as An'am 6:99 and Abasa 80:23-32, the natural environment is considered first as the Gardens of Heaven, then as the Earth which is to be molded by man. Here, it is mentioned that beings such as rain, soil, water as well as trees, plants and various fruits have been assigned to the use of man. But there can be noticed a difference between the use of the environment between the world and Heaven, as it is described. In Heaven, man's relation to the environment is unproblematic, in perfect harmony. At this stage, it can be considered that man, "left responsible for living beings" obeyed the order "procreate, live in harmony with the land and with living being, abide by the laws of nature I have set",[13] and that in the other stage, he started creating problems.

Did man, whose order of creation was appointed as that of other beings, have deviances from that will?

---

[7] Kur'an: ''Yunus'' 10:5. In: *Yuce Kur'an: text, translation & commentary by A.Sener,M.C.Sofuoglu,Yildirim*. Izmir: 12008.

[8] Kenan Rifai: *Sohbetler*. Istanbul, 2011, p. 528.

[9] Kenan Rifai: *Sohbetler*. Istanbul, 2011, p. 528.

[10] Kur'an: ''En'am'' 6:71. In: *Yuce Kur'an: text, translation & commentary by A.Sener,et.al*. Izmir: 2008.

[11] *Kur'an:* "Furkan" 25:2. In: *The Holy Quran : text, translation & commentary by Abdullah Yusuf Ali*. Lahore: 1981.

[12] *Kur'an:* "Ra'd" 13:2-4. In: *The Holy Quran : text, translation & commentary by Abdullah Yusuf Ali*. Lahore: 1981.

[13] Uygar Özesmi paraphrasing in *Yasak Meyve*. p. 26.

On the other hand, Adam's, meaning man's, appearance on Earth was the first step towards the appearance of the Light of Muhammad, which God pronounces along with his own name, and which is the reason for creation.[14]
It is necessary to dwell a bit on creation and on existence.

Being human, *insan*, from the Arabic root *alif-nun-sin* designating becoming socialable, companionable, infers becoming acquainted and gaining consciousness, gaining familiarity through knowledge. Man, was taught names, or in other words was taught knowledge, and was made deputy (khalifa – *lit.*: successor). Through eating the forbidden fruit / or through this direct expression of choice/expression of will, what responsibility did man undertake that was refused by mountains, rocks or birds.

Could this quality be interfering with the will that set the order of creation, displaying the 'partial will', limited free personal will, to attempt to continue or substitute it? As *khalifa* means successor in the sense of reigning subsequent to the original and expressing will, should man on Earth, with his partial free will be considered but only an executor of the greater will? May be, this is the crux of the issue.

The natural environment was given to us directly as a trust by God, the built environment as a trust by the history of human life, both for us to live in it for a limited period. Thus, with the will entrusted to us, we can change it, evolve it, manage it for better or for worse.

When talking of the built environment, the interaction between man and the environment he lives in immediately comes to mind.
The natural environment responds, in time, to anything that is done to it, according to its own laws. Man, on the other hand, makes a choice with the entrusted will that is found in him, tries to gain control of the environment. However, mankind, who thinks he is shaping the environment he lives in according to his own wishes, is at the end himself reshaped by this shaped environment.[15]

Yet, in the Surah Hud, it is expressed " It is He Who hath produced you from the earth and settled you therein".[16] There, man is empowered and charged with building and building civilization (**wasta'mara**).
Man, who executes this duty on the worldly stage through the activity of building, is responsible for the will that he uses. With saying "ask forgiveness of Him, and turn to Him (in repentance): for my Lord is (always) near, ready to answer",[17] man is guided to seek refuge in the absolute, complete will for the responsibilities that arise with using his will.

Thus, it seems that man, who was sent to the Earth by the creator, equipped with partial free will, with creation subjugated to him,[18] is responsible for the decisions he makes regarding the natural and built environment.
At this point, it should be pointed out that the institution of *waqf* is an instrument that can be used to realize this obligation and responsibility. This is so, because

---

[14] Süleyman Çelebi: *Mevlid.*
[15] Hüseyin Ateşin: "İnsan Yapısı ve Çevrenin Tekâmülü" Mesken ve Mesken Mimarimiz Konferansı Bildiriler, Marmara Universitesi, Istanbul, 24-24 Mart 1990. pp. 72-75.
[16] *Kur'an:* "Hud" 11:61. In: *The Holy Quran : text, translation & commentary by Abdullah Yusuf Ali*. Lahore: 1981.
[17] *Kur'an:* "Hud" 11:61. In: *The Holy Quran : text, translation & commentary by Abdullah Yusuf Ali*. Lahore: 1981.

[18] *Kur'an:* "Ibrahim" 14.

the built environment (*imâr*) presented within nature, can be regulated and made sustainable through the use of this instrument.

Ideas about change often remain constrained to shape and contours, and do not address the essence or principles. For this reason, they are not extensive nor continue on. First and foremost, man must determine his role within the environment well as a principle. His accuracy in making such a determination is the most important foundation in the organization and sustaining of his relation with his environment.

The critical question is this, is man the owner of the domain? Or is he the temporary user? Is the world given to him? Or is it entrusted to him as a steward? To what point is he effective in his will to do and to govern? Or is he an executor steward, bound within the limits assigned to him (the bounds of his limited free will)? These questions, beyond legal framework, through values, are effective in man's placing in his conscience, the rule regarding the environment and regarding its sustainability. Just like the individual, societies too determine their order of life through rules that grow from this premise.

May be the first and most important step in terms of sustainability is approaching the environment with "Ila'yi Kelimatullah, the love of furthering God's name, meaning carrying an understanding of God's unity to the whole world, intoxicating society around the altar of a single idea, stunned in worship,"[19] and creating a collective conscience. That this collective conscience, supported with knowledge and wisdom, will have a vitalizing effect resembling Israfel's trumpet raising the dead, is for sure.

Turning back to the subject matter of *waqf*s; it would be appropriate to consider the *waqf* and *waqf* civilization as an instrument of sustainability, founded by a culture that shared the above described premise of a consciousness of being created, and believed in a universe where the creator has set the order, and thus approached the environment as a vehicle, implementer, a steward of the creator.

Even though *waqf*, at first sight, can be seen as a legal institution that is found present both in ancient and modern times, it differs as far as the identity it gained within the context of Islam. Beyond a legal order, it may be defined as a civilizational order, with its particular characteristics, philosophy, organization and even economic aspects. With a sincere understanding that seeks no self-interest, it aims to gain, develop and implement a consciousness that gives what was bestowed by the creator back again to nature and to society, in the name of the creator and for his sake.

A *waqf* deed usually comprises these sections:

1. Praise to God and Kur'anic verses and Hadith about the merits of endowing *waqfs*
2. Properties that are endowed
3. How it is to be governed
4. Where the revenue is to be spent
5. The trustees, whom it is to be governed by
6. Legal attestation

---

[19] Samiha Ayverdi; ''Ondorduncu Asirdan Bu Yana Turk Ictimai Muesseselerine Kisa bir Bakis'', Yuzyıllar Boyunca Turk Sanatı, (edt) Oktay Aslanapa, Istanbul, 1977, pp.142-170.

These institutions, most of which were entrusted from one generation to the next, were centers of social and collective necessity that lived and served to let live. Rules regarding how they were to be founded, how they were to serve, how they were to continue were to be founded in the deed expressing the will of the founder.

In short, it is obvious that waqf institutions offer the possibility of resolution in many problematic areas in the various sectors of sustainability. Mainly in the areas such as: the Sustainability in Social Welfare, Eco Systems, Sustainability of Natural Environment, et.al., and of course the Sustainability of the Built Environment.

Following the path of Quranic morality and the sunnah, the Waqf Institution have been built upon the principle of : **"to love all the created for the sake of the Creator"**. Thus, it is a proper medium to convince human beings to be willing devotees for the sake of their fellow men. Having accepted himself even as a tiny part of the total holiness, for the human being has always been and will be easy to share and to be persistent. Consequently this will lead to a sustainable environment.

Either in parts or in totality all what have been conferred here, " should be poured into a unified energy, by gaining a form of organic unity "**Vahda**". If it is asked that what will be the melting power of this tune, the answer will be "the love of **ila-i Kelimatullah** , as the total awakening power"[20].

References

C. Cullinman: *The Rights of Nature.* n.p., 2011. http//www.canadians.org/rightsofnature

Hüseyin Ateşin: "İnsan Yapısı ve Çevrenin Tekâmülü" Mesken ve Mesken Mimarimiz Konferansı Bildiriler, Marmara Universitesi, Istanbul, 24-24 Mart 1990. pp. 69-98.

Kenan Rifai: *Sohbetler*. Istanbul, c2011.

Ömer Madra: "Speach" in *Ekolojık Anayasa*, (edt) Mahmut Boynudelik, Istanbul, 2011.

R. C. Foltz, F. M. Denny, A. Baharuddin: Islam and Echology A Bestowed Trust, (trns) Nurettin Elhuseyni, Istanbul 2003.

Samiha Ayverdi; ''Ondorduncu Asirdan Bu Yana Turk Ictimai Muesseselerine Kisa bir Bakis'', Yuzyıllar Boyunca Turk Sanatı, (edt) Oktay Aslanapa, Istanbul, 1977, pp.142-170
Süleyman Çelebi: *Mevlid.*

The Holy Quran : text, translation & commentary by Abdullah Yusuf Ali. Lahore: 1981.

Yuce Kur'an: text, translation & commentary by A.Sener,M.C.Sofuoglu,Yildirim. Izmir: 12008.

Yunus Emre: *Yunus Emre and his Mystical Poetry* (ed.: Talât S. Halman). Bloomington,IN: Indiana University, c1981.

[20] Samiha Ayverdi; ''Ondorduncu Asirdan Bu Yana Turk Ictimai Muesseselerine Kisa bir Bakis'', Yuzyıllar Boyunca Turk Sanatı, (edt) Oktay Aslanapa, Istanbul, 1977, pp.142-170.

Tenure stability as a key indicator of livability in informal settlements: the case of *kampung* Tungkak in Yogyakarta

Wiryono Raharjo

Department of Architecture, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Email: raharjo@uii.ac.id

Abstract

Informal settlement is an inseparable part of urban fabric in the fast-growing cities like Mumbai, Jakarta, and Caracas. The term 'informal settlement' denotes a settlement formed and developed outside the formal control of the authority. As a result of such development, residents' tenure is insecure due to the vulnerability to eviction. However, while we may claim that informal settlement lacks tenure security, many of such settlement have existed for decades. Kampung Gondolayu in Yogyakarta can be traced back in the 1970s, while Dharavi slum in Mumbai has been existed since the early 20th century. What are the key factors that make these settlements survive for a long period? How do dwellers operate the tenure system in such settlements? How does the built environment contribute to the continuity of dwellers' tenure? These are some key questions the paper intends to respond. Through historical analysis of a *kampung* Yogyakarta called Tungkak, this paper presents the gradual process of tenure stabilization that led to the continuing existence of this *kampung*.

Keywords: built form, kampung, livability, informal settlement, tenure stability

Introduction

In recent years livability has been regarded as a key indicator in looking at the sustainability of a city. According to the Economist Intelligence Unit (2011) livability assessment is a process of looking at the best and the worst of living condition in cities worldwide. There are five broad categories in livability assessment, namely stability (weight 25% of the total 100%), healthcare (weight 20%), culture and environment (weight 25%), education (weight 10%), and infrastructure (weight 20%). Based on these categories, the Economist Intelligence Units had chosen Melbourne (Australia) as the most livable city in the world in 2011 (Table 1), while Harare (Zimbabwe) was ranked as the worst city in the world in the same year (Table 2).

Among the aforementioned categories, stability poses the highest weight (note: culture and environment obviously have the same weight, i.e., 25%, but they are two categories combined). In other words, stability can be seen as the most important category in the livability assessment. Table 3 describes indicators of stability, which show that issues discussed in such category are predominantly related to crime, terror, and civil unrest. The list does not specifically mention security of tenure, yet security of tenure does not appear in four other categories. Within the Indonesian context, 'security' (fearless living) is mentioned in the livable city index issued by the Indonesian Association of Planners (IAP – *Ikatan Ahli Perencanaan Indonesia*) as one of the indicators of assessment (www.iap.or.id accessed on 9 July 2012). However, such livability index does not specifically addresses issues on security of tenure.

Table 1. Top ten livable cities in the world (source: Economist Intelligence Units, 2011)

The top ten cities
(100=ideal; 0=intolerable)

Country	City	Rank	Overall Rating (100=ideal)	Stability	Healthcare	Culture & Environment	Education	Infrastructure
Australia	Melbourne	1	97.5	95	100	95.1	100	100
Austria	Vienna	2	97.4	95	100	94.4	100	100
Canada	Vancouver	3	97.3	95	100	100	100	92.9
Canada	Toronto	4	97.2	100	100	97.2	100	89.3
Canada	Calgary	5	96.6	100	100	89.1	100	96.4
Australia	Sydney	6	96.1	90	100	94.4	100	100
Finland	Helsinki	7	96	100	100	90	91.7	96.4
Australia	Perth	8	95.9	95	100	88.7	100	100
Australia	Adelaide	9	95.9	95	100	94.2	100	92.9
New Zealand	Auckland	10	95.7	95	95.8	97	100	92.9

Table 2. Bottom ten livable cities in the world (source: Economist Intelligence Units, 2011)

The bottom ten cities
(100=ideal; 0=intolerable)

Country	City	Rank	Overall Rating (100=ideal)	Stability	Healthcare	Culture & Environment	Education	Infrastructure
Côte d'Ivoire	Abidjan	131	45.9	30	45.8	54.2	50	53.6
Iran	Tehran	132	45.8	50	62.5	35.9	50	33.9
Cameroon	Douala	133	44.0	60	25	48.4	33.3	42.9
Pakistan	Karachi	134	40.9	20	45.8	38.7	66.7	51.8
Libya	Tripoli	135	40.4	50	33.3	39.1	50	32.1
Algeria	Algiers	136	40.2	40	45.8	39.8	50	30.4
Nigeria	Lagos	137	39.0	25	33.3	52.3	33.3	48.2
PNG	Port Moresby	138	38.9	30	37.5	44.2	50	39.3
Bangladesh	Dhaka	139	38.7	50	29.2	43.3	41.7	26.8
Zimbabwe	Harare	140	38.2	25	20.8	55.8	66.7	35.7

The UN defines security of tenure as a condition where people have the right to be protected by the state against forced eviction (UN Habitat, 2004). The protection may occur in the form of legalized tenure components, such as land certificate, building permits, state water and electricity connections, and so on. However, the problem occurs when buildings do not comply with such system, which is the main issue in informal settlements. Here insecure tenure may be experienced by dwellers of such settlements, regardless of the quality of buildings and infrastructures. In other words, while the built environment in informal settlements may have the same quality as that of 'formal' settlements, dwellers' tenure is less secure due to the threat of eviction.

Table 3. Indicators of stability (source: Economist Intelligence Units, 2011)

Indicator	Source
Prevalence of petty crime	EIU rating
Prevalence of violent crime	EIU rating
Threat of terror	EIU rating
Threat of military conflict	EIU rating
Threat of civil unrest/conflict	EIU rating

Looking at Table 3 above, eviction can be seen as a ‘threat of terror’. Therefore, within the framework of livability assessment, tenure security fails within the category of stability. This paper looks at tenure issues as part of livability assessment of informal settlements. It begins with the discussion on operational definition of informal settlement, followed by the discussion on tenure stability. Furthermore, the paper discusses a case study of a *kampung* in Yogyakarta, called *kampung* Tungkak, where gradual development that involved state intervention led to the continuing existence of this *kampung*. Most of the raw data for this paper are based on author’s survey for his PhD program in 2008. Therefore it may not precisely represent the most recent condition of Tungkak. The data was gathered mainly through interview and mapping of infrastructure and building functions.

Informal settlements and the built environment

In his seminal work ‘Planet of Slum’, Mike Davis (2006) portrays how the urbanization has turned the built environment in most cities of the global-South into slum. Davis’ claim is not an exaggeration, as almost ten years ago the UN had estimated the world population of slum dwellers was almost one billion, i.e., 32 percent of the world’s urban population (UN Habitat, 2003). Caracas is an example of a city with striking division between ‘chaotic’ and ‘well-ordered’ built environment (refer to Figure 2). The former is often called ‘informal city’, which has been formed and shaped by the growth of informal settlements over time (Brillembourg, et al, 2005).

‘Slum’ and ‘informal settlement’ are words frequently interchanged in the discussions of urban settlements. The words ‘informal settlement’ cannot be divorced from the usage of the term ‘informal sector’ in the discourse of urban affairs. Extensive literature review on urban informality by Evers and Korff (2000:135) defines ‘informal sector’ as ‘the field in which the production of goods and rendering services are largely withdrawn from state control and registration’.

Referring to the above definition, informal settlements can thus be regarded as the built environment produced through development operated predominantly outside the state control and registration. The notion of ‘informal’ can be perceived as ‘not done or made according to a recognized or prescribed form; not according to order; unofficial, disorderly (Brillembourg et al, 2005:18).

The author argues that the dominant influence of state in the development may lead to the increasing of dwellers’ confidence in continuing to live in informal settlements. Guinness (2009) uses the term ‘formalization’ to call such state intervention. Forms of ‘formalization’ include connections of water and electricity supply, improvement of the built environment (e.g. slum and infrastructure upgrading), and the issuing of resident's ID card (Indonesia's KTP – *Kartu Tanda Penduduk*). However, formalization is not the same as legalization as it does not always lead to the authorization of land tenure. Land tenure status in such settlement remains largely unauthorized.

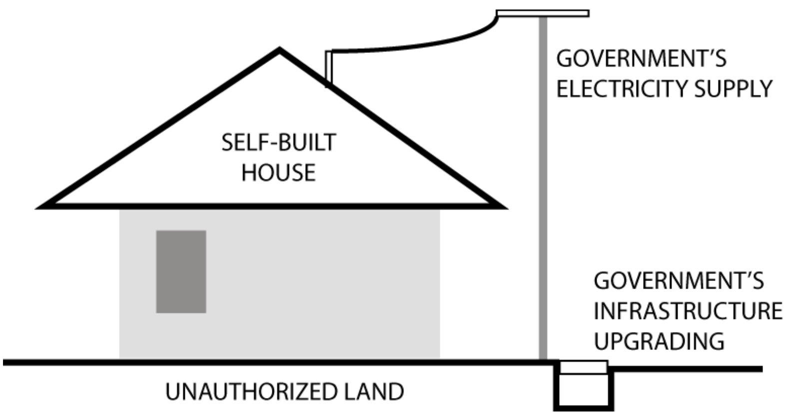


Figure 1. Forms of 'formalization' in informal settlement (drawing by author)

The nexus between unauthorized land tenure and built forms with various kinds of state intervention (see Figure 1) makes tenure in informal settlements ambiguous. On the one hand, dwellers' self-built house is vulnerable to displacement as it sits on unauthorized land. On the other hand, government's intervention in the improvement of the house and its surrounding makes the house more immune from displacement. Here we see how the reciprocal relationship of built form and tenure play in maintaining dweller's tenure stability.

Tenure stability

The definition of tenure security discussed earlier in this paper suggests that tenure is a complex system, which can be classified into two major groups: formal and informal (UN Habitat, 2004). Formal tenure basically links to the systems authorized by the government, including free-hold, registered leasehold, private rental, customary ownership, and so on (Payne, 1997). These forms of tenure are visible as they are recorded in the system administered by the government; although they are not always occurs in the form of certificate - customary land tenure is an example.

By contrast, informal tenure is unrecorded, thus it is invisible. A common example of informal tenure is 'de facto tenure'. This form of tenure does not carry legal status of the property but the settlements may exist as long as dwellers want, because the authority does not take any action to demolish them (Payne, 1997). Turkish *gecekondu* is an example. It is a spontaneous settlement[1] where dwellers quickly construct their house with permanent building materials. The authority cannot immediately demolish such house because by law, they must to go through the court in order to demolish the permanent building (Neuwirth, 2005). Here we see the nexus between built form and tenure. Modification and improvement of

[1] *Gecekondu* means settlement built overnight.

built form may lead to the achievement of tenure stability provided that the process is not contested.

Tenure stabilization may also be achieved through the application of resident's ID card - often found in Indonesian cases where *kampung* residents apply for KTP (Kartu Tanda Penduduk – Resident's ID Card) to get access to various public services like electricity and water connection, as well as neighborhood infrastructure upgrading. In Indonesia, application for electricity connection from *Perusahaan Listrik Negara* (PLN – State Electricity Company) requires applicant to submit only a KTP and a map of house location, no documents associated with land tenure are required.

However, as indicated in Figure 1, the author argues that tenure stability is not the same as tenure security. State intervention in the improvement of built environment does not guarantee the future legalization of land tenure - the essential part of secure tenure attainment. Such intervention may only allow a longer occupation of the land, which may lead to tenure stability – the attainment of 'de facto' tenure. In order to further explain this phenomenon, this paper presents a case study of kampung Tungkak, a stabilized informal settlement located in the southern fringe of Yogyakarta.

Case study: *kampung* Tungkak

This sub-chapter consists of two parts. First, it discusses the meaning of a *kampung*. Second, it describes how residents of *kampung* Tungkak gained tenure stability through neighborhood development over time. Data on this *kampung* was collected through in-depth interview triangulated with field survey (Figure 2) and secondary information, particularly on the history of the homeless housing compound.

Figure 2. The housing compound today (photo credit: author, 2008)

Kampung

Kampung is often simply translated as urban village (see for example Funo et al, 2005). In dictionary terms, kampung is originally a Malay term means village or hamlet, probably similar to compound (Apple, 2009). The term is widely used in both Indonesia and Malaysia, but in Indonesia *kampung* is generally perceived as urban settlement, while rural settlement is called *desa*. *Kampung* is characterized by the domination of self-developed built environment, not formally planned by the authority.

According to Johan Silas (in Kenworthy, 1997), *kampung* is not slum or squatter's settlements, rather it is a result of incremental housing development conducted through self-help process, usually occurs on traditionally owned lands. Therefore, unlike *barrio* in Caracas and *favela* in Rio de Janeiro[2] where the demarcation between formal and informal parts of the city tends to be clear (Figure 3), *kampung* often occurs as a solid mixture of authorized (formal) and unauthorized (informal) settlements. Such mixture can be traced back in colonial times, when major cities in Indonesia including Yogyakarta was deliberately divided into two urban settlements: the planned and the unplanned. An example of the former, as depicted in Figure 4, is a map of governmental buildings on today Malioboro Street (the CBD of Yogyakarta). The latter (also depicted in Figure 4), is the blank area indicating the unmapped *kampung*. This area usually consists of self-help housing on private or traditionally owned land.

Sustainability of *kampung* in urban Indonesia cannot be separated from the Japanese influence. In the early 1940s, Japanese administration in Indonesia introduced the so-called *tonarigumi* – a neighborhood administrative system consisting of 10 to 20 households (Niessen, 1995; Suwarno, 1995). Sullivan (1986) writes that implementation of neighborhood administrative system in Yogyakarta led to the transformation of 100 *kampung* into *aza*. Each of such *aza* was further divided into several *tonarigumi*.

The post independence of Indonesia (after 1945) saw the continuity of neighborhood administrative system in Yogyakarta. According to Suwarno (1995), Sultan Hamengu Buwono IX changed *aza* into *Rukun Kampung* (RK) and *tonarigumi* into *Rukun Tetangga* (RT)[3]. Sullivan (1986) argues that these organization were designed to be self reliant and operated through community-based approach, yet remained to stay outside the formal governance system. Hence, both RK and RT are not part of the government structure. RK has been changed into RW (*Rukun Warga*)[4] during Suharto's administration, but remains outside the government structure. However, while RT/RW are voluntarily and informally managed, i.e., both the head of RT and RW do not get salary; such organizations have the authority to endorse the application of KTP (Resident's ID Card) to the government at the district (*Kecamatan*) level. Any person who wants to apply for KTP to the district government must first get an approval from the RT head.

Since KTP is an 'access card' to obtain various public services, the authority of RT and RW heads to approve the application of KTP becomes an important aspect in the process of tenure stabilization. Both RT and RW heads can be seen as double agencies, since they manage the formal system yet may represent the voice of residents of informal settlements as long as these residents live within the jurisdiction of such RT/RW. As a result, heads of RT and RW

---

[2] *Barrio* is a term denoting informal settlement in Bolivia, while *favela* is a similar term occurs in Brazil.

[3] *Rukun* literally translated as association. Rukun Tetangga often translated as 'neighborhood association' (see Yoshihara and Dwianto, 2003).

[4] The term *Rukun Warga* – RW (literally translated as Citizens Association) has actually been used in Jakarta and other cities outside Yogyakarta since the 1960s (see Logsdon, 1974).

have the power to negotiate for development assistance from the government to improve the condition of slum, which may lead to the continuity of residents' tenure in the neighborhood. The following case study on *kampung* Tungkak presents an example of such a claim.

Figure 3. Informal and authorized (formal) settlements in Caracas, Venezuela (source: http://www.skyscrapercity.com, accessed on 1 July 2012)

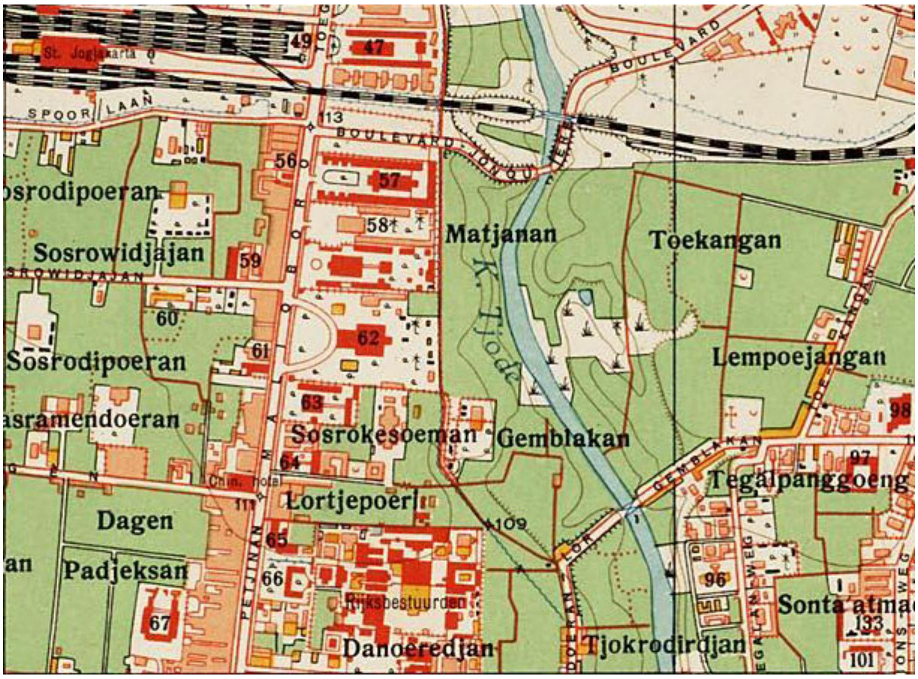


Figure 4. Partial map of Yogyakarta published in 1925 by the colonial government. The map shows part of today's Malioboro – the CBD of Yogyakarta. The blank spaces are the unmapped *kampung* (source: extracted from digital map of Yogyakarta 1925 distributed by the Royal Tropical Institute, 2009).

Kampung Tungkak: encroachment of the abandoned public buildings

Kampung Tungkak is located in Southern Yogyakarta, on the bank of Code[5] River - one of the three rivers that cut across the city of Yogyakarta (Figure 5). The history of this settlement dating back in the early 20th century, when Sultan Hamengku Buwono VIII assigned Zending – a Christian missionary organization, to manage a newly established institution called *Rumah Pakeren Tungkak* (Tungkak House for the Homeless), which was established on the land belonged to the Sultanate of Yogyakarta (Fauzanafi, 2004). Today such type of land is called 'Sultan Ground', which is managed exclusively by the Sultanate of Yogyakarta, and operates outside the government land tenure system.

Since its inception in the early 1900 to the early 1960s, the compound of housing for the homeless consisted of two zones, called Ciptomulyo and Gatitomo (Figure 6). Ciptomulyo was an area for the trainees, while Gatitomo was dedicated for the trainers. This explains the early function of such compound, i.e., to train the homeless people on various skills that enabled them to create jobs. This compound was managed under the support from the local (provincial) government, which provided salary to the management staff and trainers, free daily meals for both trainers and trainees, and free transportation to training sites outside the compound.

An interview to a resident who witnessed the everyday life in the compound since the 1960s suggests that each building within Ciptomulyo zone was not divided into rooms. In other words, each unit measured approximately 9m X 27m is a building with a single open room. The residents had to manage the subdivisions of interior space themselves.

In 1948 – three years after the self-proclaimed independence of Indonesia – the Dutch attempted to retake Yogyakarta (Ricklefs, 2001). The brief war led trainees and trainers fled from the compound to find the safer place and to avoid casualties, since the Dutch military post was established nearby. However, the war lasted only several months as the Dutch withdrawn from Yogyakarta in 1949 (Ricklefs, 2001). The provincial government of Yogyakarta then attempted to transform the deserted compound back to its previous function. The attempt did not turn as expected because the loose supervision could not adequately handle the massive return of former compound residents, during which these returning residents liberally claimed the interior spaces of each building unit for their living spaces.

The freedom of spatial claim within the interior space of Ciptomulyo resulted in spatial disorder, which led the management to impose a tighter control on dwellers' behavior. An example of such control was the construction of barbed wire around the compound (refer to Figure 6) and the improvement of training programs. The increasing demand of training activities led the management to establish a vocational training center called ATPS (*Akademi Teknologi Penilik Sosial* – Technical Academy of Social Advisor), located next to Gatitomo zone (Figure 6).

---

[5] Code is a local term, pronounced 'cho-day'.

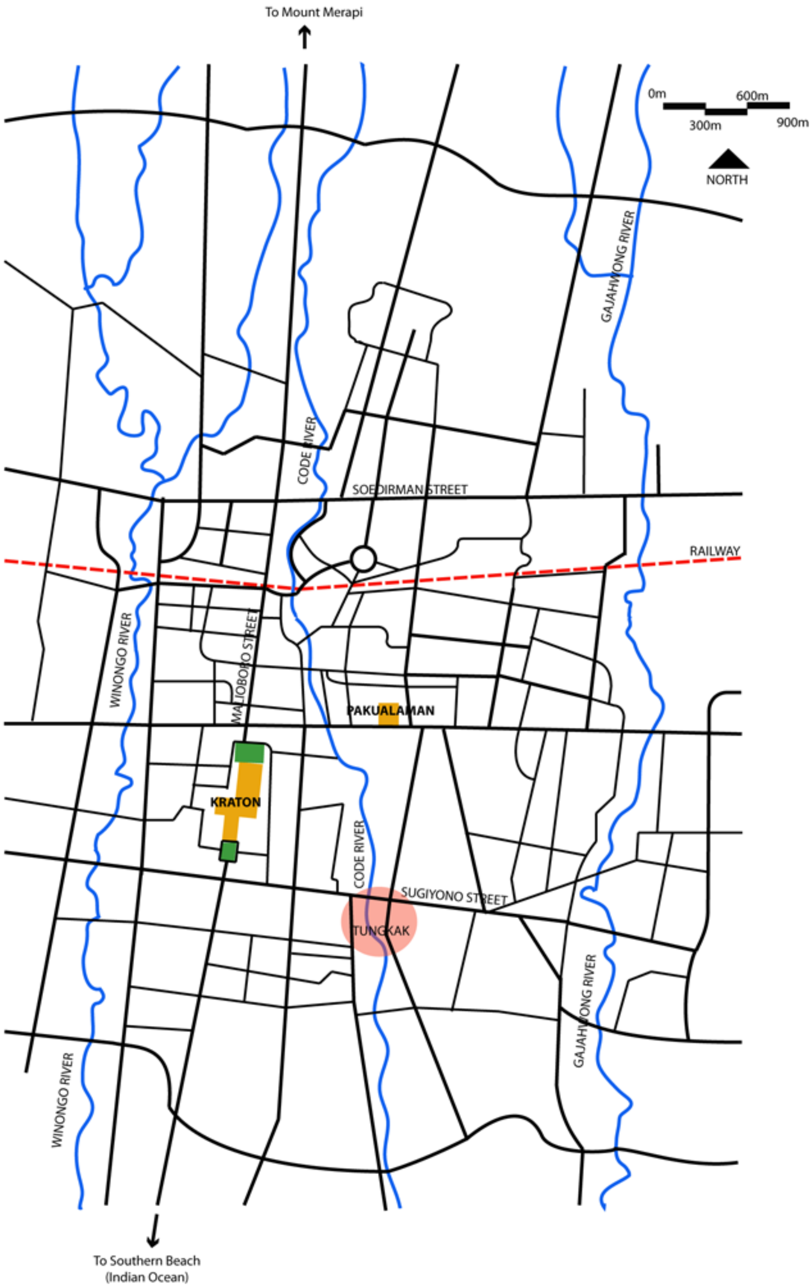


Figure 5. Location of *kampung* Tungkak (source: Yogyakarta Tourism Map (reworked), accessed from www.indonesia-tourism.com, on 10 January 2009)

The decade of 1960s saw three important events: space commodification, the raid of PKI (Communist Party of Indonesia) activists, and termination of funding by the provincial government. The practice of space commodification began when a number of residents decided to join transmigration program. Transmigration was one of the government strategies to balance the population of Indonesia, which was carried through the moving of people from Java, Madura, and Bali to other islands (mainly Sumatra and Kalimantan)[6]. These residents needed capital to join the program because the government support was not sufficient. Therefore, they decided to 'sell' their occupied space to get some

[6] Transmigration program has been discontinued since 1986 (World Bank, 1988).

money. The event marked the early practice of informal property transaction in Tungkak, which continues today.

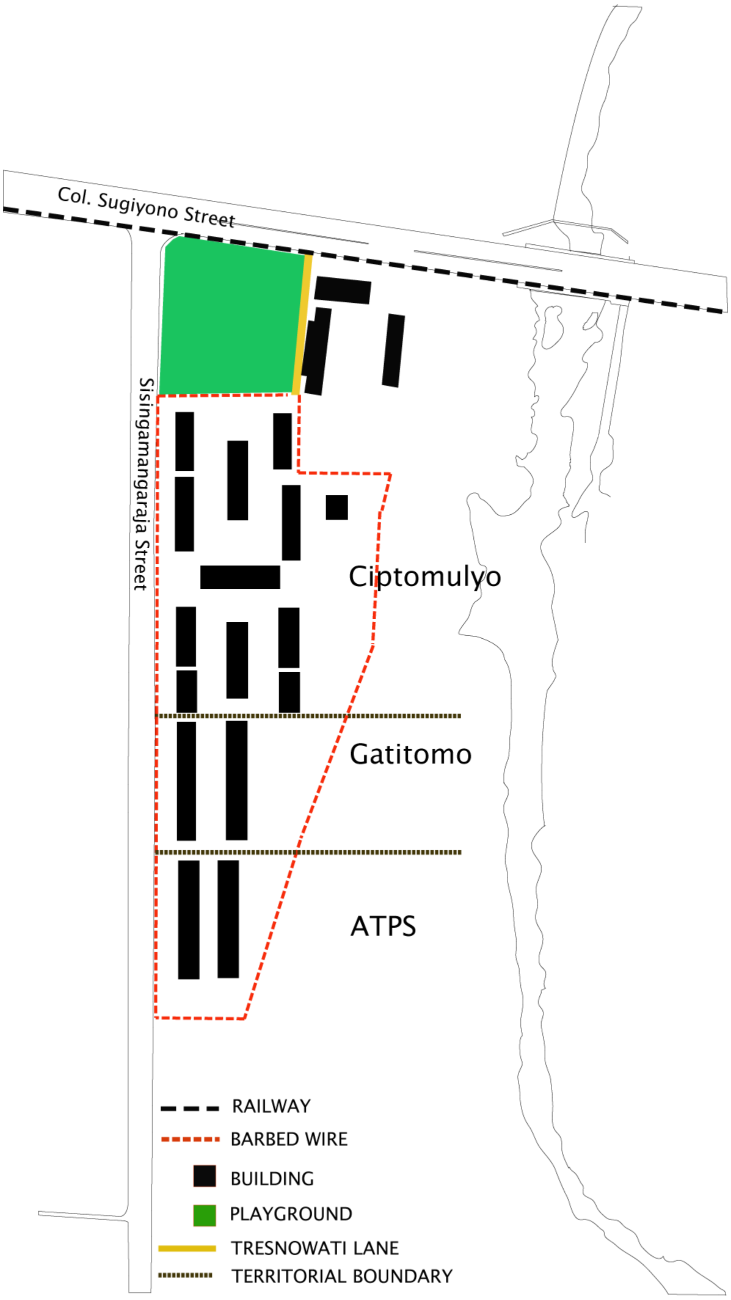


Figure 6. Pre 1970s zoning of the housing compound (source: Raharjo, 2010a).

The termination of funding from provincial government presumably was the worst hit to both residents and management of the compound. In addition, the raid of the accused PKI activists led to the dumping of the arrested people into the compound. These people were often prostitutes and homeless people who had nothing to do with PKI but caught in the raid. They added the existing population to approximately 500 people, far beyond the capacity of the compound. As a result, the management decided to cut the free daily meals and training activities due to the termination of funding mentioned above.

However, it seems that the above number of residents did not last very long as the buildings along Sisingamangaraja Street (see Figure 6) were deserted in the late 1960s and early 1970s, only buildings in the rear were inhabited. It was not clear when exactly people began to re-occupy such deserted buildings, but the interviewee suggested that these buildings were later targeted to accommodate the municipal government staff. In other words, the compound did not function as it was because the people who latter occupied these vacant buildings were not the same group of people, i.e., they were government staff not homeless people.

Authorization of the settlement

The management decided to close the compound in 1976 after a long suspension of funding, leaving the existing residents and the buildings unmanaged and abandoned. While the building belongs to the provincial government, the land belongs to the Sultan (called 'Sultan ground'). As a result, tenure status of the existing residents was ambiguous since they did not belong to any institutions due to the official closing down of the compound. However, the 1972 general election brought an opportunity to the residents to get acknowledged by the government. The government issued KTP (Resident's ID Card) to enable them vote in the election.

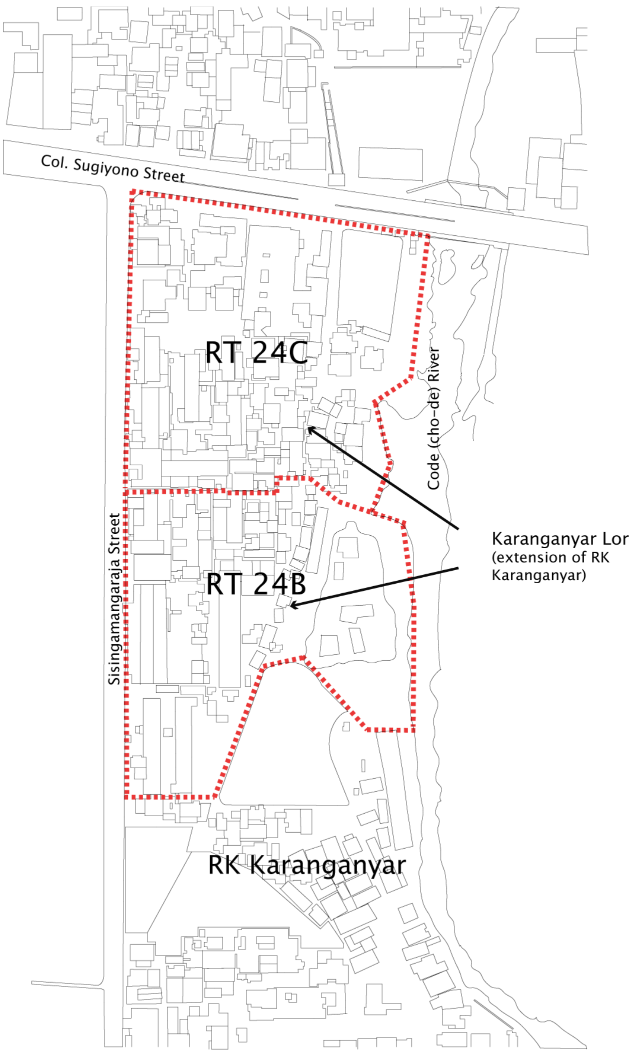


Figure 7. Authorization of homeless housing compound (source: Raharjo, 2010a)

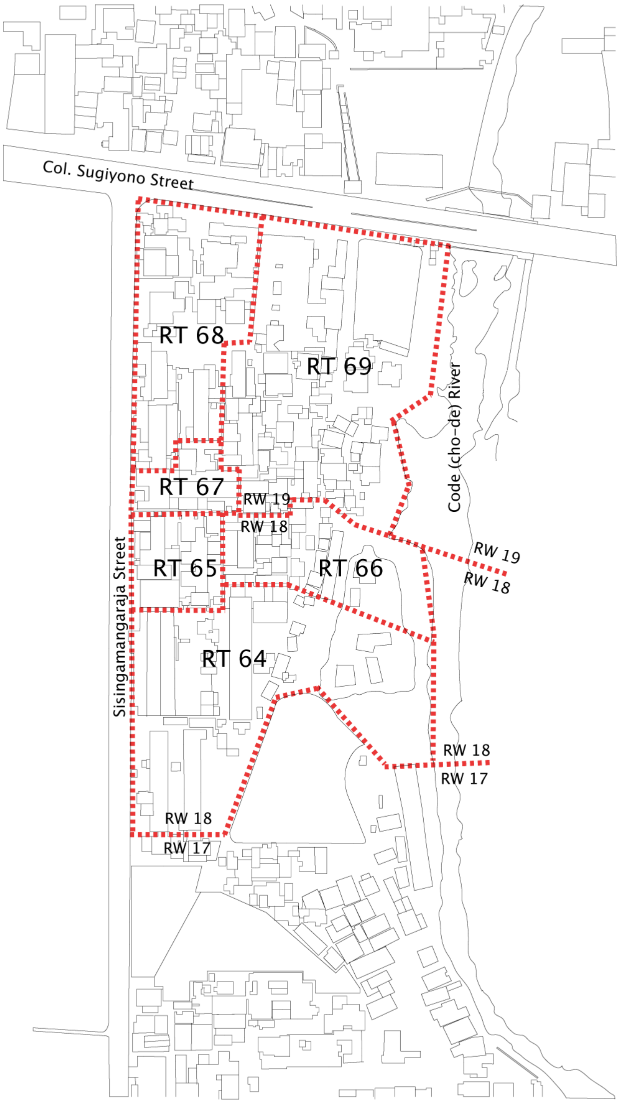


Figure 8. Neighborhood division after the implementation of RT/RW system (source: Raharjo, 2010a)

The practice went further in the 1977 general election as the government formally granted the RT (*Rukun Tetangga* – Household Association) status for the compound residents. The former compound was divided into two RTs, RT24B for Ciptomulyo and RT24C for Gatitomo and ATPS combined. These RTs became part of the existing RK (*Rukun Kampung* – *Kampung* Cluster) Karanganyar (Figure 7). Such amalgamation and authorization of the compound marked the formation of a new *kampung* and the stabilization of tenure of the compound's residents. However, while the government has acknowledged residents' status as the citizens of Yogyakarta, their tenure status remains ambiguous since they have been living in the government's owned buildings that stand on the 'Sultan Ground'. In other words, by law these people have no right to live there after the official closing of the homeless housing compound in 1976.

The second authorization took place in 1989 when the municipal government of Yogyakarta implemented the RT/RW[7] system, which further divided the area into several RTs as depicted in Figure 8. As a result, more number of resident involved in the governance affairs, since each RT has a committee who manages the RT's activities.

To sum up, authorization of homeless housing compound can be seen as a milestone in changing dwellers' status from 'non-citizen' to 'citizen'. Through the granting of KTP (Resident's ID Card) by the municipal government, these people were given the right to vote. While author did not observe directly the relationship between the granting of KTP and tenure stabilization, the sense of permanence of the built environment could be seen as an achievement of greater dweller's confidence in continuing to live at Tungkak.

Formalization of the built environment

As described earlier, formalization occurs when the development of informal settlements involves the role of authority (Guinness, 2009). The homeless housing compound was initially a government's managed accommodation and training facility, thus it was a 'formal' housing compound. However, after the closing of the compound in 1976, dwellers became squatters (informal dwellers) as they had did not have the right to occupy the compound.

Figure 9. New District Government office (photo credit: Muklas Setiawan, 2007)

Figure 10. New housing compound for the former ATPS dwellers (photo credit: author, 2008)

While houses in *kampung* Tungkak are predominantly informal, government involvement in the development of Tungkak has been intense. Survey suggests that such involvement tends to be 'community-driven' instead of 'top-down'. Electricity connections, street paving, and construction of public bathrooms are examples of collective effort in improving the quality of the built environment. There was only one case of eviction, i.e., the eviction of ATPS dwellers (refer to Figure 6) in 2004 because the building was going to be demolished for the construction of a new office for the District Government (Figure 9). Yet the evictees received compensation in the form of new housing

[7] RW stands for *Rukun Warga*, literaly translated as Neighborhood Association. RT/RW system has been formally implemented in Indonesia by New Order regime since 1983, but not until 1989 did the government of Yogyakarta began to adopt it (Raharjo, 2010a).

compound located nearby (Figure 10). In other words, the evictees gained a more stable tenure after they were evicted from ATPS building,

Government intervention in the development was more intense after the 2006 earthquake that hit Yogyakarta and the southern parts of Central Java. The earthquake that killed 6,000 people in Yogyakarta and southern Central Java severely destroyed *kampung* Tungkak and killed nine residents of this *kampung*. Major public buildings in Tungkak, such as the mosque and community hall, collapsed. A number of families became homeless as their houses were destroyed by the quake as well. Residents of Tungkak quickly responded by building temporary shelters for the victims and conducting self-survey to identify the needs for reconstruction of the affected buildings. This community initiative became an avenue to a more organized reconstruction effort supported by the provincial government and the foreign donors.

The impact of such a community-based reconstruction project in creating a better sense of permanence of the built environment was apparent, as the project was not only repaired the destroyed buildings but also constructed new infrastructures (Figure 11) and new public facilities (Figure 12) as identified by the residents during the process of Community Action Planning (CAP). Therefore, the reconstruction project contributed to the continuing existence of this informal settlement and thus maintained the residents' tenure stability.

Figure 11. New paved lane after the reconstruction project (photo credit: author, 2008)

Figure 12. New badminton court with a new youth meeting facility in the background (photo credit: author, 2008)

Conclusion

The definition of secure tenure described earlier in this paper implies that security of tenure is the basic element of livability in any types of settlements regardless of formal or informal. The concept of livability assessment issued by both the Economist Intelligence Unit (EIU) and Indonesian Association of Planners (IAP) included security as an indicator of livability. However, the term 'security' in such concept tends to be seen as protection against the fear of crime and terror. While eviction may be regarded as an act of terror in the eyes of squatters, both versions of livability concept do not mention about it. For squatters, eviction will lead to tenure instability - a common challenge in informal settlements. Consequently the goal these squatters want to achieve is to make their tenure more stable. The case study on *kampung* Tungkak suggests that tenure stability can be seen from the greater sense of permanence of the built environment, which was gained through ‘tenure negotiation’ between residents and the authority in the form of authorization and formalization of *kampung*.

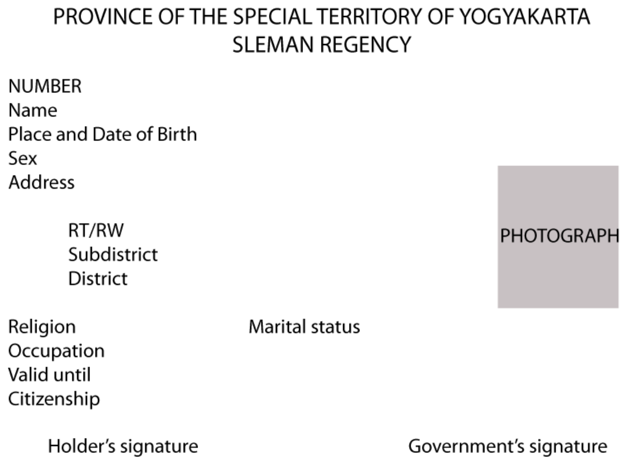


Figure 13. The structure of a KTP (source: Raharjo, 2010b)

Authorization occurred in two forms: legalization of squatters’ identity through the granting of KTP (Resident’s ID Card – see Figure 13), and authorization of settlement’s boundary through the establishment of RT (*Rukun Tetangga* – Households Association). The granting of KTP to the squatters is not the same as legalization of their tenure status, since KTP is not related to the possession of property. However, KTP holder’s address appeared on the card transformed holder’s identity from a squatter to a legitimate resident. Yet such ID card is a prerequisite for accessing various forms of public facilities, such as electricity and water connections[8], which are instrumental in maintaining residents’ livability in the *kampung*. In other words, residents of Tungkak have gained *de facto* tenure.

The establishment of new RTs that turned the homeless housing compound into a ‘normal’ *kampung* further stabilized residents’ *de facto* tenure, since RT is a well-defined organization formed to maintain the neighborhood management, which include solid waste management, KTP application and renewal, payment of electricity bills, and so forth. The role of RT committee in organizing the community to respond to the impact of earthquake disaster was very significant. In fact the decision-making in the government-assisted reconstruction project was a community-driven one. All of these evidences explain how tenure stability assures the livability of the residents of *kampung* Tungkak.

References

Brillembourg, A., Feireiss, K. and Klumpner, H., ed. *Informal City: Caracas Case*. Munich, Berlin, London, New York: Prestel Verlag, German Federal Cultural Foundation, and Urban Think Tank, 2005.

Davis, Mike. *Planet of Slums*. London, New York: Verso, 2006.

---

[8] Application of electricity connection from PLN (Perusahaan Listrik Negara – State Electricity Company) does not require applicants to give evidence of his/her tenure status.

Economist Intelligence Unit, "A Summary of the Liveability Ranking and Overview - August 2011", The Economist www.ieu.com (accessed 1 July 2012).

Evers, Hans-Dieter and Korff, Rudiger. *Southeast Asian Urbanism: The Meaning and Power of Social Space*. Singapore: Insttute of Southeast Asian Studies, 2000.

Fauzannafi, Zamzam. "Sejarah dan Institusionalisasi Kampung Tungkak." *Jurnal Kampung*, no. 1 (2004): 57-87.

Funo, Shuji; Ferianto, Bambang; and Yamada, Kyouta. "Consideration on Typology of Kampung House and Betawi House of Kampung Luar Batang (Jakarta)." *Journal of Asian Architecture and Building Engineering*, no. 136 (2005): 129-200.

Guinness, Patrick. *Kampung, Islam and State in Urban Java*. Singapore, Honolulu: NUS Press and University of Hawai'i Press, 2009.

Ikatan Ahli Perencanaan, "Indonesia Most Liveable City Index 2011", Ikatan Ahli Perencanaan Indonesia www.iap.or.id (accessed 1 July 2012).

Kenworthy, Jeff, "The Kampung Improvement Program (KIP)", Murdoch University http://www.istp.murdoch.edu.au/ISTP/casestudies/Case_Studies_Asia/kip/kip.html (accessed 10 December 2009).

Logsdon, Martha G. "Neighborhood Organization in Jakarta." *Indonesia* 18 (1974): 53-70.

Neuwirth, Robert. Shadow Cities: A Billion Squatters, a New Urban World. New York: Routledge, 2005.

Niessen, Nicole. "Indonesian Municipalities under Japanese Rules." In *Issues in Urban Development: Case Studies from Indonesia*, edited by P.J.M. Nas. Leiden: Research School CNWS, 1995.

Payne, Geoffrey. *Urban Land Tenure and Property Rights in Developing Countries: A Review*. London: IT Publications/ODA, 1997.

Raharjo, Wiryono. "Speculative Settlements: Built Form/Tenure Ambiguity in Kampung Development." (PhD Thesis) University of Melbourne, 2010.

_______________. "Neighbourhood Association and Tenure Stabilisation in Informal Settlement: The Case of Lengkong." *Review of Indonesian and Malaysian Affairs* 44, no. 2 (2010): 49-67.

Ricklefs, M.C. *A History of Modern Indonesia since C.1200*. 3th ed. Stanford: Stanford University Press, 2001.

Sullivan, John. "Kampung and State: The Role of Government in the Development of Urban Community in Yogyakarta." *Indonesia* 41 (1986): 63-88.

Suwarno, P.J. Dari Azazyookai Dan Tonarigumi Ke Rukun Kampung dan Rukun Tetangga Di Yogyakarta (1942 - 1989): Sebuah Tinjauan Historis. Yogyakarta: Penerbitan Universitas Sanata Dharma, 1995.

UN-Habitat. *The Challenge of Slums: Global Report on Human Settlements, 2003*. London; Sterling, VA: United Nations Human Settlements Programme, 2003.

UN-Habitat. *Urban Land for All*. Nairobi: United Nations Human Settlements Programme, 2004.
World Bank. *Indonesia: The Transmigration Program in Perspective*. Washington, D.C: The World Bank, 1988.

Yoshihara, Naoki and Dwianto, Raphaela Dewantari. *Grass Roots and the Neighbourhood Associations: On Japan's Chonakai and Indonesia's Rt/Rw*. Jakarta: PT Gramedia Widiasarana Indonesia, 2003.

Airborne radioactive contamination in urban areas from the nuclear accident in Fukushima

Kazuhiro Toyoda

Hokkaido University, Japan

+81-11-706-4512

+81-11-706-4512

kazuhiro@ees.hokudai.ac.jp

Abstract

After the nuclear accident in Fukushima following the earthquake/tsunami on March 11 2011, many researchers have been investigating the following issues: estimation of the release of some radionuclides from the accident; the dispersion, wet and dry deposition and resuspension of the atmospheric radioactive contamination; the contamination of humans and the internal exposure; measurement and estimation of doses in contaminated inhabited areas; migration of the radionuclides on outdoor surface in the areas: the restoration methodology and reduction of does in contaminated areas. I review latest publication on airborne radioactive contamination from the accident at Fukushima, comparing with the case of Chernobyl accident in 1986. The total release of radioactivity into the atmosphere from the accident is estimated approximately as one-tenth of that from the Chernobyl accident. Three nuclides (Cs-134, Cs-137, I-131) in the fallout are main targets for the countermeasure of the accident. While, Sr-90 and Pu were detectable at a trace level in the airborne contamination.

The internal exposure dose by I-131 and external dose by radiocesium in the habitant of Tokyo metropolitan erea are shown. Some outstanding issues in the urban areas were reported as unexpected consequence of the nuclear accident: highly radioactive sludge and radioactive hotspot. The geochemical behavior of radiocesium is explained to understand the condensation process. Building of repository for radioactively contaminated waste is highlighted for the first priority for the restoration of contaminated inhabitant areas.

Keywords: Fukushima nuclear accident, Chernobyl accident, Cs-137, I-131, Tokyo

Introduction

A large amount of radioactive materials were discharged into the atmosphere during the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in Japan caused by a magnitude-9.0 (Richter scale) earthquake and tsunami on March 11, 2011. Since then, many researchers have been investigating the following issues: estimation of the release of some radionuclides from the accident; the dispersion, deposition and resuspension of the atmospheric radioactive contamination; the contamination of humans and the internal exposure; measurement, screening and estimation of doses in the contaminated areas; migration of the radionuclides on outdoor surface in the areas: the restoration methodology and reduction of does in contaminated areas. Although the most of these topics had already been investigated in the prior cases, e.g., Chernobyl accident in 1986, for many decades

(Anderson, 2009), the investigation on the behavior of airborne radioactive contamination in the environment mainly focused on agricultural and rural areas and food production.

Tokyo metropolitan area, one of the world's largest megacities (population, 30 milion) is located 120-270 km south-southwest of FDNPP and also got hit with the airborne radioactive contamination from FDNPP. Some outstanding issues in the urban areas including Tokyo around FDNPP were reported as unexpected consequence of the Fukushima accident. But these phenomena were explainable by the geochemical behavior of the radionuclides in the environment. In this paper, with comparing to the past publication on the airborne radioactive contamination on land by the severe accident, I review the latest publication on airborne radioactive contamination in urban areas by FDNPP accident from the viewpoint of environmental geochemistry. I hope this review would be a help for constructing countermeasures for radioactive urban disaster.

Radionuclides in nuclear spent fuel

The fuels of nuclear power plants consist of pellets of U-235-enriched (ca. 4%) uranium dioxide or of a mixed oxide of both uranium and plutonium isotopes (MOX fuel). These pellets are stacked in long tubes made of zirconium alloy and the tubes are bundled to form a fuel assembly. Nuclear reactors use the heat mainly produced by nuclear fission of U-235 in the fuel to boil water. The energy released per U-235 fission is about 200 MeV. The thermal heat production of the spent-fuel rods is around 6% of that of the reactor immediately after shutdown. The spent-fuel assemblies are temporarily stored in a water pool of more than a dozen meters deep. At least several years of continuous cooling of the spent fuel rods are then required before transfer to dry steel storage casks.

The fission yields vary as a function of their mass numbers, following a bimodal distribution with atomic mass numbers in the range of 80–110 (krypton, strontium, etc.) and 125–155 (iodine, xenon, cesium, etc.). In spent fuel, there is a significant amount of radioactive fission products: Xe-133 (half-life, 5.3 days); I-131 (half-life, 8 days); Cs-134 (half-life, 2.1 years); Cs-137 (half-life, 30 years); Sr-89 (half-life, 51 days); Sr-90 (half-life, 29 years); Kr-85 (half-life, 11 years), etc. Some longer-lived transuranic nuclides, generated by neutron capture reaction in reactors, are also in spent fuels: Pu-239 (half-life, 24,000 years); Am-241 (half-life, 433 years).

Noble gas fission products (Xe-133, Kr-85) are most easily released from spent fuels, but doesn't deposit on outdoor surfaces. Radioiodine is volatile and is associated with thyroid cancer. Iodine is accumulated in the thyroid gland specifically, whereas caesium is distributed in the human muscle uniformly. The chemical behavior of Cesium is similar with that of potassium and the metal is volatile (melting point: 28˚C). The reported biological half-life of radiocesium in human body varies 60-150 days among publications. Strontium has a chemical behavior similar to calcium and then it may accumulate in bones. The presence of Sr-90 in bones of human body can cause bone cancer, cancer of nearby tissues, and leukemia.

Transuranics (such as Pu-239), alpha emitter radioisotopes, are generally non-volatile. Alpha emitters are an average of about 20 times more dangerous than an equivalent activity of beta emitting nuclides (such as I-131, Cs-137, Sr-90 etc.) Especially, it is thought that plutonium is most dangerous when inhaled and it increases the risk of lung cancer significantly.

Radioactive source in the accident

At the Fukushima accident, three reactors overheated and caused core meltdown, following hydrogen gas explosions and the venting of radioactive contaminated steam. A reactor of the three used MOX fuels. A spent fuel pool was also damaged by another hydrogen gas explosion, but the loss of fuel pool cooling water was restored. The accident released a large amount of radioactive materials into the air. A key difference between the Fukushima accident and the Chernobyl accident was that the Chernobyl explosion shattered the spent fuel, while at Fukushima there was no steam explosion. For example, the larger airborne particulates from the Chernobyl accident had an average nuclide composition (e.g., Ru-103 (half-life, 39 days), Ru-106 (half-life, 368 days)), which was quite similar to that of the reactor fuel after 3 years of burning incident (Choppin et al., 2001).

The estimated percentages of release in radionuclides from Chernobyl core inventory into the atmosphere are as follows: 4% of radiostrontium (Sr-90, Sr-89), 3% of plutonium (Pu-238, Pu-239, Pu-240), 2.9% of ruthenium (Ru-103, Ru-106), while 10% of Cs-134, 13% of Cs-137, 20% of I-131, 100% of noble gas fission products (Xe-133, Kr-85) (Choppin et al., 2001). In contrast, although small amount of radiostrontium and plutonium deposition has been detected around FDNPP, these isotopic ratios (^{241}Pu/^{239}Pu; ^{90}Sr/^{89}Sr) indicate that the most is from the global fallout during the era of atmospheric nuclear weapon test. Besides, in soil samples around FDNPP, ^{129m}Te (half life: 34 days) were determined, and trace amounts of ^{95}Nb, ^{110m}Ag and ^{140}La were detected. But, radionuclides, such as ^{95}Zr, $^{103,\ 106}$Ru and ^{140}Ba that were found in Chernobyl fallout, were not found in these soil samples (Tagami et al., 2011). Thus, target nuclides in airborne radioactive fallout from FDNPP are limited to I-131, Cs-134 and Cs-137 for the countermeasure.

Bowyer et al. (2011) indicated that approximately 12 EBq (x10^{18}Bq) of Xe-133 (half-life corrected to March 11, 2011; hereinafter the same shall apply) was released into the environment. Stohl et al. (2012) also found a total release of 12.2-18.3 EBq (exabecquerel: x10^{18}Bq) of Xe-133, which is at least more than twice as high as the total release from Chernobyl nuclear reactor accident in Ukraine (6.5 EBq: NEA; 2-6 EBq; Ginzburg and Reis, 1991; Bergichev et al., 1990). For Cs-137, Stohl et al. (2012) shown total emission of 36.6 (20.1-53.1) PBq (pentabecquerel: x10^{15}Bq) or about 43 % of the estimated Chernobyl emission of 85 PBq (NEA). But lower values of 10-19 PBq of Cs-137 have also suggested for that (Chino et al., 2011; Winiarek et al., 2012; Yoshida and Kanda, 2012). The ^{134}Cs/^{137}Cs ratio in the Chernobyl fallout in 1986 was in the range 0.5 - 0.6, whereas it was close to 0.9 for the Fukushima fallout. Variation of this ratio was fairly constant with time and place in Japan and Europe (Kinashita et al., 2011; Tagami et al., 2011; Masson et al., 2011). Regarding I-131, Chino et al. (2011) and Winiarek et al. (2012) estimated that 150 PBq and 190-380 PBq, respectively, were released into the atmosphere by the accident. In contrast, the Chernobyl accident released over 1.85 EBq of radioiodine with thyroidal doses among children in the surrounding general population (NCRP, 2008). Dauer et al. (2011) reviewed that the total release of radioactivity into the atmosphere from the Fukushima Daiichi accident (770 PBq) has been estimated as about one-tenth of that from the Chernobyl accident (5.2 EBq).

Atmospheric behavior and deposition of radioactivity

Atmospheric transportation from the radioactive source to urban area can be broken down into dispersion and deposition. Dilution process (dispersion) occurs by radioactive plume depletion and the potential for downwind transport. Atmospheric radioactive concentration is important especially in determining inhalation dose. The deposition process can occur by its direct interaction with a surface (dry deposition) or by its incorporation into precipitation (wet deposition) when it is rain or snow.

Clark and Smith (1988) observed the deposition of radionuclides during the passage of the Chernobyl plume over the United Kingdom. They reported radiogenic Cs was presented in the air mostly as particulate with wet deposition mechanisms dominating. In contrast, I-131 was present as particulate and vapor phase material and then both wet and dry deposition mechanisms were important. In the natural environment, gaseous iodine exists as I_2, HOI, IO, HI, $IONO_2$ and organic iodine (majority CH_3I) in the air. Tschiersch et al. (2009) also reported dry deposition of gaseous radioiodine was significantly higher compared to the particulate cesium deposition onto vegetable leaf in laboratory experiment. In the FDNPP accident, Hsu et al. (2012) and Yamauchi (2012) reported that I-131 and Cs-137 were fractionated during transport, with Cs-137 concentrated in the shallower layer, susceptible to depositional removal, while I-131 moving faster and higher. Probably, it is depend on weather of the time and area.

In Japan, a system for prediction of environmental emergency dose information (SPEEDI) were developed to predict environmental doses from radioactive materials accidentally released from a nuclear plant (Terada and Chino , 2008). From 23 March 2011, SPEEDI data after the FDNPP accident were released to the public. Thus, many researchers have simulated the transport and deposition of I-131 and Cs-137 in areas around FDNPP. Radiometric determination of soil samples around FDNNP was also performed. Radiometric contamination was fairly widespread within the 20-km radius from FDNNP, as well as in a northwestern plume extending to about 50 km. The Cs-134 and Cs-137 deposited concentrations ranged from 1 to 30 MBq/m^2 within the FDNNP plume areas within the 20-km radius from FDNNP and below 300 kBq/m^2 outside the plume and out of the 30-km radius. Kinoshita et al. (2011) show the annual dose can be estimated using the following equation:

$$\text{Annual dose (mSv/y)} = 0.06 \times {}^{137}\text{Cs deposition (kBq/m}^2\text{)}.$$

Conversion factors at 1 m away from the planar source, which estimate external radiation doses from individual radionuclides, with siting these conversion factors and 0.9 as the $^{134}Cs/^{137}Cs$ activity ratio. Cesium mostly stays in the top 5 cm of soil (Tanaka et al, 2012). As the gamma-ray energies emitted from the radiogenic Cs contaminated substance are mainly in the range of 600-800 keV, the attenuation of the gamma-ray intensity through few-cm thick of soil is not so significant.

Putting the Cs-137 deposited concentrations is over 0.5 MBq/m^2 within the FDNNP plume area, annual external dose of habitant in the area should be calculated to be over 30 mSv/y, if they don't evacuate from the area. Incidentally, the International Commission on Radiological Protection suggests that a reference level for the optimum protection of people living in contaminated areas should be acceptable in the 1–20 mSv/y range (ICRP. 2009), with past experience demonstrating that a suitable value in long-term postaccident situations is 1 mSv/y (ICRP. 2007). The area in Japan contaminated with cesium-137 the same levels that caused evacuation around Chernobyl is also about one-tenth as large (von Hippel, 2011).

In Japan, many monitoring points for environmental radioactivity level by each prefecture have been also available. For example, the fallout in March 2011 on metropolitan area (Shinjyuku) of Tokyo is as follows: 29 kBq/m^2 of I-131; 8.5 kBq/m^2 of Cs-134; 8.1 kBq/m^2 of Cs-137 (MEXT, 2011). Although Tokyo metropolitan area is out of the target area of SPEEDI system, 100 x 100 km^2 around FDNNP, on the basis of aircraft and onshore gannma-ray monitoring, radiation dose maps covering East Japan have been uploaded in MEXT websites. Morino et al. (2011) developed the simulation about atmospheric behavior and deposition of radioactive materials from FDNNP including Tokyo area using a chemical transport model. Terada et al. (2012) summarized their previous studies and show the analytical results of atmospheric dispersion of radionuclides at east and central Honsyu-island. They show that ^{137}Cs strongly contaminated the soils in large areas of eastern and northeastern Japan, whereas western Japan was sheltered by mountain ranges. Stohl et al. (2012) estimated 18% of the total fallout of Cs-137 were deposited over Japanese land area. Morino et al. (2011) indicated that approximately 22% of Cs-137 and 13% of I-131 were deposited over land in Japan.

External and internal doses in Tokyo metropolitan area

Substituting 8 kBq/m^2 of Cs-137 as the cumulative surface radioactivity at Tokyo metropolitan area into the above equation, we came up with 0.48 mSv/y of equivalent annual external dose. The value is a half of the permissible value of ordinary times (1.0 mSv/y). Incidentally, annual exposure dose by natural radioactivity is 1-2 mSv/y at ordinary area.

Regarding internal dose by I-131 at the Tokyo metropolitan area, on 23 March 2011, Tokyo Metropolitan Institute of Public Health announced that 210 Bq/kg of radioactive iodine is detected in tap water from a water treatment plant in Tokyo area. They appealed to resist giving tap water to the baby, because the protective-action activity concentration limit (in Bq/L or Bq/kg) on milk and drinking water for baby was 100 Bq/kg (300 Bq/kg for adult). Epidemiologic studies have shown a statistically significant dose–response relationship between the radiation exposure and thyroid cancer, with young children being at greatest risk. The concentration of I-131 in the tap water peaked on 26 March, but it is not detected since 4 May 2011. The contaminations of I-131 were also reported in milk and dairy products (e.g., vegetables, fish) and then they were recommended to refrain to sell out. Tagami and Uchida (2011) demonstrated we are not able to remove I-131 from tap water by boiling.

Murakami and Oki (2012) estimated thyroid doses and health risks resulting from the intake of radioactive iodine in foods and drinking water by the citizens of Tokyo after the Fukushima nuclear accident. The calculated average thyroid equivalent doses without countermeasures from 21 March 2011 were 0.42 mSv in adults, 1.49 mSv in children, and 2.08 mSv in infants. Those with countermeasures were 0.28, 0.97, and 1.14 mSv, respectively. It is supposed that 100 mSv is a judgmental standard for the decision of whether to take KI salt in adequate quantities and at the appropriate time to block thyroidal uptake of radioiodine (Dauer et al., 2011). The estimated average risks of cancer by ingestion of I-131 were 3 $\times 10^{-5}$ for infants, 2 $\times 10^{-5}$ for children, and 0.3 $\times 10^{-5}$ for adults, which were lower than the cancer risks from annual intakes of K-40 (6.2 $\times 10^{-5}$). Owing to the short half-life (8 days), they emphasized that rapid countermeasures are important in reducing intake of I-131.

Migration of radiocesium on surface in urban area

After April 2011, radioactive cesium made news everyday in Japan. The activity and the behavior of Cs-137 and Cs-134 are of particular interest in the environment after the fadeout of I-131 activities. The characteristics of geochemical behavior of Cs ions is as follows: Cesium ion is highly soluble in water; it is easily adsorbed on organic matters; it is selectively fixed in some soil clay minerals; it is less adsorbed on anthropogenic surfaces, e.g., asphaltic pavement.

The solubility of monovalent cations decreases in the order of periodic table; it is due to the change of ionic potential (Mason, 1966).

$$Cs^+ > Rb^+ > K^+ > Na^+$$

But, the selectivity of sorption of cations in clays generally decreases in the order (Bergaya and Lagaly, 2006):

$$Cs^+ > Rb^+ > NH_3^+ > K^+ > Na^+\text{; For smectite clays, } Ba^{2+} > Sr^{2+} > Ca^{2+} > Mg^{2+}$$

Smectite clay exhibited the highest values of the adsorption capacity and the highest affinity for cesium, compared to specific selective adsorption on illite-type clay minerals (e.g., Vejsada et al., 2005; Gil-Garcia et al., 2009). Sorption of trace amounts of radiocesium on illitic-type clay minerals in the natural environment has often been described as largely “irreversible,” as most of the radiocesium becomes fixed in the interlayers between the platelets of the minerals (e.g., Comans and Hockley, 1992). After aging of clay fixed radiocesium, it is very hard to leach out the most of once-adsorbed radiocesium by any leachates (e.g., 7M nitric acid) (Salbu et al., 1994). Analysis of data collected after the Chernobyl accident has shown that ^{137}Cs adsorbed in the top soil layer can remain there for many years (Andersson, 2009).

Organic matter in soil has also large adsorption capacity of cesium ions, but has little selectivity to cesium ions comparing with the other ions. For example, Schimmack et al. (1994) show that at low rain intensities, the organic surface layer of a forest soil (0-4 cm) was an effective sink for deposited cesium, but at high rain intensity (30 mm/h), the 30% rapidly became distributed over an underlaying ca. 15 cm deep layer. Andersson (2009) summarized the investigation on migration of radionuclides including radiocesium deposited on various materials of roofs, walls and paved surface. These results indicate anthropogenic surfaces absorbed significantly less than soils.

In October 2011, newspaper reported that radiation levels as high as those in the evacuation zone around Japan's Fukushima nuclear plant have been detected in a Tokyo suburb. We can say that there should be some clay materials at water catchment area in the “hotspot”. From the geochemical behavior of Cs ions as mentioned above, it is conceivable that the hotspot was created after radioactive cesium carried in rain water became concentrated in clay materials at a broken gutter.

Similarly, radioactive sewage sludge has since turned up at sewage treatment facilities in Tohoku and Kanto areas including Tokyo prefectures. The outdoor surface in urban area is covered with anthropogenic surfaces. Similarly, radioactive materials from the FDNNP flowed into sewage pipes with rainwater and were condensed in activated sludge in sewage plants during sewage treatment. Activated sludge, flock of microorganism, is probably contains clay and then it concentrate radiocesium from a huge amount of effluent water from urban district as a non-point source. The sewage sludge was being burned in incinerators and it caused extremely radioactive ash. Japan government temporary decided to set a temporary disposal limit of 8,000 Bq/kg under which the radioactive sewage sludge could be buried for disposal. In normal times, about 80 percent of sewage sludge nationwide is recycled into cement and fertilizers after it is incinerated into ash. But cement company frequently refuses to accept it since radioactive cesium were found from sludge and ash. So in the polluted area including Tokyo and Yokohama, Large amount of radioactive ash is piling up at many sewage facilities.

Including huge amount of waste (e.g., soil, fallen leaves) generated by countermeasures for reduction of dose in contaminated urban areas, planning to build repositories and manage for radioactive waste is inevitable for restoration strategies of contaminated urban areas. Some examples of a repository for radioactively contaminated waste were already proposed (Andersson, 2009). The repository construction should be sufficient that it does not contribute significantly to the external doze rate in the area. The ecological assessment is required. Mitigation of radionuclide from the waste with rainwater must be prevented with sheet and bentonite. Drainpipe and drain layer should be equipped. The design should be simple, but against erosion.

Acknowledgements

I would like to appreciate to all ICSBE members for the inviting me to this conference and I will express many thanks to Prof.S.Tanaka of Hokkaido Univ. for giving me a chance to make a review on this topic.

References

Andersson KG (2009) Airborne Radioactive Contamination in Inhabited Areas, Volume 15 (Radioactivity in the Environment) Elsevier Science. p368

Choppin G, Rydberg J, Liljenzinb J-O (2001) Radiochemistry and Nuclear Chemistry (3rd- ed) Butterworth-Heinemann, p720

Comans RNJ, Hockley DE (1992) Kinetics of caesium sorption on illite. Geochim Cosmochim Acta 56: 1157–1164

Begichev SN, Borovoi AA, Burlakova EV, Gagarinskyu AYu, Demin VF, Khodakovsky IL, Khurlev AA (1990) Radioactive releases due to the Chernobyl accident, fission product transport processes in reactor accidents. In: Rogers, J.T. (Ed.), Hemisphere Publishing Corporation

Bergaya F, Lagaly G, Vayer M (2006) Cation and anion exchange, in Handbook of Clay Science, Developments in Clay Science, Vol. 1, Edited by Bergaya F, Theng BKG, Lagaly G.

Bowyer TW, Biegalski SR, Cooper M, Eslinger PW, Haas D, Hayes JC, Miley HS, Strom DJ, Woods V (2011) Elevated radioxenon detected remotely following the Fukushima nuclear accident, J Environ Radioact 102: 681–687

Brandt J, Christensen JH, Frohn LM (2002) Modelling transport and deposition of caesium and iodine from the Chernobyl accident using the DREAM model. Atmos Chem Phys 2:397–417.

Clark MJ, Smith FB (1988) Wet and dry deposition of Chernobyl releases. Nature 332:245-249

Chino M, Nakayama H, Nagai H, Terada H, Katata G, Yamazawa H (2011) Preliminary estimation of release amounts of ^{131}I and ^{137}Cs accidentally discharged from the Fukushima Daiichi nuclear power plant into the atmosphere. J Nucl. Sci Technol 48:1129–1134

Dauer LT, Zanzonico P, Tuttle RM, Quinn DM, Strauss HW (2011) The Japanese tsunami and resulting nuclear emergency at the Fukushima Daiichi power facility: technical, radiologic, and response perspectives. J Nucl Med 52: 1423-1432

Gil-Garcia C, Rigol A, Vidal M (2009) New best estimates for radionuclide solid-liquid distribution coefficients in soils, Part 1: radiostrontium and radiocaesium. J Environ Radioact 100: 690–696

Ginzburg, HM, Reis E (1991) Consequences of the nuclear power plant accident at chernobyl. Pub Health Rep 106 (1): 32-40

Hsu SC, Huh CA, Chan CY, Lin SH, Lin FJ, Liu SC (2012) Hemispheric dispersion of radioactive plume laced with fission nuclides from the Fukushima nuclear event. Geophys Res Lett (2012) 39: L00G22

ICRP (2009) Application of the Commission's recommendations to the protection of people living in long-term contaminated areas after a nuclear accident or a radiation emergency: ICRP publication 111. Ann ICRP 39:1–69

ICRP (2007) The 2007 recommendations of the International Commission on Radiological Protection: ICRP publication 103. Ann ICRP. 37:1–332

Kinoshita N, Sueki K, Sasa K, Handa K, Takahashi T, Sato M, Yamagata T. (2011) Assessment of individual radionuclide distributions from the Fukushima nuclear accident covering central- east Japan. Proc Natl Acad Sci U S A 108: 19526-19529

Mason B (1966) Principles of Geochemistry, John Wiley & Sons Inc, p346

Masson O, Baeza A, Bieringer J, et al. (2011) Tracking of airborne radionuclides from the damaged Fukushima Dai-ichi nuclear reactors by European networks. Environ Sci Technol 45(18): 7670-7677

Ministry of Education, Culture, Sports, Science, and Technology (MEXT) (2011), Reading of radioactivity level in fallout by prefecture, Tokyo. [Available at http://www.mext.go.jp/english/incident/1305529.htm.]

Ministry of Health, Labour, and Welfare (2011) Detection of radioactive materials in tap water in Fukushima Prefecture and Tokyo, Tokyo. [Available at http://www.mhlw.go.jp/english/topics/2011eq/dl/march_23_01.pdf]
iichinuclear power plant into the atmosphere. J Nuc Sci Tech 48: 1129–1134

Morino Y, Ohara T, Nishizawa M (2011) Atmospheric behavior, deposition, and budget of radioactive materials from the Fukushima Daiichi nuclear power plant in March 2011. Geophys Res Lett 38: 1-28

Murakami M, Oki T (2012) Estimation of thyroid doses and health risks resulting from the intake of radioactive iodine in foods and drinking water by the citizens of Tokyo after the Fukushima nuclear accident. Chemos 87: 1355-1360

Nuclear Energy Agency (NEA) (2002) Chernobyl: Assessment of Radiological and Health Impacts – 2002 Update of Chernobyl: Ten Years On, Organisation for Economic Co-Operation and Development (OECD) Publications, p155 Paris

Risk to the thyroid from ionizing radiation: NCRP report no. 159. (2008) Bethesda, MD: National Council on Radiation Protection and Measurements

Salbu B, D. H. Oughton DH, Ratnikov AV, Zhigareva TL, Kruglov SV, Petrov KV, Grebenshakikova NV, Firsakova SK, Astasheva NP, Loshchilov NA, Hove K, Strand P (1994). The mobility of Cs-137 and Sr-90 in agricultural Soils in the Ukraine, Belarus and Russia. Health Physics 64: 518-528

Schimmack K. Bunzl F. Dietl DK (1994) Infiltration of radionuclides with low mobility (^{137}Cs and ^{60}Co) into a forest soil. Effect of the irrigation intensity. J Environ Radioactivity 24: 53-63

Sportisse B (2007) A review of parameterization for modeling dry deposition and scavenging of radionuclides. Atmos Environ 41:2683–98

Stohl A, Seibert P, Wotawa G, Arnold D, Burkhart JF, Eckhardt S, Tapia C, Vargas A, Yasunari TJ (2012) Xenon-133 and caesium-137 releases into the atmosphere from the Fukushima Dai-ichi nuclear power plant: determination of the source term, atmospheric dispersion, and deposition. Atmos chem phys, 12: 2313-2343

Tagami K, Uchida S (2011) Can we remove iodine-131 from tap water in Japan by boiling? - Experimental testing in response to the Fukushima Daiichi Nuclear Power Plant accident. Chemos 84: 1282-1284

Tagami K, Uchida S, Uchihori Y, Ishii N, Kitamura H, Shirakawa Y (2011) Specific activity and activity ratios of radionuclides in soil collected about 20 km from the Fukushima Daiichi Nuclear Power Plant: Radionuclide release to the south and southwest. Sci Total Environ 409: 4885-4888

Tanaka K, Takahashi Y, Sakaguchi A, Umeo M, Hayakawa S, Tanida H, Saito T, Kani Y (2012) Vertical profiles of Iodine-131 and Cesium-137 in soils in Fukushima Prefecture related to the Fukushima Daiichi Nuclear Power Station Accident. Geochem J 46: 73-76

Terada H, Chino M (2008) Development of an atmospheric dispersion model for accidental discharge of radionuclides with the function of simultaneous prediction for multiple domains and its evaluation by application to the Chernobyl nuclear accident. J Nucl Sci Technol 45(9); 920–931

Tokyo Metropolitan Institute of Public Health (2011) <http://monitoring.tokyoeiken.go.jp/monitoring/w-past_data.html> (accessed 01.08.11.).

Tschiersch J, Shinonaga T, Heuberger H. (2009) Dry deposition of gaseous radioiodine and particulate radiocaesium onto leafy vegetables. Sci Total Environ 407: 5685-5693.

Vejsada J, Hradil D, Řanda Z, Jelínek E, Štuklík K (2005) Adsorption of cesium on Czech smectite-rich clays—a comparative study. Appl Clay Sci 30: 53–66

von Hippel FN (2011) The radiological and psychological consequences of the Fukushima Daiichi accident. Bulletin of the Atomic Scientists 67: 27-36

Yamauchi M (2012) Secondary wind transport of radioactive materials after the Fukushima accident Earth Planets Space 64: e1–e4

Yoshida N, Kanda J (2012) Tracking the Fukushima Radionuclides. Science 336: 1115-1116

PANEL 1

URBAN DISASTER MITIGATION AND CONFLICT MANAGEMENT

Flood Risks in Coastal Cities and Management Strategies: A Case Study of Soil Consolidation in Jakarta, Indonesia

Md. Anisuzzaman[1], Dicky Muslim[2], Emi Sukiyah[3], Irvan Sophian[4] and M. Reza F. Hasibuan[5]

[1,2,4,5]*Laboratory of Geotechnical Research, Faculty of Geological Engineering*

[3]*Laboratory of Geomorphology and Remote Sensing, Faculty of Geological Engineering*

University of Padjadjaran, Indonesia

E-Mail: anisuzzaman.ru@gmail.com

Abstract

The recent floods in different coastal cities all over the world have shown the devastating effects of large floods on societies and the economy of countries and cities. Climate change and socio-economic trends –such as population growth will increase the impacts of flood risks on global coastal cities if we do not invest in innovative flood risk management strategies**.** Jakarta, the capital city of Indonesia, is one of the most vulnerable coastal cities in the world. This paper provides an overview of how large the city of Jakarta can deal, and is dealing, with the problem of flooding, and how the adaptation strategies can be improved for the future. Research methods used are zonation mapping of Consolidation (Subsidence) and map of flood-affected area. The correlation between the two maps clearly shows that the increase in subsidence enhances the risks of flood in Jakarta and adaptation strategies are also presented. Innovative solutions through combinations with architecture and flood engineering show that measures can be cost effective and add value to the city. For example, by controlling groundwater extraction, rehabilitating waterways, wetlands as buffer areas or by building houses on dikes.

Keywords: *floods, coastal cities, climate adaptation, risk management strategies, groundwater extraction and rehabilitating waterways.*

1. Introduction

1.1. Background

Jakarta, the capital city of Indonesia, is one of the most vulnerable coastal cities in the world. North Jakarta area is bounded by the coast, which extends from east to west. The population residing in Jakarta is increasing every year. With the increasing population growth in Jakarta, the development in coastal areas is also growing very rapidly. Development in Jakarta includes the addition of the settlement, tourist attractions, fisheries, ports, and so forth. Another impact of the growing number of population in Jakarta is the excessive use of groundwater.

Jakarta is often faced with one of its main problems, namely floods. In fact, the disaster that often occurs in Jakarta has taken place since several hundred years ago. Research Center for Geotechnology LIPI explained that the floods that hit Jakarta have occurred since long time ago. Recorded largest floods ever occurred in Jakarta in 1621, 1654 and 1725. Meanwhile, most major flood occurred in 1918, which is a result of forest logging for tea plantation in Puncak. At that time, flooding caused many human casualties and property. That flooding hazard made the Dutch government to plan to prevent flood hazards in Batavia. That prevention plan became known as "Herman van Breen Strategy" (1920–

1926), according to the name of the flood prevention team leader in Batavia at the time, meneer van Breen.

A type of flood hazard that often occurs in Jakarta is called tidal flood, a flooding that caused by high tides. These floods occur because of subsidence of the ground surface. Subsidence in Jakarta occurs due to the consolidation of soil. It cannot be separated from the increasing number of regional development in Jakarta. The load of buildings impacts high pressure for soil. Thus, it leads to consolidation. In addition, excessive use of groundwater also gives a role for consolidation occurrence. This event is further exacerbated by poor drainage system in Jakarta.

Flooding in Jakarta gives a lot of harm. Several effects of the disaster were the emergence of disease outbreaks, deaths, costly loss of the economic sector, and so forth. According to Media Indonesia, the floods in the year of 2007 - which is part of the 5-year flood cycle assumption - happened at about 70 points in Jakarta, caused death of 57 people and about 398 thousand people evacuated. In addition, this disaster was caused losses up to ± 8 trillion rupiah. As a city that becomes the center of economic progress and as a state government, the impact of this disaster will surely give a very big problem.

Therefore, the mitigation plan is required to reduce or even prevent flooding in Jakarta. For mitigation planning, geology has a very good role. One of the great countermeasures of flood is to make the infiltration wells and the addition of a green area so that water can be absorbed quickly.

Regional planning also needs to be done correctly because most of Jakarta composed by alluvial deposits that are susceptible to high pressure. That way, the environment will be improved safety. It will also prevent the emergence of large number of victims.

1.2. Location of the study area

The study focused on the points in the area of North Jakarta to find out the details of the decline in soil surface (subsidence) and its relation with flooding area.

1.3. Physiography of Jakarta basin

Jakarta basin is located in the Lowlands of Jakarta Beach. This zone occupies the northern part of West Java, stretches from west to east starting from Cirebon up to 40 km long. This zone is dominated by alluvium deposits, beach deposits and mud flows and the products of Quaternary volcanic activity (Van Bemellen, 1949).

The Jakarta area is relatively flat with topographical slopes ranging between 0° and 2° in the northern and central part, and up to 5° in the southern part. The southern area has an altitude of about 50m above mean sea level. There are 13 natural and artificial rivers flowing through Jakarta, of which the main rivers are Ciliwung, Sunter, Pasanggrahan, Grogol and their tributaries, which forms the main drainage system of Jakarta (Abidin et al 2001). The Jakarta area is dominated by the northern floodplain deposits, Beach and Beachridge Deposits, Mangrove Swamp Deposits, and the Nearshore and Shallow Marine Deposits. Therefore, the soils in this area have a relatively soft character.

Jakarta is located on a groundwater basin, known as the Jakarta Groundwater Basin. The base of the aquifer system is formed by impermeable Miocene sediments which also cropped out at the southern boundary of the basin.

The basin fill consists of marine Pliocene and Quaternary sand and delta sediments of up to 300 meter thick. Individual sand horizons are typically 1 – 5 m thick and comprise only 20% of the total fill deposits. Silts and clays separate these horizons. Fine sand and silt are a very frequent component of these aquifers (Djaja, R. et al. 2004).

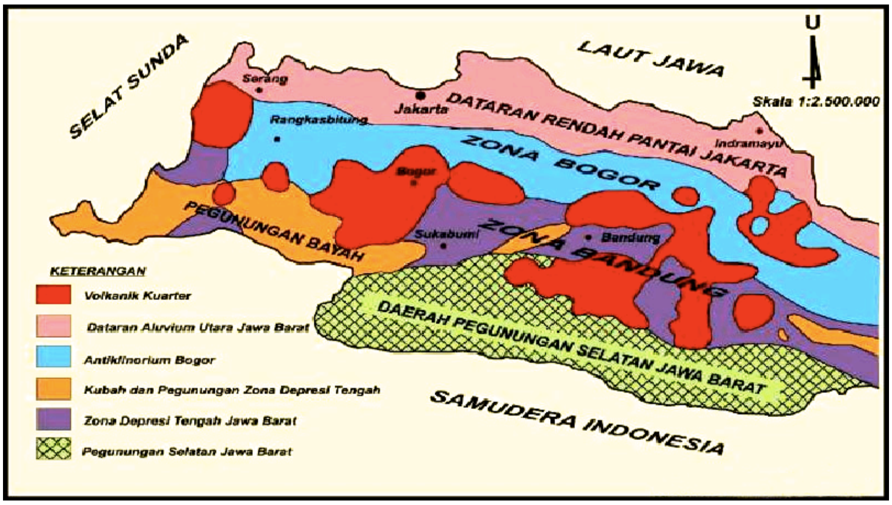


Figure 1.1. Physiographic Map of West Java (Modified after Van Bemmelen, 1949)

2. Methodology

Research methods used are zonation mapping of Consolidation (Subsidence) and map of flood-affected area. The correlation between the two maps clearly shows that the increase in subsidence enhances the risks of flood in Jakarta even the sea level remains unchanged.

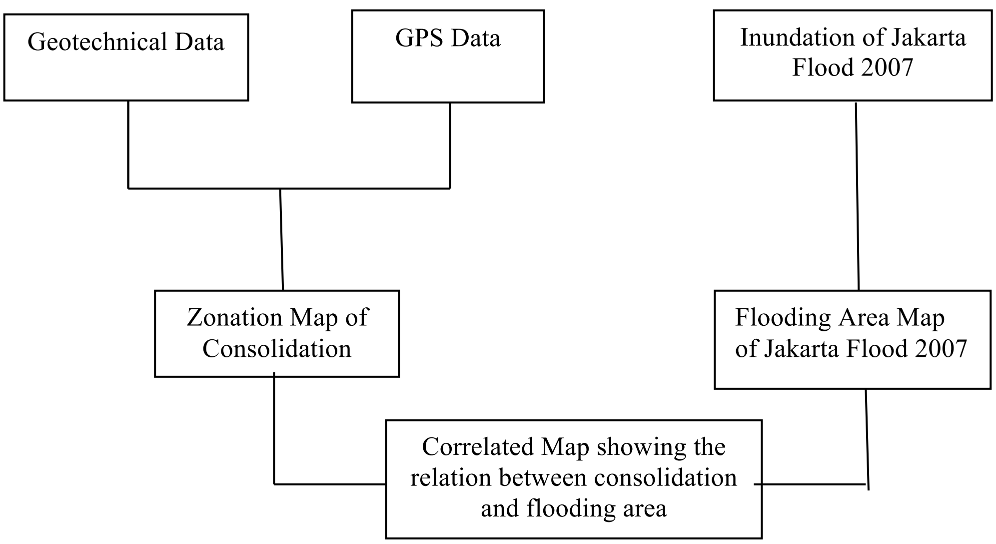


Figure 2.1. Flowchart of the research methodology used

3. Result and discussion

3.1. Zonation mapping of Consolidation (Subsidence)

The research was conducted along the northern Jakarta, namely Cakung, Sunter, Muara Angke, Tanjung Priok, West Semper, and Pantai Indah Kapuk. The focus of this research was conducted on the native soil, which are deposited in the sampling site and not a transported soil. The data in this study obtained from the results of fieldtesting of undisturbed soil sampling and laboratory testing to determine the geotechnical conditions of soil.

A) Water Content, Unit Weight and Specific Weight

Water content test, which performed on the samples of undisturbed soil is meant to get the unit weight of the sample contents; both are the wet unit weight, as well as the dry unit weight. Meanwhile, the specific weight test is used to determine the condition of the soil density.

Table 3.1 Water content, unit weight and specific weight of samples

No.	Sample	Sampling site	Water Content ω (%)	Unit Weight γ (gr/cm3)	Specific Weight γs (g/cm³)
1	TS. 04A	Cakung	46.16	1.69	2.48
2	TS. 04B	Cakung	33.56	1.85	2.59
3	TS. 05	Sunter	82.87	1.45	2.48
4	TS. 08	Wdk. Muara	73.09	1.54	2.56
5	TS. 09	Mr. Angke	33.00	1.83	2.57
6	TS. 13A	Tj. Priuk	56.02	1.51	2.40
7	TS. 13B	Tj. Priuk	46.93	1.65	2.68
8	TS. 14A	Pnt. Kapuk	46.81	1.61	2.49
9	TS. 14B	Pnt. Kapuk	56.12	1.53	2.40
10	TS. 18	Semper Brt.	50.71	1.62	2.64
11	TS. 19	Pedongkelan	55.92	1.62	2.55
12	TS. 24	PIK 1-1.3 m	50.58	1.67	2.74
13	TS. 25B	PIK 2.5 m	93.87	1.45	2.64
14	TS. 25C	PIK 3.5 m	63.78	1.53	2.67

B) Consistency and Plasticity:

Consistency of the soil is defined as a physical condition of a fine-grained soil at a certain water contents, while the plasticity is a characteristic of fine-grained soil (clay) which is very important. Plasticity describes the ability of soil to deforming at a constant volume without cracks or crumbs.

The majority of soil samples have a high liquid limit values with the average value of more than 100%. It indicates that the samples contain unfavorable engineering properties, weak, and hard compacted.

On the plastic limit analysis, the value of each sample is obtained fairly even. These values are in the range of 28% to 42%, where the TS. 24 (Pantai Indah Kapuk) are obtained to be sampled as the highest value, that is to say 41.15%.

Based on the plasticity index analysis, the entire sample has a value of more than 17%. Based on the classification of the value of soil plasticity index by Braja M. Das, all samples belonging to the high plasticity cohesive clay.

Table 3.2 Mean of Consistency and Plasticity Parameters (Plasticity Limit, Liquid Limit & Plasticity Index)

No	Sample	Sampling Site	PL	LL	IP
1	TS. 04A	Cakung	28.61	75.35	46.74
2	TS. 04B	Cakung	29.50	68.42	38.92
3	TS. 05	Sunter	37.93	131.39	93.47
4	TS. 08	Wdk. Muara	38.42	87.72	49.30
5	TS. 09	Mr. Angke	37.43	107.60	70.16
6	TS. 13A	Tj. Priuk	39.71	133.42	93.71
7	TS. 13B	Tj. Priuk	26.67	79.94	53.27
8	TS. 14A	Pnt. Kapuk	36.09	98.60	62.51
9	TS. 14B	Pnt. Kapuk	30.04	106.76	76.72
10	TS. 18	Semper Brt.	29.79	105.49	75.69
11	TS. 19	Pedongkelan	30.99	96.00	65.02
12	TS. 24	PIK 1-1.3 m	41.15	104.41	63.26
13	TS. 25B	PIK 2.5 m	28.93	73.41	44.48
14	TS. 25C	PIK 3.5 m	37.23	115.21	77.98

With the acquisition of these values, the soil types can be known. The following table is the types of soil based on **USCS** classification.

Table 3.3 Soil types at sampling site based on **USCS** classification

No	Sample	Sampling Site	Coordinate		Group Symbol
1.	TS. 04A	Cakung	06° 08' 98.0"	106° 55' 44.8"	CH
2.	TS. 04B	Cakung	06° 08' 98.0"	106° 55' 44.8"	CH
3.	TS. 05	Sunter	06° 08' 65.7"	106° 53' 07.4"	CH
4.	TS. 08	Wdk. Muara	06° 07' 03.7"	106° 47' 68.0"	MH
5.	TS. 09	Mr. Angke	06° 06' 47.2"	106° 46' 15.5"	CH
6.	TS. 13A	Tj. Priuk	06° 06' 38.8"	106° 52' 44.7"	CH
7.	TS. 13B	Tj. Priuk	06° 06' 38.8"	106° 52' 44.7"	CH
8.	TS. 14A	Pnt. Kapuk	06° 06' 26.8"	106° 44' 11.8"	CH
9.	TS. 14B	Pnt. Kapuk	06° 06' 26.8"	106° 44' 11.8"	CH
10.	TS. 18	Semper Brt.	06° 07' 93.0"	106° 55' 73.2"	CH
11.	TS. 19	Pedongkelan	06° 10' 21.3"	106° 52' 85.2"	CH
12.	TS. 24	PIK 1-1.3 m	06° 07' 30.7"	106° 45' 29.1"	CH
13.	TS. 25B	PIK 2.5 m	06° 06' 92.7"	106° 44' 13.6"	CH
14.	TS. 25C	PIK 3.5 m	06° 06' 92.7"	106° 44' 13.6"	CH

Based on table 3.3, the entire sample is a type of high plasticity soil that is easy to be reformatted without making cracks or crumbs.

C) Consolidation:

Consolidation test in the laboratory produces multiple values, including:
1. Compression index (C_c);
2. Swell index (C_s);
3. Preconsolidation stress (σ);
4. Coefficient of Consolidation (C_v)

Table 3.4 Consolidation Test Results

No	Sample	Sampling Site	C_c	C_s	C_v
					(cm^2/det)
1.	TS. 04A	Cakung	0.3166	0.0637	0.00056
2.	TS. 04B	Cakung	0.3789	0.0758	0.00054
3.	TS. 05	Sunter	0.8366	0.1465	0.00050
4.	TS. 08	Wdk. Muara	0.4188	0.0696	0.00065
5.	TS. 09	Mr. Angke	0.2540	0.0423	0.00067
6.	TS. 13A	Tj. Priuk	0.5969	0.0833	0.00042
7.	TS. 13B	Tj. Priuk	0.5305	0.0975	0.00050
8.	TS. 14A	Pnt. Kapuk	0.3798	0.0772	0.00065
9.	TS. 14B	Pnt. Kapuk	0.5162	0.0749	0.00048
10.	TS. 18	Semper Brt.	0.5721	0.1043	0.00052
11.	TS. 19	Pedongkelan	0.2415	0.0483	0.00059
12.	TS. 24	PIK 1-1.3 m	0.3977	0.0986	0.00066
13.	TS. 25B	PIK 2.5 m	0.6112	0.0660	0.00048

With the C_c value in the range of 0.15 - 1.0, the soil should be classified as medium clay – soft clay. It can be inferred by looking at table 3.5.

Table 3.5 Range of Compression Index of any soil types (source: Santosa, 1998, Mekanika Tanah Lanjutan, Chapter 2 pg. 36)

Soil Type	Cc
Dense sand Undense sand	0.0005 - 0.01 0.025 - 0.05
Slightly spongy clay Spongy clay	0.03 - 0.06 0.06 - 0.15
Medium clay – soft clay	0.15 – 1.0
Organic soil Rock	1.0 - 4.5 0

In the analysis of consolidation, the values that were obtained earlier become the parameters that affect the soil surface decreased due to consolidation. These parameters are, among others:

- Void ratio (γ)
- Initial pressure
- Total pressure
- Thickness of the layer (h)
- Compression index (Cc)
- Coefficient of consolidation (Cv)
- Consolidation Settlement (δc)
- Time (t)
- The time factor (Tv)
- The degree of consolidation (U)

There are three steps of the calculation to obtain the value of the settlement due to consolidation for 1 year.

a) Calculation of consolidation settlement

The formulas and equations that used in the calculation of consolidation settlement analysis in table 3.6 can be seen as follows:

$$Po = H - (\gamma s - \gamma w)$$

$$\delta c = \frac{Cc.H}{1 + eo} \log \frac{\sigma' zf}{\sigma' zo}$$

b) Calculation of the amount of time required for the final consolidation

On the calculation of the amount of time required for the final consolidation, the parameters are thickness of the layer, the degree of consolidation, the time factor, and coefficient of consolidation.

On this calculation, the degree of consolidation is considered to have value 90% so that the time factor has a value of 0848 (see table 3.7). The formula used in the calculation of the table 3.6 to get the value of time (t) in units of seconds, namely:

$$t = \frac{Tv}{Cv} \times H^2$$

Table 3.6 Calculation of the length of time it takes to achieve a reduced rate

Sample	Soil Layer Thickness *H* *(Cm)*	Degree of Consolidation *U* *(%)*	Time Factor T_v	Coefficient of Consolidation C_v	Time *t*		
					Second(s)	*Day(s)*	*Year(s)*
TS. 04A	3000	90	0.848	0.00056	13628571429	161094.22	441.35
TS. 04B	3000	90	0.848	0.00054	14133333333	167060.68	457.70
TS. 05	3000	90	0.848	0.00050	15264000000	180425.53	494.32
TS. 08	3000	90	0.848	0.00065	11741538462	138788.87	380.24
TS. 9	1000	90	0.848	0.00067	1265671642	14960.66	40.99
TS. 13A	1000	90	0.848	0.00042	2019047619	23865.81	65.39
TS. 13B	1000	90	0.848	0.00050	1696000000	20047.28	54.92
TS. 14A	2000	90	0.848	0.00065	5218461538	61683.94	169.00
TS. 14B	2000	90	0.848	0.00048	7066666667	83530.34	228.85
TS. 18	1000	90	0.848	0.00052	1630769231	19276.23	52.81
TS. 19	2500	90	0.848	0.00059	8983050847	106182.63	290.91
TS. 24	2000	90	0.848	0.00066	5139393939	60749.34	166.44
TS 25B	2000	90	0.848	0.00048	7066666667	83530.34	228.85
TS. 25C	2000	90	0.848	0.00049	6922448980	81825.64	224.18

Table 3.7 Relationship between the average degree of consolidation (U) and time factor (Tv)

U (%)	Tv
20	0.031
40	0.126
50	0.197
60	0.287
80	0.565
90	0.848

c) Calculation of consolidation settlement during one year

This step is the last step of calculations. The parameters of the consolidation settlement during one year are thickness of layer, the coefficient of consolidation, time, time factors, the degree of consolidation, and total settlement.

Calculation results of this stage can be seen in the table 3.7. Meanwhile, formulas and equations used in the table are:

$$Tv = \frac{t}{H^2}.Cv$$

$$U = \sqrt[2]{\frac{4Tv}{3,14}}$$

- where is consolidation settlement for 1 year = Tv. δ_{total}

Formula to obtain the value of Tv as can be seen above, is determined by the degree of consolidation that is worth less than 60%. Unit value of time (t) is seconds.

4. The Relationship between Each Parameter

Some aspect or parameter contained in the calculations of consolidation before it has a relationship with one another. The relationship between these aspects can be described in graphical form. Some of these relationships, among others:

a. The Relationship between void ratio and total pressure

This graph on figure 3.1 describes that if the total pressure increases, the value of void ratio will shrink. Trend line that extends at figure 3.1 moves very significant. This can be seen from the "swift" moves downward trend line.

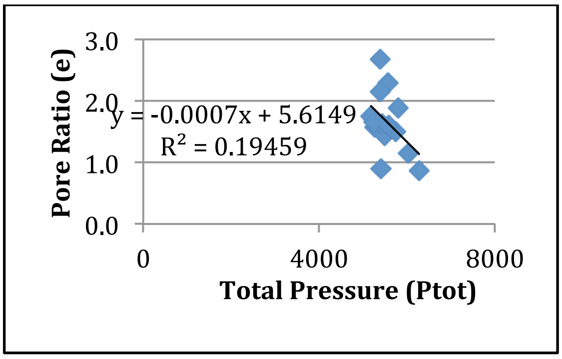


Figure 3.1. Scatter chart of relationship between pore ratio (e) and Total Pressure (σ_{tot})

It is clearly described that if the greater the pressure received by the ground, then the cavity between the pores will be closer to each other due to compaction by the pressure. Therefore, the void ratio will shrink when the pressure received greater.

b. The Relationship between Void Ratio and Consolidation Settlement

The graphics on fig. 3.2 describes the relationship between void ratio and the settlement of consolidation. Linear trend line gets rise when it moves further to the right. It indicates that the greater void ratio, the greater the soil settles.

It indicates that a large value of void ratio means the settlement will be easier to proceed. It describes that the large value of void ratio indicates that the soil is unsettled. Therefore, soil will be settled when the cavity between every particles move closer to each other.

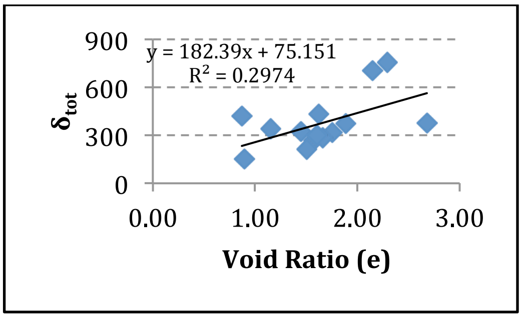


Figure 3.2. Scatter chart of relationship between pore ratio (e) and settlement consolidation (δ_{tot})

c. Compression index and a decrease in total

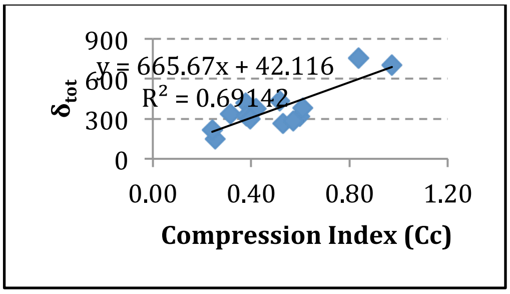


Figure 3.3. Scatter chart of relationship between compression index (Cc) & settlement consolidation (δ_{tot})

There is a similarity with the graph 3.2 which is the trend line that extends from left to right be significantly rises. It indicates the greater the compression index, then the settlement would be even greater.

The compression index represents the degree of soil compressibility; therefore the settlement will be exacerbated because of the large compression index value.

5. Processing of zonation map of consolidation by Using Software Surfer

Basically, this software plots between sampling site location with the values of settlement during one year of each tested sample. Every point that has had value of settlement, interpolated by a geostatistical method, kriging, so that the application of spatial structure with a probabilistic model of the contours can be obtained.

Kriging is considered to be the most capable method to show the probability of subsidence appearance of the Jakarta's soil surface because it calculates the spatial correlation from each of data points, also between the data points with a point/block that will be estimated.

After the appearance of one-year subsidence of the soil surface is obtained by using this method, interpretation performed by dividing soil into five groups. Five groups, among others, is very low (<1 cm), low (1-2cm), moderate (2-3cm), high (3-4cm), and very high (> 4 cm). Zoning that has been done to interpret, and then converted into maps.

6. Interpretation of Soil Geotechnical Condition Based on the appearance of decline Consolidated Zoning Map for 1 Year (2010-2011)

Based on the Zoning Map decline Consolidation over 1 Year (see attached), it can be concluded that further to the north, the rate of decline occurring soil surface is increasing. Under such conditions, caused by two main factors, among others:

1. Pore Water Pressure

Jakarta coastal area has rapid sedimentation process so that pore water pressure becomes higher. This process at every strata will reduce the effective pressure resulting soils that are normally consolidated. In this case, if the pressure of the loads on it (overburden) is increased, the levels of salinity of pore water will decrease rapidly.

2. Soil Desiccation

Samples that are taken in the sampling site are located close to the ground below the surface, so the soil will begin to dry when the surface of sediment deposition is open and have a direct contact with air. Water will seep from the soil profile deeper into the capillary to the surface caused by the loss of a number of water due to evaporation. This effect appears due to the reduced capillary pore water pressure until it becomes negative, which further led to increase the working effective pressure.

Both of the factors above led to the increase of effective stress. High effective stress caused a further consolidation and result in an increase in shear strength of soil.

Because of the location of the research is a salty water environment, it produces deposits that has a specific orientation of the flocculation structure. The combined effect of high-speed flocculation and sedimentation of it resulted a fenceless and also the formation of an unstable soil structure, which in turn has very high water content.

Near shore areas get a greater pressure than the area that far from the coast due to seawater intrusion in coastal areas of Jakarta. A thing like that happen because of the specific weight of seawater is higher than the specific weight of ground water. It caused the pressure that received by Jakarta coastal areas are larger than the area that are far away from the beach. Therefore, the northern Jakarta area (the coast) have a greater consolidation than in the southern region.

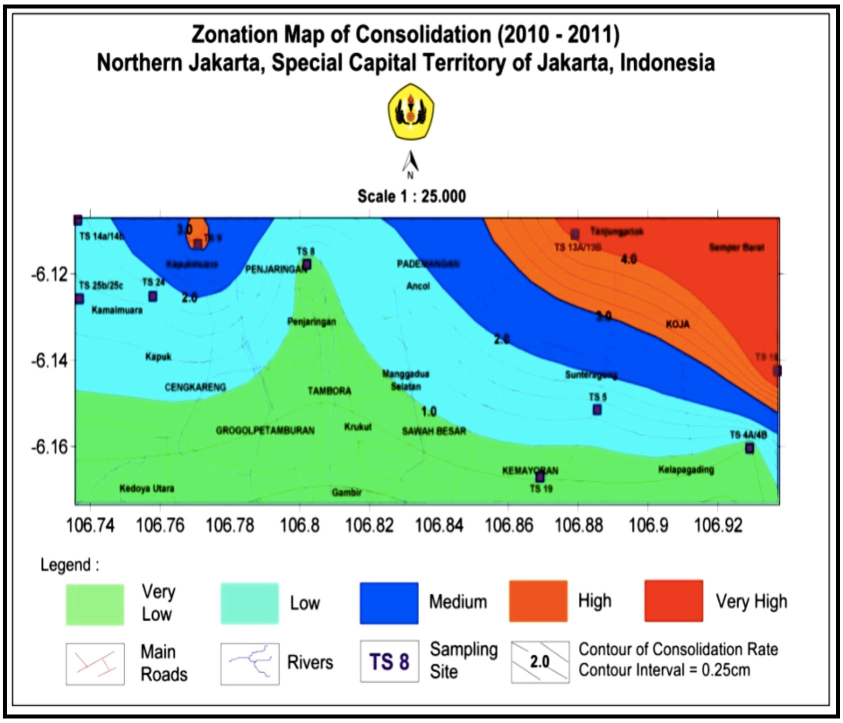


Figure 3.4. Zonation Map of Consolidation (2010-2011)

3.2. Map of flooding Area of Jakarta

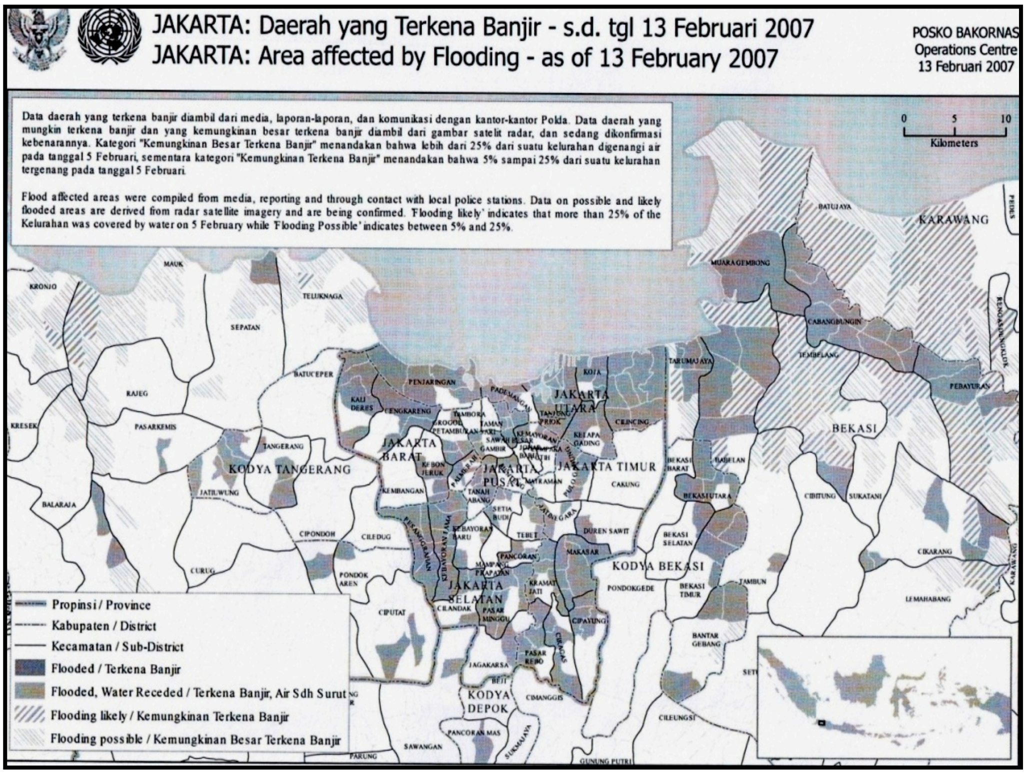


Figure 3.5. Flooding area map of Jakarta, 2007(source: Posko Bakornas Operations Centre, 2007)

Jakarta flood 2007 hits Jakarta and surrounding areas since February 1, 2007 night. In addition to poor drainage system, flooding from heavy rain began which lasted from the afternoon of February 1 until the next day on February 2, plus the amount of volume of water that crosses 13 rivers originating from the Bogor Jakarta-Puncak-Cianjur, and also high tides, resulting in nearly 60% of the Jakarta area flooded with depths reaching up to 5 meters at some point location of the flood. Figure 3.5 shows the flood-affected areas of Jakarta during the devastating flood in 2007.

3.3. Correlation between the Zonation Map of Consolidation (Subsidence) and the Flooding Area Map

The correlation between the above two maps (the zonation map of consolidation and flooding area map of Jakarta, 2007) clearly shows (figure 3.6) the relation between the consolidation (subsidence) and the area of flooding. The relation shows that the more consolidation (subsidence) occurs the more area goes under flood water even the sea level remains the same.

Table 3.8 shows the result of consolidation (subsidence) and sea level rise (source: Illustration of topography of Jakarta, modified after Heri Andreas, Geodesy, ITB, 2011)

No	Year	Area under MSL	Area above MSL	Total	Percentage
1	2000	3287.3 Ha	61352.5 Ha	64639.8 Ha	5.1
2	2007	5483.6 Ha	59156.14 Ha	64639.8 Ha	8.5

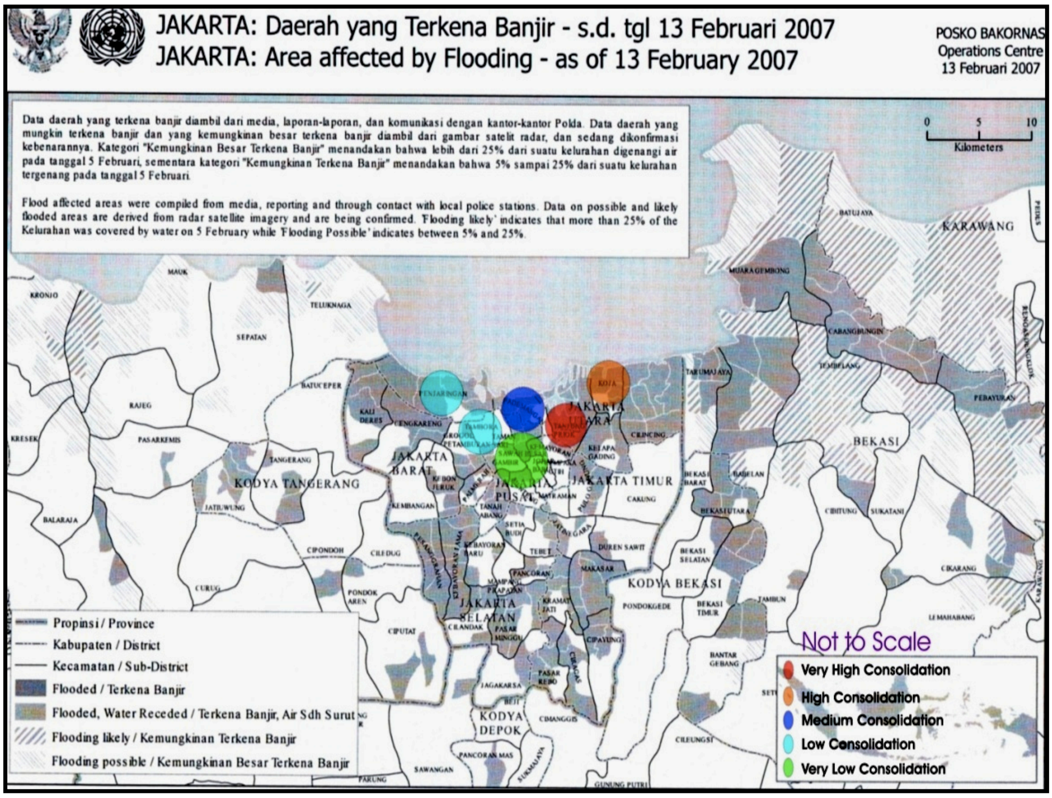


Figure 3.6. The relation between the consolidation (subsidence) and area of flooding

4. Management Strategies

Considering the present status of flooding in Jakarta with the special emphasis on soil consolidation (subsidence) the following management or mitigation strategies can be suggested:

1. Controlling Groundwater Extraction: As excessive groundwater extraction is one of the major causes of land subsidence, there must have groundwater extraction regulation so that the excessive extraction of groundwater can be controlled.
2. Land use planning: Land use change is another cause of land subsidence which has an ultimate relation with flooding in Jakarta. Thus, land use planning is essential as a mitigation way.
3. Restoration of Wetlands as buffer area: Sea water intrusion has a significant impact on land subsidence in Jakarta, restoring the wetlands can prevent the intrusion of sea water.
4. Rehabilitating water ways: Studies show that the most beneficial step for flood mitigation in Jakarta is to rehabilitate the city's flood management system back to its original design capacity. In addition to dredging, flood mitigation would also benefit from routine operation and maintenance.
5. Developing Seawalls along the coast: High tide also causes sea water flooding in Jakarta. The embankments on Jakarta's coast are 300 centimeters high and High tides have been recorded to reach 250 centimeters and it could get worse. To anticipate this tidal flooding in Jakarta the city would raise the embankments over the next few years.
6. Building houses on dikes: In flood prone coastal areas this practice may also reduce flood risks.

5. Conclusion

One approach will not solve the flooding problem in a coastal city like Jakarta – there need to be many solutions, and there needs to be a venue where administrations and academics can pool their ideas and decide what to do.

References

Abidin, HZ et al, 2001, Land Subsidence of Jakarta (Indonesia) and its Geodetic Monitoring System, Natural Hazards, Kluwer Academic Publishers, Netherlands.

Anonymous,http://rovicky.wordpress.com/2010/12/30/bisakah-banjir-jakarta-dikurangi/

Bemmelen, RW van, 1949, The Geology of Indonesia, The Hague: Govt. Printing Office; sole agents, Nijhoff, Netherlands. 2 volumes.

Das, Braja M, 1988. Mekanika Tanah Jilid 1, Erlangga Publisher, Indonesia.

Djaja, R, Jacub R, Abidin HZ, and Kuntjoro W, 2004, Land Subsidence of Jakarta Metropolitan Area, 3rd FIG Regional Conference, Jakarta, Indonesia.

Heri Andreas, , 2011, Illustration of topography of Jakarta, Geodesy, ITB,(unpublished).

Posko Bakornas Operations Centre, 2007, Flooding area map of Jakarta, Indonesia.

Santosa, B, Suprapto H, and Suryadi H, 1998, Dasar Mekanika Tanah, Gunadarma Publisher, Jakarta, Indonesia.

Seismic Activity and Tsunami Potential in Bali-Banda Basin

Suci Dewi Anugrah[1] and Bambang Sunardi[2]

[1]*Tsunami Mitigation Subdivision*

Indonesian Meteorological Climatological and Geophysical Agency,

sucirahman@yahoo.com

[2]*Research and Development Centre*

Indonesian Meteorological Climatological and Geophysical Agency,

b.sunardi@gmail.com

Abstract

Since the year of 1975 to 2011, Bali-Banda Basin had been shaked by 83 times earthquakes above 5.0 Mw. All of the earthquakes were occurred in the sea, however only one earthquake generated tsunami in 1992 at Flores. The objective of this study is to determine the most potential areas for tsunami hazard by analyzing and conducting the tsunami modeling based on the earthquake historical data at the area.The NEIC earthquake catalog from 1973-2011 and Global CMT catalog were used to analyze seismotectonic parameters and earthquake recurrence time at the area 6^o-12^{o}S and 114^o-126^{o}E. To determine tsunami hazard in this region, we use three tsunami simulation models which have high tsunami run up potential.The result shows that seismic activity with the magnitude more than 5 Mw tends to get higher exponentially. The recurrence time of earthquake with magnitude 6.5 is about 7-35 years, magnitude 7 is about 18-85 years and magnitude 7.5 is about 40-200 years. Tsunami wave distribution from tsunami simulation will be the discussion materials to decide tsunami potential along Bali-BandaBasin.

Keywords: *Seiscmic activity, tsunami potential, Bali-Banda Basin*

Introduction

As a consequence of having surrounded by Indo-Australian plate, Pacifik plate and Philippine plate which subduct beneath the Eurasian plate, made Indonesia as a very seismically active region. Many big earthquakes and tsunami events are recorded in this area. After the Sumatera Tsunami 2004 event, many research studied about the tsunami potential due to the earthquake subduction along the Indian Ocean. Sumatera and Java are the threatened area due to the earthquake. Beside those two islands, Sulawesi, Papua and some small islands in the eastern part of Indonesia like Bali, Nusa Tenggara and Flores has also a potential tsunami threat due to another earthquake mechanism. Generally, the tsunami potential of these areas is caused by some small fault segments that surrounded the islands.

This research studies the seismic activity and tsunami potential in the east part of Indonesia namely Bali-Banda Basin which is located along the north part of Bali in the west to the northeast of Flores island in the east. A history of an earthquake generated a big tsunami event was recorded in this region which is known as The Flores Tsunami 1992 (Yieh, et al., 1993). This even had caused substantial casualties and property damage. About 2080 people were dead while half of that was caused by tsunami. Most of the tolls are the people of Maumere, an area that are located in the north part of Flores, and people of Pulau Babi, and island in the north of Flores. Further tsunami potential studies in this area, based on the historical fact, are needed to understand tsunami potential in the future. The main reason of this study is the lack of research of seismic activity related to the tsunami potential in this region. Another research background is the presence of some fault segments in the Bali-Banda Basin as a source of earthquake which can generate a very local tsunami that impact to the closest islands along the Basin. In relation to the Tsunami Early Warning System which is run by Meteorological Climatological and Geophysical Agency, it needs a lot of effort to give some knowledge to the people in the area that has a potential experience of a very local tsunami, if the tsunami early warning system could not give a warn due to the very fast tsunami arrival time.

Tectonic and Geology Bali-Banda Basin

Geographic and Tectonic Aspects of Bali-Banda Basin

The Bali-Banda Basin is located at the eastern part Indonesia. It is a prolongation of Sunda Arc. At the north of Bali-Banda Basin, a series of fault segments extend from east to west. The fault segments are known as Sunda back arc. Silver, et al., (1983) stated that the Sunda back arc structure is dominated by two large north directed thrusts, the Wetar and Flores thrusts and more minor thrusts. Those thrusts may represent early stage of subduction polarity reversal of the arc. In addition, the Wetar thrust has negative relation to the volcanism system.

The Bali-Banda Basin is also dominated by the collision between the eastern Sunda Arc and Indo-Australia Plate. Collision zone is located in the south of Sumba, where Indo Australian plates grind the front of the arc (forearc) with a reverse fault mechanism. This collision has occurred since 3 million years ago. Irsyam, et al., (Australia 2010), reviewed the existence of the all the fault segments and subduction zona in Indonesia, which stated that there are four major segments located around the Bali to Flores, beside the Indo-Australia subduction zone (**Fig 1**). The faults are known as Sumba fault, Wetar fault, Timor fault, and Flores fault.

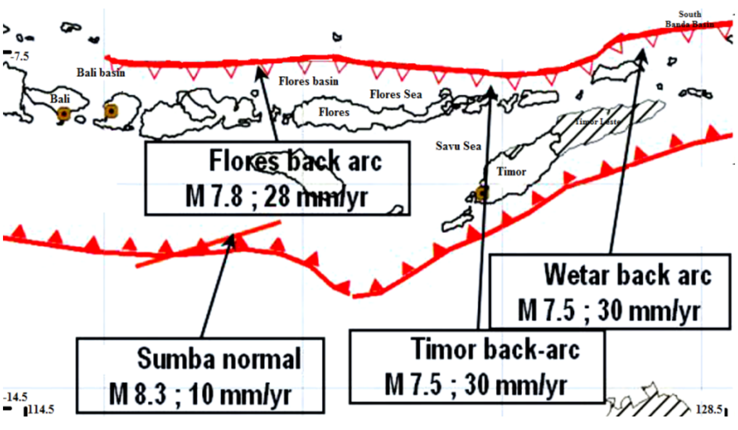


Figure 1. Fault segments around the Bali-Banda Basin (Irsyam, et al., 2010)

Geological Conditions and Bali-Banda Basin Structure

The basement underlying the Bali Basin is still a matter of controversy. Curray et al., (1977) and Hamilton, (1979) stated it was formed by a transitional crust that has a thickness between oceanic and continental crust; Ben-Avreham and Emery (1973) inferred that the oceanic crust is the basement material of the basin as a western extension of the Flores Basin; McCaffrey and Nabalek (1987) argued that the basement of the basin was formed by the continental crust having some thickness and origin as that beneth the Sunda Shelf. Cretaceous rocks that reflect sunda exposure can be traced to the northern of basin under Kangean-Sepanjang ridge.

Based on the gravity and seismic refraction data, the north part of the basin represents a Paleocene extensional tectonic regime, while the back arc fold thrusts zone formed since Neogene time was associated with both the Australian margin-Banda Arc collision as well as subducting of the oceanic plate in the Sunda trench in the south of Bali (Prasetya, 1992).

The Bali Basin is a narrow (100 x 200 km), half circle shape, gradually getting deeper bathymetry to the east with the maximum depth of 1.5 km. Between the Bali Basin and Flores Basin an elongated Lombok Trough exists from north of Lombok to the central of Sumbawa. It is a short and narrow trough. The dimension of the trough length and width is about 100 x 50 km. The maximum bathymetry of the through is about 1.5 km whereas the southern ridge are between 1000 to 1300 m. The trough is underlain by oceanic crust as a continuation of the Flores Basin.

The Flores Basin is an E-W turned to SE oriented. The Basin is deeper than Bali Basin with the maximum bathymetry of about 5 km. The eastern part of the basin is bounded by the east Salayar Ridge extending onto South Sulawesi. In the western part of the ridge, the basin is composed of Neogene volcanic and sedimentary rock dipping to the west and southwest.

The eastern most part is the Banda Basin. It is near the triple junction area between three major plates, namely the Eurasian, Pacific and The Indo-Australian Basin which are converging since Mesozoic times. The basin exhibits an elongated shape with ENE-WSW direction, parallel to the Banda Arc. The dimension of the basin is about 800 km long and 150 km wide. The basin can be divided into two parts which are separated by the volcanoes fracture zone: the Wetar Basin and The Damar Basin. The depth of the two basins is about 4500 m and 5000 m respectively. The nature of the basement underlying the Banda Basin is oceanic crust and has been interpreted as a Cretaceous-Eocene basin related to the Celebes and Sulu Basin, but a Neogene back arc origin was also considered (Hinschberger, et al., 2001).

Method

Seismic Analysis

A series of seismic catalog in the Bali-Banda Basin was analyzed to know the seismic activity and its characteristic of the area. The characteristics refer to the earthquake recurrence period, the possible of the biggest magnitude, and the earthquake mechanism.

The Gutenberg-Richter relation (1954) is used to find out the earthquake characteristic of an area. The Gutenberg-Richter relation is simply formulated as follows:

$$\log n(M) = a - bM \quad (1)$$

The $n(M)$ is a number of earthquake with a magnitude of M, while the a and b parameters referred to a seismic activity representing a seismic rate of a certain period. The first parameter is depended to the observation period and the dimension of the field observation, while the second one can be estimated statistically (Utsu, 1965). One of the formulas to estimate the b parameter is :

$$b = \frac{\log e}{\bar{M} - M_{min}} = \frac{0.4343}{\bar{M} - M_{min}} \qquad (2)$$

whereas $\overline{M}$ is a magnitude average and M_{min} is a minimum magnitude.

The value of a can be a estimated by using the formula :

$$a = logN(M \geq M_0) + log(b\ ln10) + M_0\hat{b}(3)$$

The cumulative distribution can be calculated as follow:

$$a = a - \log(bln10) \ (4)$$

Number of earthquake occurrence/year can be estimated by divided the value of a with the observation period (T):

$$a_1 = a/logT$$

$$a_1^{'} = a/logT \ (5)$$

The number of earthquake cumulative frequency every year or seismicity index is:

$$N_1M = 10^{a_1^{'} - bM} \qquad (6)$$

Therefore, one can calculate the probability of once or more earthquake occurences with a bigger than M magnitude of T period as follows:

$$P(M,T) = (1 - e^{-N(M)T}) \quad (7)$$

The average of return period can be estimated by:

$$\theta = \frac{1}{N_1(M)} \text{ tahun} \qquad (8)$$

The Tsunami Potencial Analysis

The back arc thrust reactivation at the Bali-Banda Basin causes many shallow depth earthquakes in this area. Historical seismicity recorded a Seririt Earthquake on the year of 1976 with a magnitude of 6 Mw. The earthquake was located in the north of Bali Island, killed more than 500 people. This event might be a proof that the back arc thrust reaches to the north of Bali, and also as a reason about the presence of tsunami potential in the north of Bali.

The Flores Tsunami 1992 was also recorded as a big tsunami in this study domain caused by the back arc thurst in the Bali-Banda Basin. The presence of the back arc thrust in the Bali-Banda Basin might be considered as a source of the shallow earthquake generated tsunami to the north coast of Bali-Flores Island.

The tsunami potential analysis was also carried out in this study by using a deterministic method of tsunami numerical modeling. A series of tsunami modeling based on earthquake and tsunami catalog were done in this study such as the Flores Tsunami 1992. Three tsunami simulations in this region had been done in this study to prove the tsunami potential at the basin of Bali-Banda. The Mamuru Nakamura Tsunami Software was used to conduct the tsunami simulations.

Data

In this study we used a series data of earthquake event in the area of 6^o-12^o S and114^o-126^o E. The CMT Harvard earthquake catalog from the year of 1973 to 2011 and the NEIC earthquake catalog of the period 1973-2011 were used to obtain the data. Seismic analysis was performed with the ZMAP software (Wiemer, S., 2001).

For tsunami modeling, we used bathymetry data from ETOPO2 (can be downloaded from http://www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html) with 2' resolution. The bathymetry grid interval is 2.5 x 2.5 km. Modeling of tsunami could be applied for near-shore region run-up specifically by using a non-linearshallow water equations (Satake, 1995). The open boundary condition is used atthe edge of the computational area (Nakamura, 2006). The finite-difference is a method that is used to calculate tsunami run-up. Three tsunami simulation with different scenario as listed in the **Table 1** were done in this study. Some earthquake parameters data as well as a set of bathymetry data are needed in this simulation. The parameters are the fault dimension, strike, dip, slip, moment magnitude (*Mw*) and the location of the earthquake source.

Table 1. Fault parameters for each model used for tsunami simulation

Parameter	Model 1	Model 2	Model 3
Length (km)	110	50	50
Width (km)	35	20	20
Strike (o)	80	132	90
Dip (o)	40	13	25
Slip (m)	6	2.5	2.5
Mw	7.7	7	7
Center fault Coordinat	122.49 -8.34	116.28 -7.74	118.72 -8.23

Results and Discussion

Seismic Activity in Bali-Banda Basin

Figure 2a shows seismic density in the region of Bali-Banda Basin and its surrounding obtained from NEIC catalog. The contrast red colour zone shows that Sumba, Sumbawa, Flores and some small islands in the south part of Banda Basin are the most active seismic region in this study area.

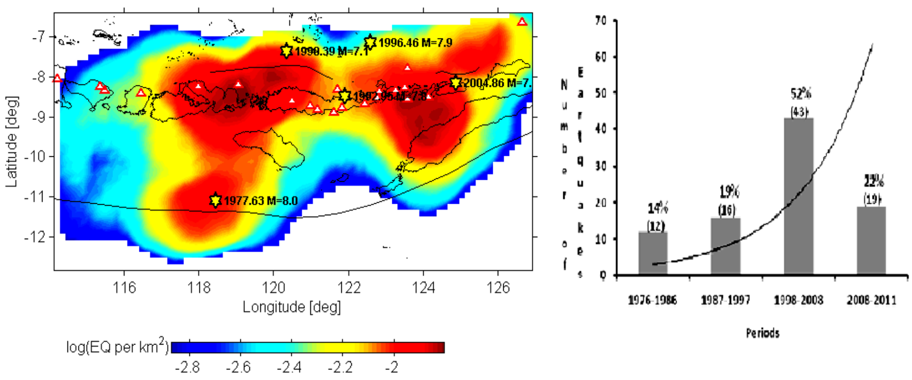


Figure 2. Earthquake density based on the seismic catalog and earthquake occurrence (>5 Mw) of the Bali-Banda Basin

Based on both the Global CMT seismic catalog, there are 83 earthquakes that occurred in this area during 1976-2011 with magnitude more than 5 Mw. The curve of seismic even with the magnitude more than 5 Mw tends to get higher exponentially (**Fig 2b**). The earthquake frequency tends to get higher in the period of 1998-2008 after the tsunami earthquake event of 1992 in Flores. **Figure 3** shows that most of the events are located in the sea. Four earthquakes have a magnitude more than 6.9 Mw are located at the eastern part of the basin. The biggest one was the 7.7 Mw of the 1992 Flores Earthquake. This earthquake generated a big tsunami. The other ones have a magnitude of 7 and 7.5 Mw. Those tsunami earthquakes were located in the basin of Sumba. Although those big earthquakes were a shallow earthquake but they did not generate a tsunami.

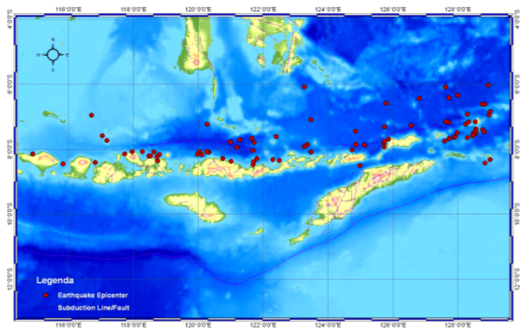


Figure 3. The Earthquake epicenters of Bali-Banda Basin (M>5 Mw) during 1976-2011

Seismotectonic

The measurement of *b*-value resulted that the values varied spatially. It is showed that the *b* value are relatively low at southeast of Bali, north of Lombok, and at the north of Flores. The *b* value represents a stress rate of an area. A low *b* value is correlated with a high stress rate. The result of the *b* value as seen in the **Figure 4** is appropriate to the earthquake density as it was showed in the Figure 2a.

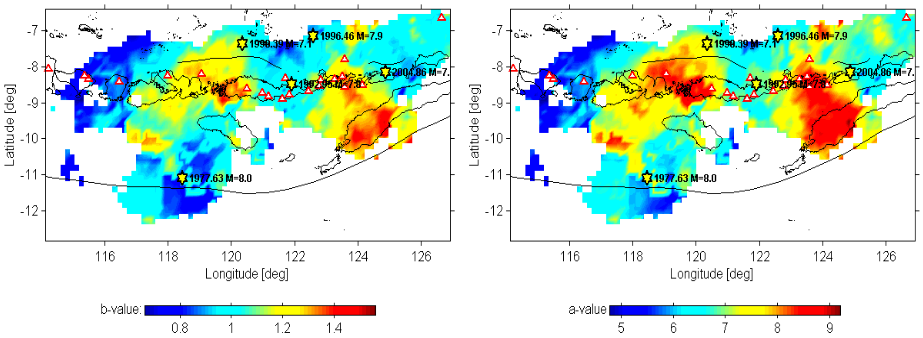


Figure 4. Spatial variations of *b*-value and *a* value Bali-Bandabased on NEIC catalog 1973-2011

The value of *a* represents an earthquake activity rate of an area. For this study area, the values vary approximately from 5 to 9. Two blocks are obviously seen having about 9 of *a* value. Both areas have a high rate seismic activity.

Earthquake Recurrence Time

The earthquake with a magnitude 6.5 Mw in the region of Bali-Banda Basin has a recurrence time about 7 to 35 years as showed in **Figure 5a**. **Figure 5b** shows that the range of recurrence time of the bigger earthquake magnitude 7 Mw is about 18-85 years, while **Figure 6** shows that the earthquake with a magnitude 7.5 has a recurrence time range about 40-100 years.

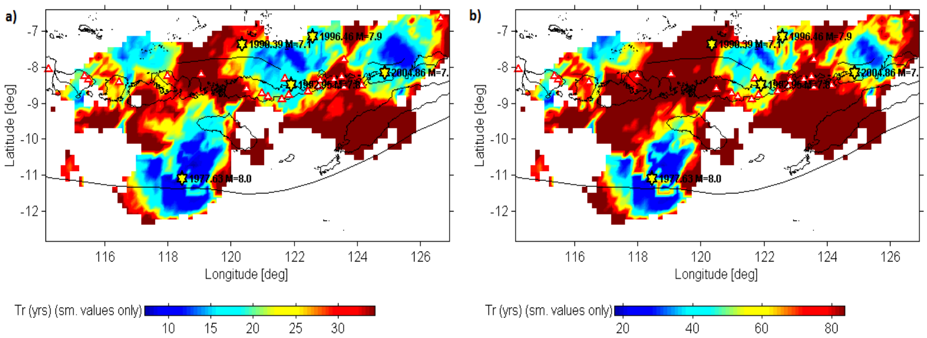


Figure 5. Earthquake recurrence time with magnitude 6.5 and 7 Mw

The short recurrence time is correlated with a high *a* and *b* value. The short recurrence time represents a very active seismic activity. For this study domain we find the area of north Flores and the South of Sumba and Sumbawa as the region with a high seismic activity.

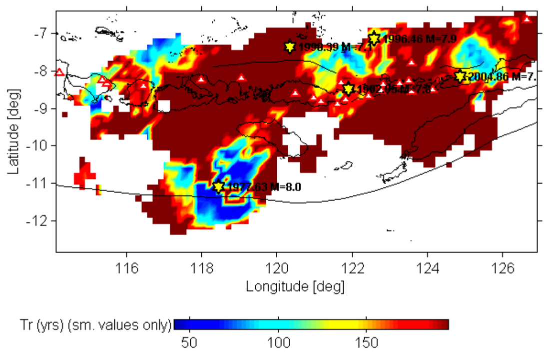


Figure 6. Earthquake recurrence time with magnitude 7.5 Mw

Bali-Banda Basin Tsunami Potencial

The length dimension of the back arc thrust in the Bali-Banda Basin is more than 1000 km. Due to its length it is possible to generate an earthquake with a magnitude more than 7 Mw in that region. It can be proved by some earthquakes recorded with a magnitude more than 7 Mw. However, an earthquake potential with magnitude more than 7 Mw in the north of Bali Island is less than the earthquake potential in the north of Lombok-Flores Island. The biggest earthquake magnitude recorded in the Bali Basin was only 6.5 Mw.

Three scenarios of tsunami simulation in the Bali-Banda Basin had been done in this study based on seismic history, earthquake characteristic and considering the tectonic setting in that area.

Tsunami Numerical Simulation 1

We conducted a Flores Tsunami simulation based on CMT Harvard solution. In this case, the tsunami was caused by an earthquake with a magnitude of 7.7 Mw, 20 km depth and the earthquake parameters were 80^{o} of strike, 40^{o} dip, and 95^{o} slip. The earthquake was a thrust fault with the length and width dimension is about 100 km and 35 km respectively. We obtained 6 m of dislocation based on computational calculation.

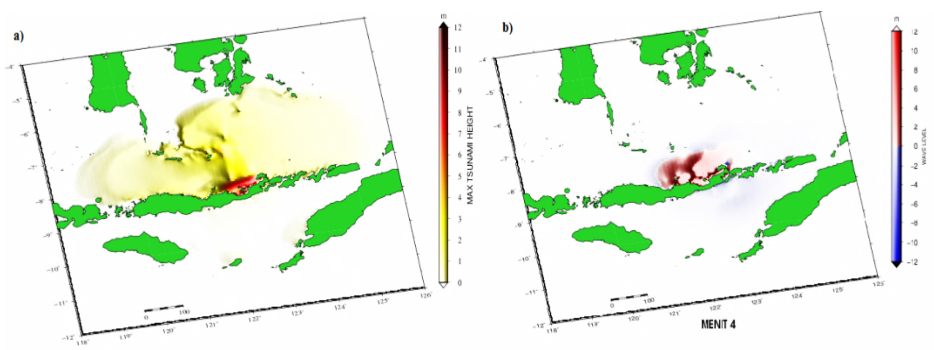


Figure 7. Distribution of maximum tsunami height (a) and tsunami propagation at minute 4 (b) for simulation model 1.

The simulation result shows that some areas have a tsunami wave height more than 3 meters which were happened at Lewobunga, Pamana Island, Lato beach, Babi Island and Nebe. The tsunami reaches the beach at 4 minutes after the earthquake. **Figure 7** shows the tsunami maximum height and its propagation at *t* (time) = 4 minute for tsunami case model 1.

Figure 8 shows the tsunami wave height comparison between our tsunami simulation and tsunami filed survey conducted by International Tsunami Survey Team ITST (Imamura, 1995). The simulation shows a closed result to the field survey.

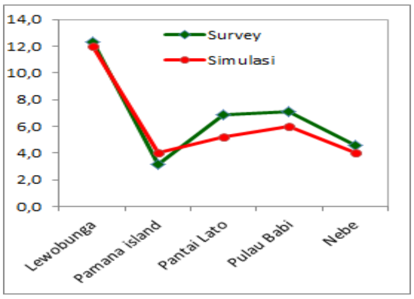


Figure 8. The comparison of tsunami wave height between field survey and numerical simulation

The tsunami risk in those areas is relatively high considering a very high seismic activity. The possibility of local tsunami occurrence, a less 10 minutes tsunami arrival time, is another reason to enhance the risk in those areas.

Tsunami Numerical Simulation 2

The second simulation took a part in the Bali Basin region. This simulation referred to the earthquake event on Januari 6th 2000. We assumed that the earthquake has a magnitude 7 Mw, 20 km depths, and the fault parameters are based on the CMT Harvard: 132^o strike, and 13^o dip. The fault dimension is about 50 km long and 20 km wide. A computational calculation results a dislocation value about 2.5 m.

The simulation results that some areas experience a high tsunami wave more than 3 meters. The wave reached the coast at 4 minutes after the earthquake. **Figure 9** shows the wave height distributions and the tsunami propagation at 10 minutes after the earthquake.

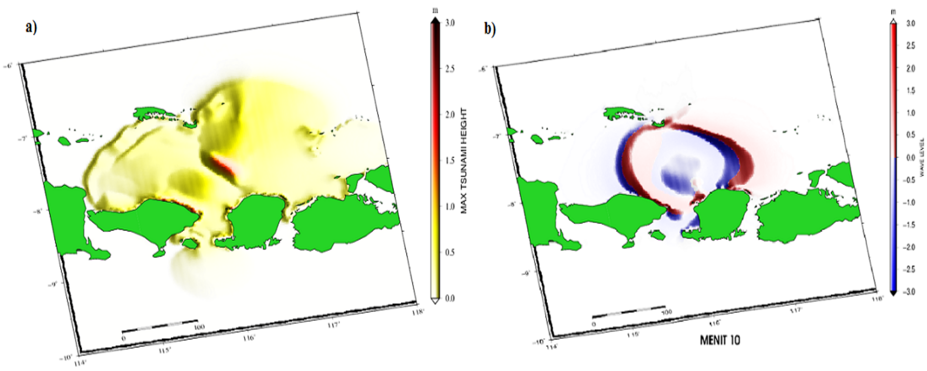


Figure 9. Distribution of maximum tsunami height (a) and tsunami propagation at minute 10 (b) for simulation model 2

Tsunami Numerical Simulation 3

The third simulation took a part in the region around Sumbawa Island. This simulation referred to the earthquake event on November8th 2009. We assumed that the earthquake has a magnitude 7 Mw, 20 km depths, and the fault parameters are based on the CMT Harvard: 90^{o} strike, and 25^{o} dip. The fault dimension is about 50 km long and 20 km wide. A computational calculation results a dislocation value about 2.5 m.

The simulation results that the tsunami height reached more than 3.5 meters in some areas. The wave come the coast at 4 minutes after the earthquake. **Figure 10** shows the simulation model 3 of the wave height distributions and the tsunami propagation model at 4 minutes after the earthquake when tsunami reached the coast for the first time.

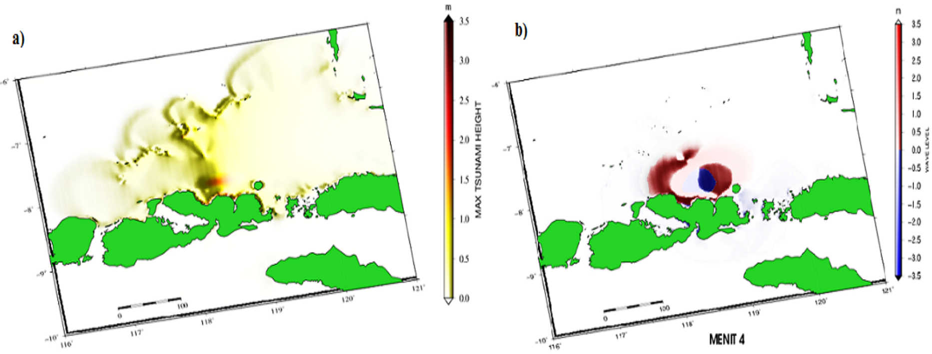


Figure 10. Distribution of maximum tsunami height (a) and tsunami propagation at minute 4 (b) for simulation model 3

Conclusion

1. Considering the trend of seismic activity during 1976-2011 in the region of Bali-Banda Basin, the frequency of a big earthquake with magnitude more than 5 Mw is predicted to get higher along the Bali-Banda Basin.
2. Based on the earthquake density rate, the Flores to Banda Basin is the most seismically active region compared to the Bali Basin.
3. The Bali- Banda Basin earthquake recurrence times vary for each magnitude. For magnitude 6.5 Mw, the recurrence times are about 7-35 years, while for the magnitude 7 and 7.5 Mw are about 18-85 and 20-200 years respectively.
4. According to the both tsunami history and tsunami simulation the north part of Flores Island is the most tsunami risk experienced area compared to the north of Bali, Sumba and Sumbawa.
5. Due to the distance of the earthquake source to the coast, it is predicted that the tsunami at the north coast of Flores will be a very local tsunami. Therefore, it is important to educate people in that area to understand the very local tsunami characteristic and prepare whether the Tsunami Early Warning System will run well if the tsunami occurred.
6. Although the historical tsunami did not record a tsunami event in the north coast of Bali, Lombok, and Sumbawa Island, but the length dimension of the back arc in the north of the islands is considered as a source of an earthquake generated tsunami with a magnitude more than 7 Mw. Due to the tsunami

simulation this area is also predicted will have a very local tsunami experience.

References

Ben-Avraham, Z and K.O. Emery (1973), Structural framework of Sunda Shelf, *Bull. Am. Assoc. Pet Geol., 57, pages 2323-2366.*

Curray, J.R., Shor, G.G., Raitt, R.W., and Henry (1977), Seismic refraction and reflection studies of crustal structure of the eastern Sunda and Western Banda Arcs, *Journal of Geophysical Research., 82 No 17 pages 2497-2489*.

Gutenberg, B., and Richter, C.F (1954), Seismicity of the earth and associated phenomena, *Princeton Univ, Press, Princeton N, J., 2nd edition*.

Hinschberger, F., Malod, J, A., Dyment, J., Honthaas, C., Réhault, P., and Burhanuddin, S (2001), Magnetic lineations constraints for the back-arc opening of the Late Neogene South Banda Basin (eastern Indonesia), *Tectonophysics., 333, pages 47-59.*

Imamura, F., Gica, E., Takahashi, T., and Shuto, N (1995), Numerical simulation of Flores Tsunami, interpretation of tsunami phenomena in northeastern Flores Island and damage at Babi Island, *Pageoph., 144, pages 555-568*.

Irsyam, M., Sengara, W., Aldiamar, F., Widiyantoro, S., Triyoso, W., Natawidjaja, D.H., Kertapati, E., Meilano, I., Suhardjono., Asrurifak, M., and Ridwan, M (2010), Ringkasan Hasil Studi Tim Revisi Peta Gempa Indonesia 2010.

Mamoru, N (2006), Source Fault Model of the 1771 Yaeyama Tsunami- Southern Ryukyu Island Japan Inferred From Numerical Simulation, *PureAppl. Geophys., 163, 41-54.*

McCaffrey R and Nabale, J (1987), Earthquakes, gravity, and the origin of Bali Basin: an example of an ascent continental fold and thrust belt, *Journal Geophysics Res., pages 441-459*.

Mogi, K. Magnitude-frequency relationship for elastic shocks accompanying fractures of various materials and some related problems in earthquakes, Bull. Earthquake Res. Inst. Univ. Tokyo., 40, pages 831-883, 1962.

Prasetya (1992), The Bali-Flores Basin, *Proceedings Indonesian Petroleum Association.*

Satake, K., and Imamura, F (1995), Introduction to “Tsunamis: 1992-94”, *Pageoph, nos 3/4*.

Silver, E.A., Reed, D., and McCaffrey, R (1983), Back arc thrusting in the eastern Sunda Arc, Indonesia: a consequence of arc-continent collision, *Journal of Geophysical Research., Vol 88, no 89, pages 7429-7448.*

Utsu, T (1965), A method for determining the value of b in a formula of log N=a-bM showing the magnitude frequency relation for earthquakes, *Geophys. Bull. Hokkaido Univ., 13 pages 99-103*.

Wiemer, S (2001), A software package to analyze seismicity: ZMAP, *Seis. Res. Lett., 72, pages 374-383*.

Yeh, H., Imamura, F., Synolakis, C., Tsuji, Y., Liu, P., and Shi, S (1993), The Flores Island Tsunamis, *EOS., Vol. 74, No 33*.

http://www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html.

Prediction of Sediment Transport in the River

Sri Amini Yuni Astuti

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Abstract

As one of important natural resources, rivers must be preserved in a sustainable condition. One way to make such a condition, sediment transport along its course must be managed. This research tries to find out a model for predicting and analyzing sediment transport that can be used as bases in controlling sediment for maintaining the good sustainable condition of rivers.

The unsteady one-dimensional flow and sediment transport are used to model the river of interest. Coupled approach between flow and sediment transport is the chosen scheme to solve the related governing equations. The sediment transport equations used in this model are Engelund- Hansen's and Tang's formulas. Finite difference method with Preissmann's implicit scheme is used in this model.

In general, the results of the model are confirmed by theories in several aspect such as continuity, Mild-1 and Mild-2 curves, steady flow and sediment transport. Specifically, the numerical analysis shows that the difference equation is consistent with its original partial differential equation. By changing the Cr number and the grid size (Δx and Δt), give results which show agreements of trend and values whatever changes that have been done. These meant that the numerical scheme is stable. Furthermore, if this model is compared with other similar models, those are HEC-6, DELTA, and also the analytical solution, show the same proof. The results shown above proved that the model can satisfactorily predict the sediment tansport and the river bed change. Therfore, proper advice on sediment management can be arranged.

Keywords : sediment transport, numerical model, coupled approach and finite difference mehod (Preissmann's implicit scheme)

Introduction

Background

To obtain optimum benefits of the river, the sediment transport should be controlled. Before controlling could be carried out, we have to know the sediment transport's characteristic, which is happening at the important check-point locations. One of the methods to predict the sediment transport's behavior is modeling.

Thus, building a model that is able to describe the sediment transport's characteristic which is happening in a river is necessary. The model could be used for sediment control guide of the river.

Innovation

The research will be done by building a one-dimension numerical mathematic model of sediment transport in the river. Until now, there are same typical researches and models. However, the used solving-methods and approaches are different to each other. When the other used uncoupled solving method, this research will use the coupled one.

The result of the research will be compared to some of the others, using the same condition and input data. Furthermore, it will also be checked using the logic of the theory.

The aim of the research is dominantly used for science. To be suitably applied for field cases, some adjustments to the real field condition are necessary.

Goal and Objective

The goal of this research is to understand and to analyze the sediment transport happening in a river by building a mathematic model as an engineering analysis tool.

Significance

By building numerical mathematic model of sediment transport in the river, we could get the sediment transport and the bed elevation change of the river to be simulated. We could know how the sediment transport at the important check-point locations is. And for further impact, advices in how to well-organize the sediment transport could be given in order to control the river's morphology.

Scope

1) This research is conducted by building a mathematic model of sediment transport in the river,
2) Analyzing logically and theoretically: numerical analysis (stability, consistency, and convergence), analysis of the sediment transport continuity, analysis of the steady uniform flow, analysis of the water surface profile, and analysis about the sediment transport theory.
3) Comparing the model with: parabolic model's analytical calculation, simple numeric program of DELTA, and HEC-6 program.

Literature Review

Previous Research

There are some previous researches related: Ialluvial : Analysis of Sediment Continuity and Application to the Missouri River (MF Karim,1985), Numerical simulation of bed evolution in multi channel river system (Yang, JC,1986) , HEC-6 Program (US Army Corps, version 4.2, May 2004), GSTAR 1-D Program Version 2.0 (USBR, 2007).

Basic Literatures

Basic Literatures related: The Basic Calculations of Analytical Solution (Graf, 1998) and simple numeric program of DELTA (Graf, 1998).

Theoretical Basis

Mathematical Modeling

Model study has been used for handling various problems of river controlling. There are two types of model. They are physical model and mathematical model. Mathematical model could be used when the problem tried to solve could be formulated mathematically. In Mathematical modeling, there is a process of transferring some simplified specific aspects of real life to virtual world in mathematic concept.

Mathematical modeling in rivers is the simulation of flow condition based on the formulation and solution of mathematical relationships expressing known hydraulic principles. The technique finds its origin in the 19^{th} century work of de St.Venant and Boussinessq, who formulated the unsteady flow equations. Mathematical modeling in rivers is much more than the use of computers and computer programs to simulate hydraulics (Cunge, Holly, Verwey, 1980).

In mathematical modeling, it is necessary to assume some definitions, which are: 1) exact reproduction of the real system is impossible, so we need some system simplification, 2) model calibration is a must, if the model will be applied for field cases, with this calibration hopefully the empiric coefficient used in the model could be obtained.

Equations of One-Dimensional Unsteady Open Channel Flow

The river or channel flow could be approached as one-dimensional unsteady open channel flow. Barre de St. Venant, 1871 (Budi WS, 1998) developed the equations of one dimensional unsteady open channel flow, which is stated with flow continuity equation and momentum equation. The flow continuity equation is stated as:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0 \tag{3.1}$$

And the momentum equation:

$$\frac{\partial Q}{\partial t} + 2\alpha \frac{Q}{A}\frac{\partial Q}{\partial x} - \alpha\left(\frac{Q}{A}\right)^2\left(\frac{\partial A}{\partial x}\right) + gA\frac{\partial y}{\partial x} + gAS_f = 0 \tag{3.2}$$

The Continuity Transport Sediment Equation

The continuity transport sediment equation is known as the Exner equation.

This equation is: $\frac{\partial Q_s}{\partial x} + (1-p)\ \gamma_s \frac{\partial (B_z.z)}{\partial t} = 0$ (3.3)

Total Sediment Transport

The amount of sediment transport is influenced by some factors: flow characteristics, sediment characteristics, and interrelationship between them. The flow characteristics include Q (discharge), y (surface elevation), V (flow velocity rate), u_* (friction velocity), ρ (water mass density), ν (water kinematics viscosity) and cross sectional flow area. The sediment characteristics independently are ρ_s (sediment mass density), particle size, particle shape, and particle fall velocity ; and the sediment characteristics collectively are gradation (size distribution), specific weight and porosity (Yang, CT, 1996).

Then what is called as total sediment transport is the amount of bed load and suspended load (Kironoto, 2001). In this research, used total sediment transport formulas of Engelund and Hansen, and CT Yang's.

1. Engelund & Hansen formula.

$$Q_s = 0.05\gamma_s.B.V^2 \left[\frac{d_{50}}{g\left(\frac{\gamma_s}{\gamma} - 1\right)} \right]^{1/2} \left[\frac{\tau_0}{(\gamma_s - \gamma) d_{50}} \right]^{3/2}, \text{ with } \tau_0 = \gamma(y - z)S_f \tag{3.4}$$

2. Yang formula

Yang (1972) defines the unit stream power as the velocity-slope product. The rate of work being done by a unit weight of water in transporting sediment must be directly related to the rate of work available to unit weight of water. The equation thus obtained is

$$\log C_t = 5{,}435 - 0{,}286 \log\left(\frac{\omega d}{\nu}\right) - 0{,}457 \log\left(\frac{U_*}{\omega}\right) + \left(1{,}799 - 0{,}409 \log \frac{\omega d}{\nu} - 0{,}314 \log \frac{U_*}{\omega}\right) \log\left(\frac{V S_f}{\omega} - \frac{V_{cr} S_f}{\omega}\right) \tag{3.5}$$

The relation between sediment transport concentration and sediment transport debit is stated as:

$$C_t = \frac{Q_s.10^6}{\gamma.Q} \quad \Rightarrow \quad Q_s = C_t.\gamma.Q.10^{-6} \tag{3.6}$$

Finite Difference Method

Equations 3.1, 3.2 and 3.3 are too complex to be solved by analytical methods, so it will be done by numerical methods, method of finite difference. The foundation of the finite difference is the following: functions of continuous arguments, which describe the state of flow, are replaced by functions defined on a finite number of grid points within the considered domain. The derivatives are then replaced by divided differences. Thus the differential equations, i.e. the laws describing the evolution of the continuum, are replaced by algebraic finite difference relationships. The different ways in which derivatives are expressed by discrete functions are called finite difference schemes (Cunge, Holly, Verwey, 1980). Here, it will be used Preissmann's implicit scheme.

1) $f_i^{n+1} = f_i^n + \Delta f_i \Rightarrow \Delta f_i = f_i^{n+1} - f_i^n$

2) $\frac{\partial f}{\partial x} = \theta \frac{f_{i+1}^{n+1} - f_i^{n+1}}{\Delta x} + (1-\theta)\frac{f_{i+1}^{n} - f_i^{n}}{\Delta x}$

3) $\frac{\partial f}{\partial t} = \varphi \frac{f_i^{n+1} - f_i^{n}}{\Delta t} + (1-\varphi)\frac{f_{i+1}^{n+1} - f_{i+1}^{n}}{\Delta t}$

4) $f(x,t) = \theta\left(\varphi f_i^{n+1} + (1-\varphi) f_{i+1}^{n+1}\right) + (1-\theta)\left(\varphi f_i^{n} + (1-\varphi) f_{i+1}^{n}\right)$ (3.7)

With : $0 < \varphi < 1$ as the space weighting factor

$0 < \theta < 1$ as the time weighting factor

Research Method

Model Building

Considering the dynamic changing phenomena of the river flow, such as the rainy season flood flow in some relatively short period of time, that we will model, the flow is approached as 1-D unsteady flow. Though, later this model could also be used to represent almost steady and steady flow, with relatively long period.

This mathematical model of river bed elevation change caused by sedimentation has 4 variables, including 3 independent variables: Q, y, and z; and 1 dependent variable: Q_s (sediment transport discharge). Q_s is a function of Q, y, and z. The model built with equations 3.1, 3.2, 3.3, 3.4, or 3.5.

All equations forming the model are solved thoroughly (*coupled*) without partial solving (*one-by-one*). In this research, Equation 3.1, 3.2, and 3.3 are solved in once, together, using double-sweep method algorithm which is a solving method by doing double sweep in one time. The first sweep is a sweep to the downstream which determines the influencing coefficient of inter-points and inter-variables relations. After the first sweep, the second sweep which is a sweep to the upstream is done to calculate variables at the next time point t_{n+1} which then included to Equation 3.4.

Equation 3.1, 3.2, and 3.3 will be turned to discrete to get some working equations suitable for numeric calculations. With Preissmann's implicit scheme Finite Difference Method, Equation 3.1, 3.2, and 3.3 are turned into these equations: $A1.\Delta y_{i+1} + B1.\Delta Q_{i+1} + C1.\Delta z_{i+1} = D1.\Delta y_i + E1.\Delta Q_i + F1.\Delta z_i + G1$ (4.1)

$A2.\Delta y_{i+1} + B2.\Delta Q_{i+1} + C2.\Delta z_{i+1} = D2.\Delta y_i + E2.\Delta Q_i + F2.\Delta z_i + G2$ (4.2)

$A3.\Delta y_{i+1} + B3.\Delta Q_{i+1} + C3.\Delta z_{i+1} = D3.\Delta y_i + E3.\Delta Q_i + F3.\Delta z_i + G3$ (4.3)

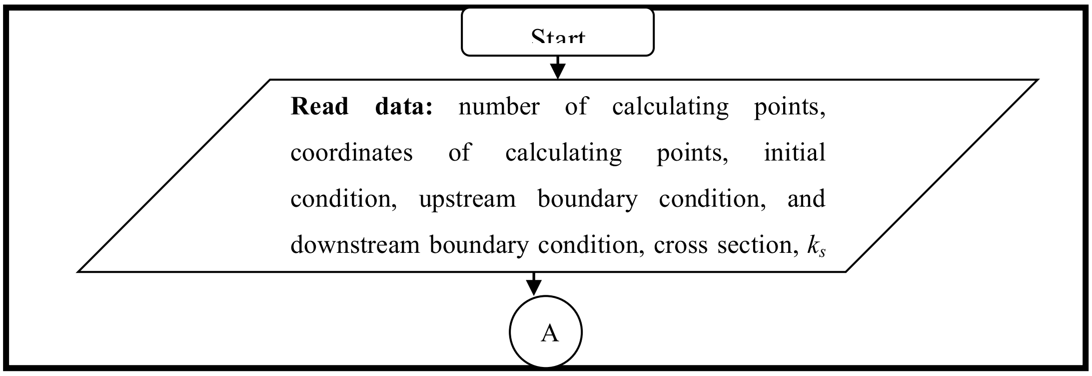
Calculation to get the coefficient in the working equation could be seen in Appendix 1, Mathematical Model of River Bed Elevation Change Dissertation.

To state that there are influences or relations between one point and the next one or between the parameters in one point we need to determine influencing coefficient. The calculation of this influencing coefficient could be seen in Appendix 2, in the dissertation.

Then, to solve the equations, we need the upstream boundary condition which is described with water debit hydrograph and river bed elevation, and also the downstream boundary condition which is embodied by surface elevation.

Then, we need the initial condition on every point represented by their surface elevation, flow debit, and river bed elevation.

The order of the steps could be seen in the solving flow chart (Figure 4.1).



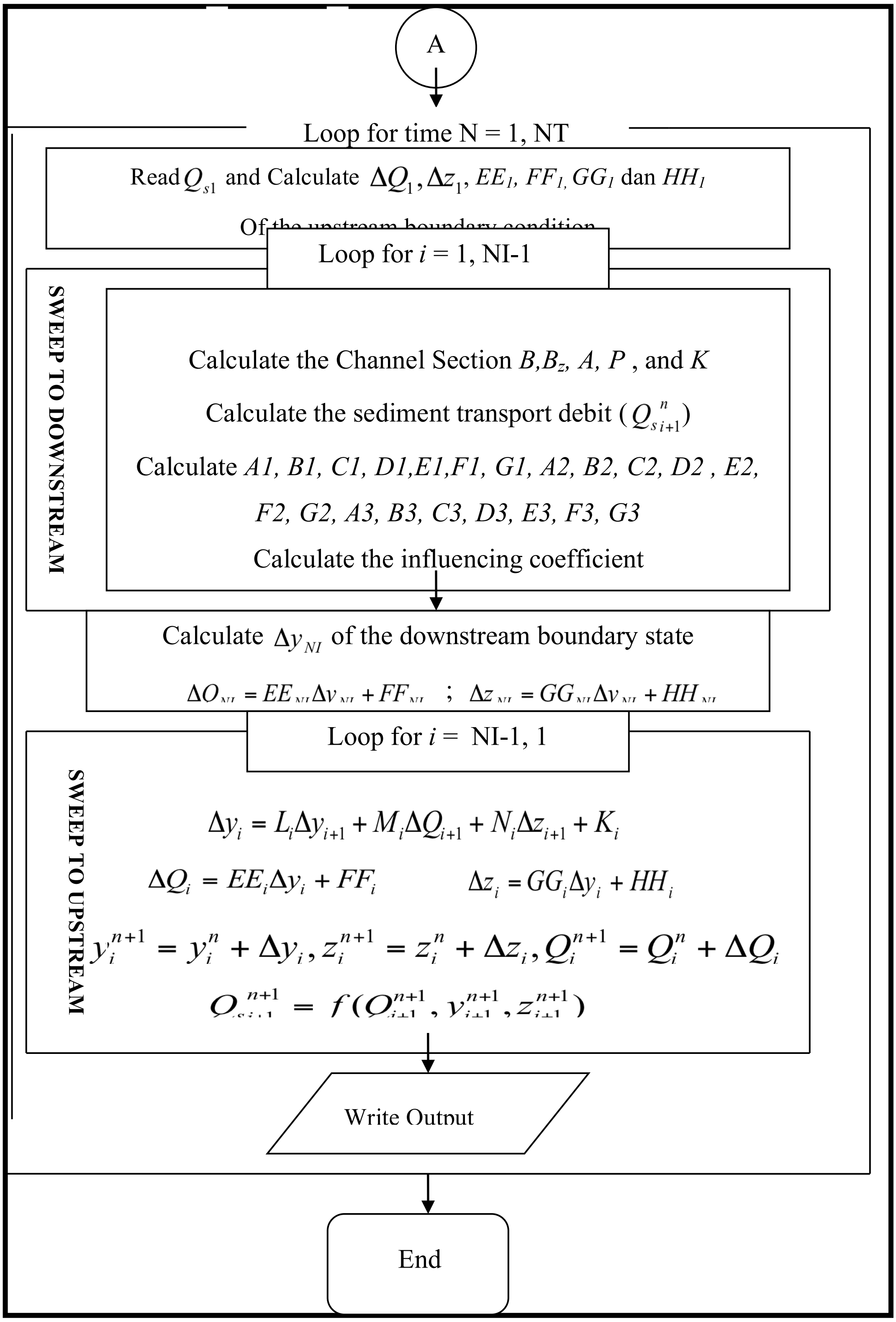


Figure 4.1. Solving Flow Chart

Model Validity

1. Tested logically (by using theories)

Logical testing includes: numeric analysis such as numeric scheme stability, consistency, and convergence, and also non numeric analysis such as sediment transport continuity, steady uniform flow, surface profile, and sediment transport theory.

2. Compared with Other Programs

The model's result will be compared with the parabolic model analytic calculation, simple numeric program of DELTA, and HEC-6 program.

Model Application

The model is applied using some hypothetic data as stated afterward. A river with 30 km long, with natural and unstructured form. The cross sections of the river on some points are shown in Figure 4.3. Initial slope: from the first point of the upstream on the 0 km to the 5^{th} km is 0,0002, afterward from the 5^{th} km to the 15^{th} km is 0,00015, from the 15^{th} km to the 23^{rd} km is 0,00005, from the 23^{rd} km to the 26^{th} km is 0,00002 and from the 26^{th} km to the 30^{th} km is 0,00001. The initial condition is steady flow with 10 m^3/s debit. The next flow is unsteady, with changing in debit. The upstream boundary condition is shown in flow (debit) hydrograph and bed elevation, whether the downstream boundary condition is shown in hydrograph of surface elevation (could be seen in Figure 4.2). The Strickler roughness coefficient is 33. The sediment transported is almost in uniform as d_{50}, with 1 mm diameter. Water weight density is 9810 N/m^3, and sediment weight density is 25996,5 N/m^3. The porosity is assumed constant as 0,3. The tasks are predicting the flow and the sediment transport happened in the river, and also the bed change of the river, and furthermore giving advices on what kind of suitable management should be done to the river.

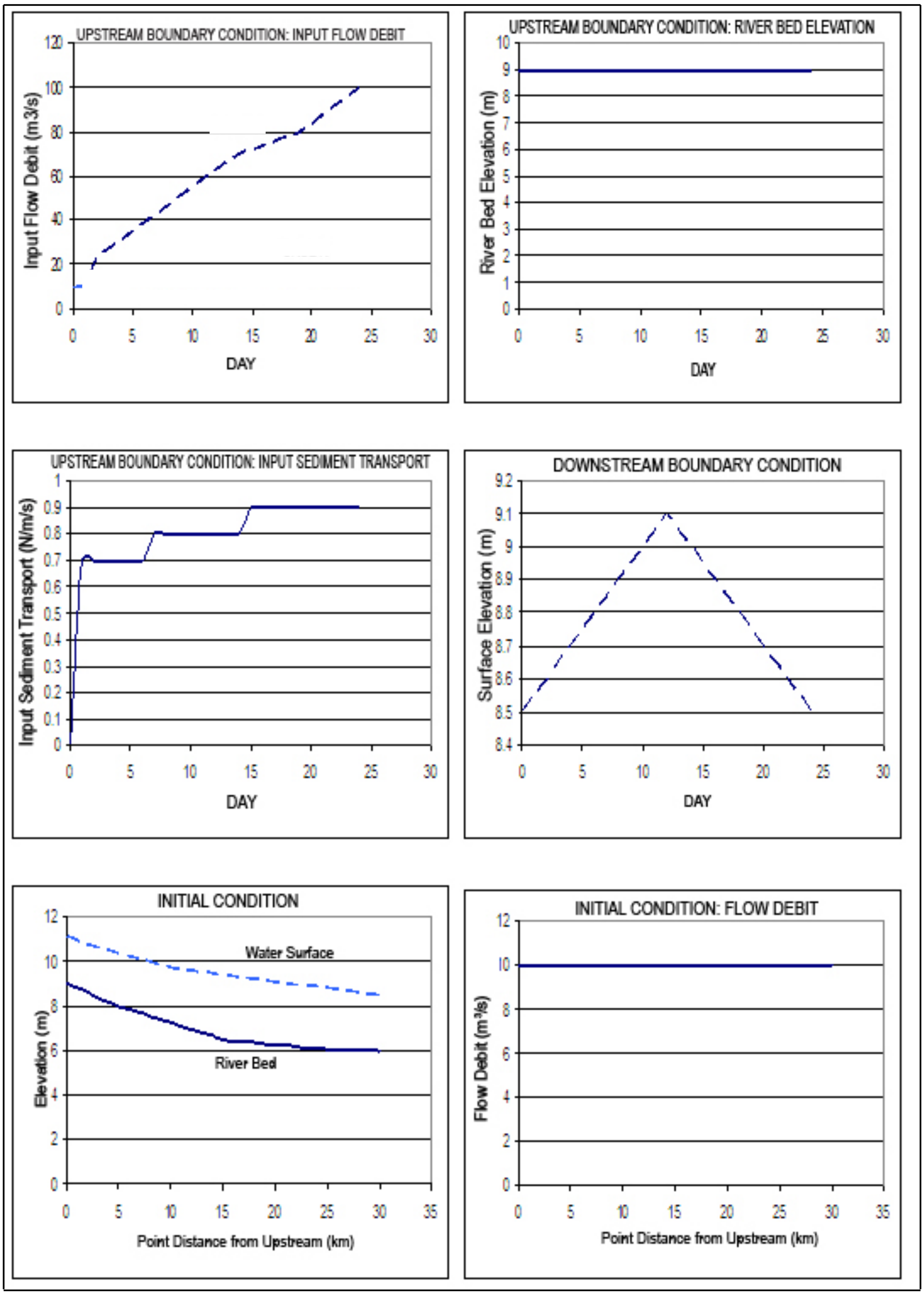
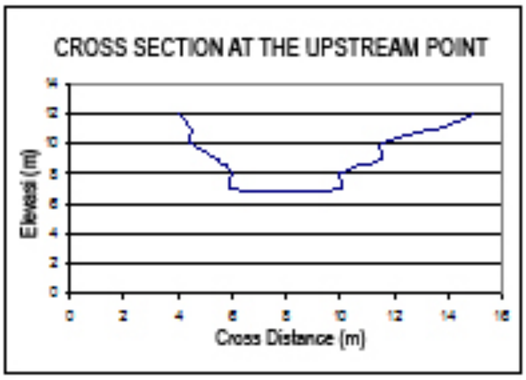
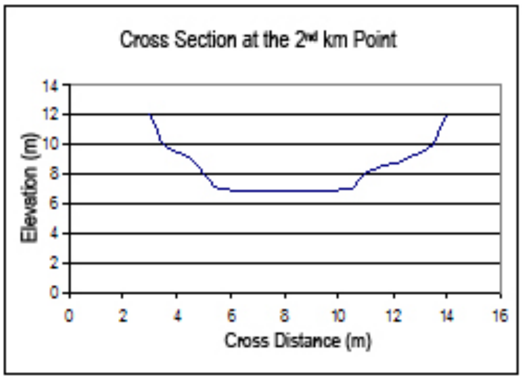
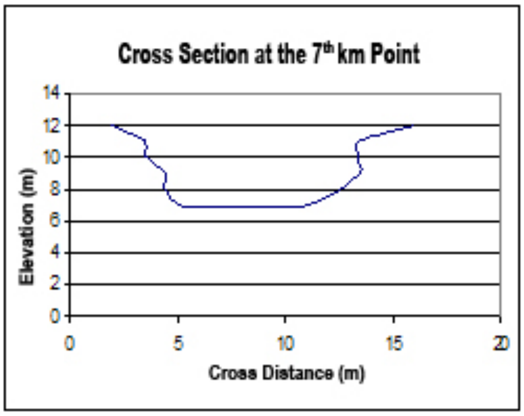
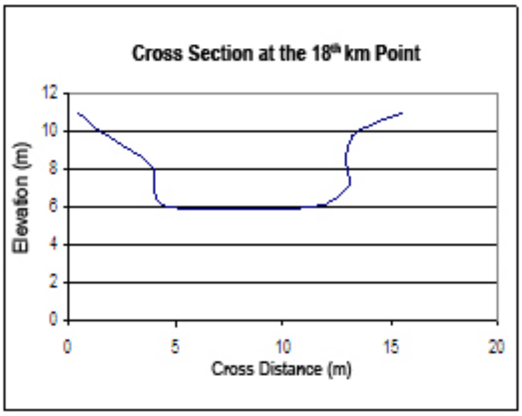


Figure 4.2 Upstream Boundary Condition, Downstream Boundary Condition, and Initial Condition.


CROSS SECTION AT THE UPSTREAM POINT
Cross Distance (m)


Cross Section at the 2nd km Point
14
12
10
8
6
4
2
0
Elevation (m)
0
2
4
6
8
10
12
14
16
Cross Distance (m)


Cross Section at the 7th km Point
14
12
10
8
6
4
2
0
Elevation (m)
0
5
10
15
20
Cross Distance (m)


Cross Section at the 18th km Point
12
10
8
6
4
2
0
Elevation (m)
0
5
10
15
20
Cross Distance (m)

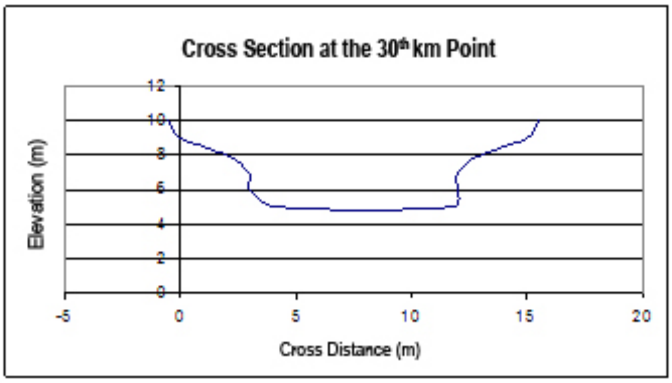


Figure 4.3 Cross Section at the 0, 2nd, 7th, 18th, and 30th km

Result and Discussion

Result

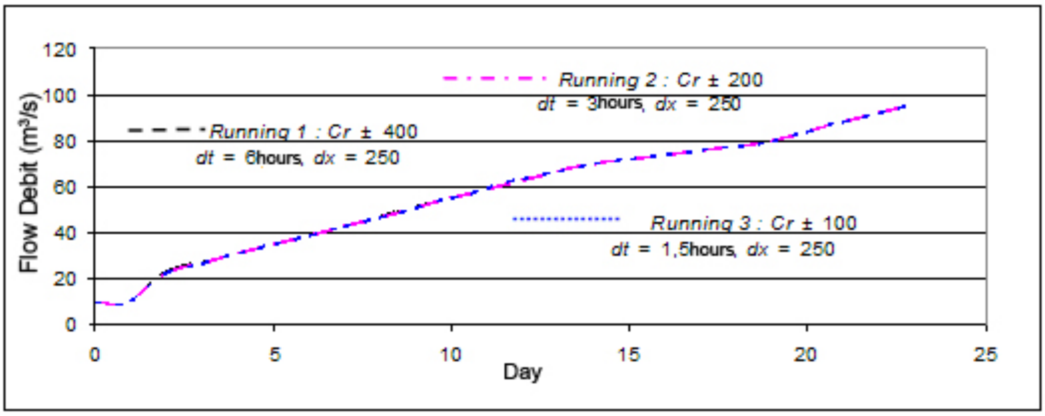


Figure 5.1 Comparison of flow debit on the 2nd km point (with 2000 m distance from upstream) with (dt= 6 hours, dx=250 m), (dt=3 hours, dx =250 m) and (dt=1,5 hours, dx = 250 m)

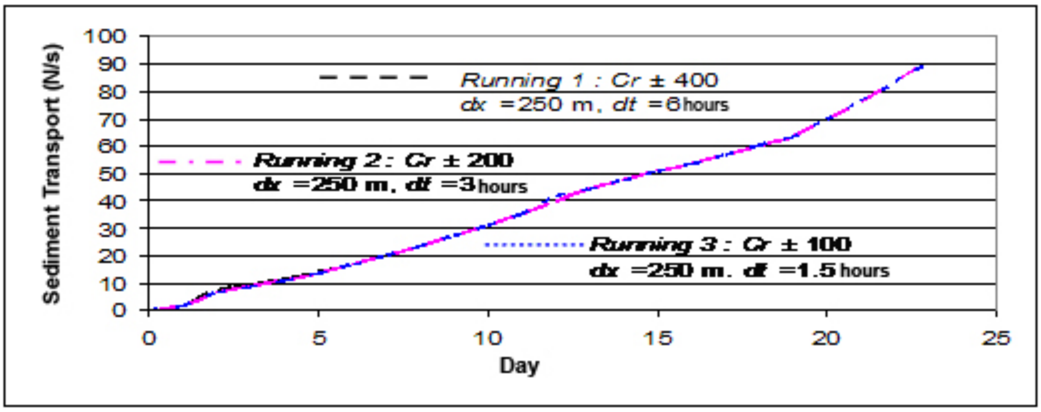


Figure 5.2 Comparison of sediment transport on the 2nd km point with (dt= 6 hours, dx=250 m), (dt=3 hours, dx =250 m) and (dt=1,5 hours, dx = 250 m)

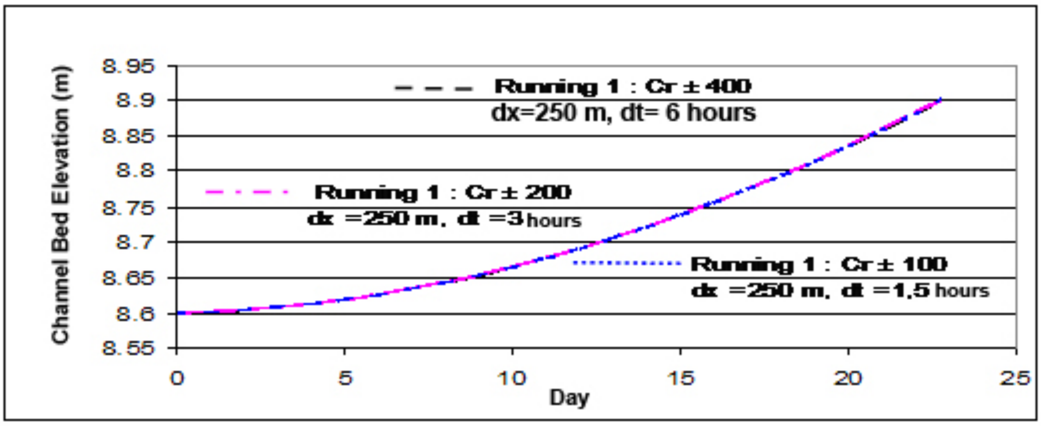


Figure 5.3 Comparison of channel bed elevation on the 2nd km point with (dt= 6 hours , dx=250 m; dt=3 hours, dx=250 m; and dt=1,5 hours; dx=250 m)

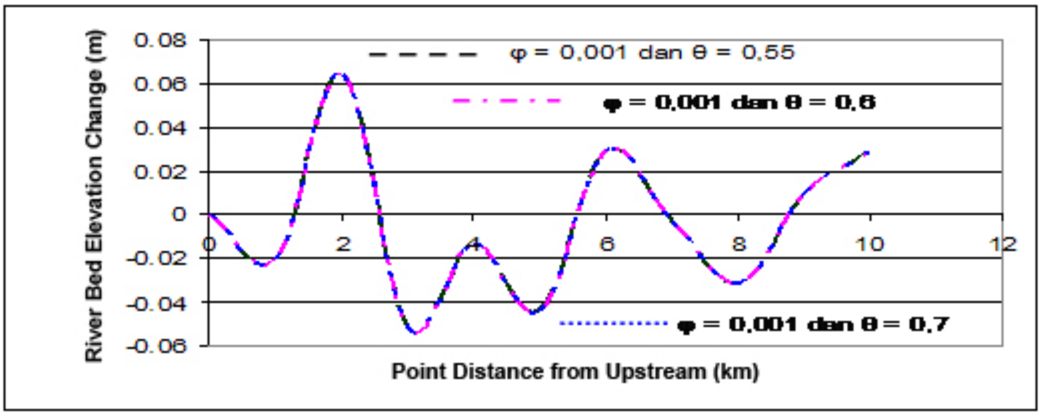


Figure 5.4 Comparison of river bed elevation change on day 10 with (dt=1,5 hours, dx=250 m, $\varphi = 0{,}001$), between $\theta = 0{,}55$, 0,60 dan 0,70)

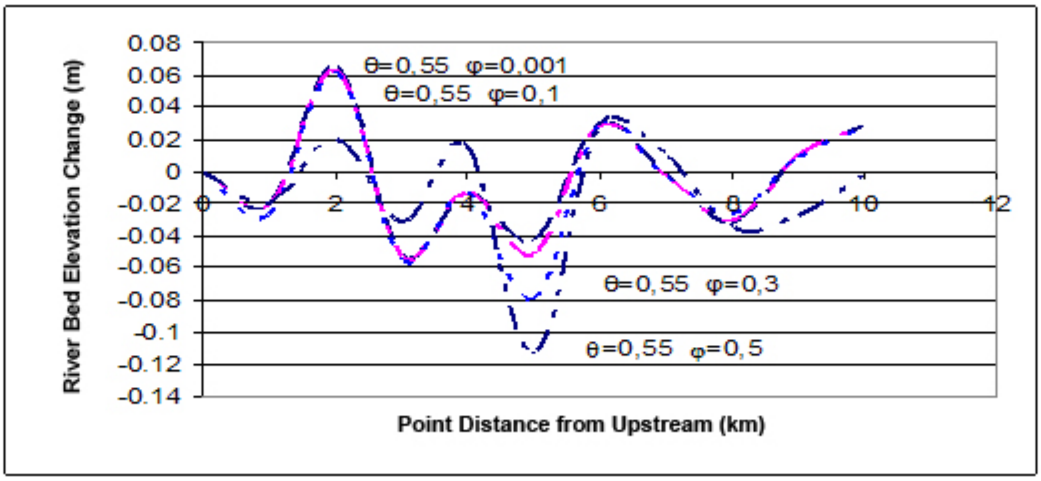


Figure 5.5 Comparison of river bed elevation on day 10 with (dt=1,5 hours, dx=250 m, $\theta = 0{,}55$) between $\varphi = 0{,}001$, 0,01 dan 0,5)

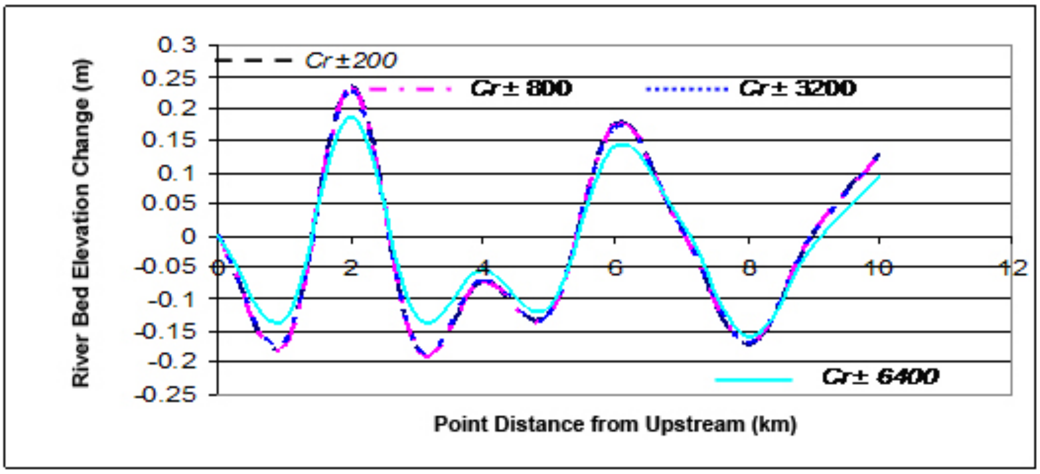


Figure 5.6 Comparison of river bed elevation change on day 10 with *Cr* number ± 200, 800, 3200 dan 6400

Discussion

From Figure 5.1 until 5.3, could be seen that even though we change the grid size ($\Delta x, \Delta t$), the result has the same *trend*, and the value are almost the same. This shows that the numeric solving is stable.

If we check the sediment transport continuity equation:

$$\Rightarrow \theta\left[\frac{Q_{si+1}^{n+1}-Q_{si}^{n+1}}{\Delta x}\right]+(1-\theta)\left[\frac{Q_{si+1}^{n}-Q_{si}^{n}}{\Delta x}\right]+(1-p)\gamma_s\left\{\varphi\left[\frac{Bz_i.\Delta z_i}{\Delta t}\right]+(1-\varphi)\left[\frac{Bz_{i+1}.\Delta z_{i+1}}{\Delta t}\right]\right\}=0$$

For the point of 2 km and 2.25 km, on day 20 and 20.5:

$$\Rightarrow 0,55\left[\frac{2,2312-2,162}{250}\right]+(1-0,55)\left[\frac{2,2114-2,1399}{250}\right]$$

$$+(1-0,3)25996,5\left\{0,001\left[\frac{7,25.(8,6239-8,6232)}{43200}\right]+(1-0,001)\left[\frac{6,95.(8,5403-8,5405)}{43200}\right]\right\}\approx 0$$

$$\Rightarrow -0,0003\approx 0$$

From that calculation, we could see that the model has accomplished the equation of sediment transport continuity on a control volume.

Using varied θ doesn't really change the result. This is shown on Figure 5.4, when we use φ=0,001 with θ=0,55, 0,6 and 0,7. However, it is different with φ, on Figure 5.5, could be seen the comparison of the river bed elevation change using θ=0,55 and φ=0,001; 0,1; 0,3 and 0,5. For φ=0,001 and 0,1 the results are almost the same, whether for φ= 0,3, the result still has the same *trend*, but different in value. Then, for φ=0,5 there is a *trend* difference; on point 4 km, there should be some erosion, but what is happening is sedimentation; and also on km 9 point, there should be sedimentation, but erosion occurs. It means that φ=0,5 could not be used. If we used φ> 0,6 , the program won't work. It could be concluded that it is better to use small φ which is about: φ < 0,1.

On Figure 5.6, could be seen that by using *Cr* number = 200, 800, 3200, and 6400, the scheme is still stable. However, when it is tried using *Cr* number=12800, the program could not work. It means that the highest constraint of the *Cr* number is 6400 for this case.

For the sediment management, excavation on some specific points should be planned so that there is no over sedimentation. If we see Figure 5.4, on point km 2, km 6, km 9 and km 10, excavations could be done.

Figure 5.7 shows a comparison the one with management and the one without. The management should be taken is:

Excavation in 2 km point, 6 km, 9 km, and 10 km point, with amount of 5,6 N/s; 2,35 N/s ; 0,4 N/s and 1,55 N/s.

Excavation amount as 1 N/s is the same with $\frac{1.24.3600}{25996{,}5} = 3{,}324\,m^3/\text{day}$.

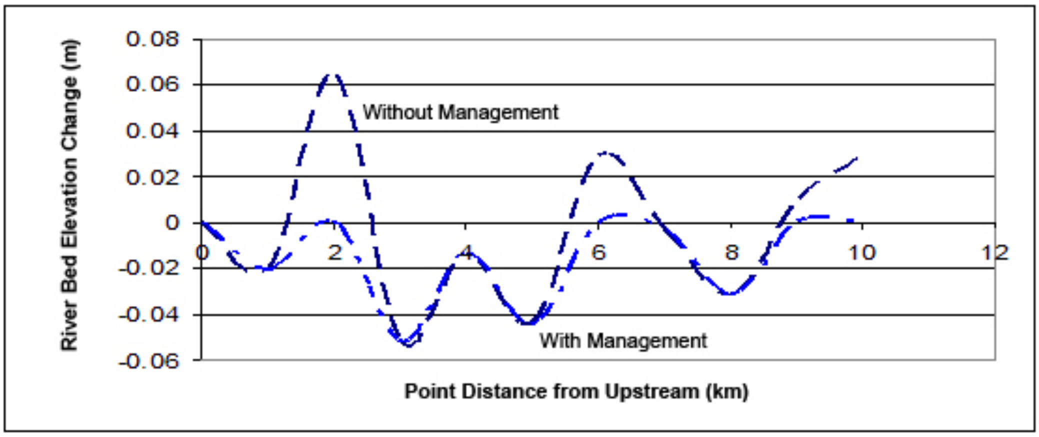


Figure 5.13 Comparison of river bed elevation change on day 10 (with and without management)

Conclusion and Recommendation

Conclusion

From previous explanation, could be concluded that:

1) The model built in this research could be used to predict sediment transport in a river.
2) The finite difference equation is consistent with the original partial differential equation.
3) By changing the grid size (the $\Delta x, \Delta t$), could still be resulted the same *trend*, with almost the same value, it means that the numeric scheme is stable.
4) By taking the constant ratio of $\Delta t / \Delta x$, the smaller the Δx, the result will be closer to a specific value which is the real solved value. It means that the numeric solution is convergent.
5) After checked logically using related theories (theories about sediment transport continuity, uniform permanent flow, M1 and M2 curve, about sediment transport) could be concluded that the model goes along with the theories.

6) If compared with the parabolic model analytic solving, and other programs (simple numeric program DELTA, and HEC-6 program), the result's *trend* is the same, even though there are differences in their values. These are caused by varied assumptions and approaches used by the model and the other programs.
7) The use of varied time weighting factor (θ = 0,55 ; 0,60 and 0,70) doesn't really change the result, but by using varied spatial weighting factor (φ) will change the result. The spatial weighting factor φ > 0,60 could not be used, because the program won't work. The value φ =0,50 could not be used either, which could result in unstable scheme. It means that it is better to use small value of φ, less than 0,1.
8) The model could be used to predict the sediment transport on single river, without building, with small slope that transports almost uniformed sediment.
9) The numeric scheme could still be stable if we use the *Cr* number ≤ 6400.

Recommendation

It will be better if the model built also considering the changing of porosity, considering the *sorting armoring*, sediment particles gradation, and furthermore developed not only for single channel, but also developed for a river network.

References

Abbot, MB, 1979, *Computational Hydraulics,* Pitman Advanced Publishing Program, Boston.

Bambang A. Kironoto, 2001, *Teknik Sedimen,* Jurusan Teknik Sipil Fakultas Tenik Universitas Gadjah Mada, Yogyakarta.

Bambang Tri Atmojo, 1992, *Metode Numerik,* Beta Offset, Yogyakarta.

Budi WS, 1986, *Hidraulika Numerik*, PAU- Ilmu Teknik Universitas Gadjah Mada, Yogyakarta.

Budi WS, 1988, *Hidraulika Saluran Terbuka,* Kursus Singkat Hidrodinamika Sungai dan Estuari, PAU- Ilmu Teknik Universitas Gadjah Mada, Yogyakarta.

Cunge, J.A., Holly, F.M. and Verwey, A., 1980, *Practical Aspect of Computational River Hydraulics,* Pitman Publishing Ltd, London.

Djoko Luknanto, 1992, *Aliran Tidak Permanen 1-D untuk Saluran Tunggal,*Yayasan Areina, Yogyakarta.

Graf, W.,H., 1998, *Fluvial Hydraulics,* John Willey & Sons Ltd Baffins Lane, Chichester, West Sussex PO 19 IUD, England.

Istiarto, 2002, *Teknik Sungai,* Bahan Kuliah, Program Studi Teknik Sipil, Program Pasca Sarjana, Universitas Gadjah Mada.

Kironoto, Bambang A., 2001, *Teknik Sedimen,* Jurusan Teknik Sipil Fakultas Tenik Universitas Gadjah Mada, Yogyakarta.

Yang, C.T., 1996, *Sediment Transport,* The Mac Graw Hill Companies Inc., New York.

Yang, J.C., 1986, *Numerical Simulation of Bed Evolution in Multi Channel River System,* a thesis for PhD in Civil Engineering, Univ. of IOWA City.

…………, 2004, *HEC-6 V 4.2 User Manual,* US Army Corps of Engineers, California.

…………., 2007, *GSTAR-1D V 2.0 User Manual,* US Department of Interior Bureau of Reclamation Technical Service Center Sedimentation and River Hydrologic Group.

Vulnerability Study of Building Caused by Earthquake (Case study in Bantul housing)

Adi Setiabudi Bawono

Department of Civil Engineering Univeritas Teknologi Yogyakarta,

Master of Civil Engineering, Earthquake Engineering Management

Universitas Islam Indonesia

Email: adisetiabb@yahoo.com

Abstract

One of earthquake mitigation activities is to know the probability of damage to buildings and the estimated loss caused by the earthquake on each typical building in an area. In developed countries attempt to predict the probability of damage to buildings caused by the earthquake have been found. One method used is a method of HAZUS (Hazard United States). In evaluating damage to buildings, one of the methods HAZUS by assessing the probability of damage to each building in an area using Fragility curve. In Indonesia, research on the Fragility Curve is still less. This study is an initial study to develop a Fragility curve which in turn will be compared with the version HAZUS Fragility curve building, so that it can be seen a typical residential buildings in Bantul, near the type of building whether in the United States.

This study uses data reference damage to housing caused by the Yogyakarta earthquake May 27, 2006. Studied housing is housing that has the same type of building, which houses tembokan with retrofitting. Map data used mikrozonasi Bantul is a map Pariatmono (2008). The data collected includes data characteristic of houses and damage. House defects studied using media images or interviews with houseowners. To determine the probability of damage using FAHP (Fuzzy Analytic Hierarchy Process). Conclusions obtained from this study is that housing in Bantul are studied when compared with the type of building types URML tembokan HAZUS approach (Unreinforced Masonry Bearing Walls)

Key words: earthquake mitigation, reseidential building, FAHP, HAZUS

Introduction

Events of the past May 27, 2006 was a historical day for our nation Indonesia, especially for the city of Yogyakarta. On that date a very powerful earthquake rocked the province of Yogyakarta and surrounding areas. The impact of the earthquake May 27, 2006 in Yogyakarta causing damage to building structures and infrastructure, public facilities, tourist attractions and places of public business.

The number of casualties and victims of property damage was often caused by the building. The number of casualties and victims of property can be minimized if mitigation efforts have been made. One of the methods used in the United States to evaluate building damage using HAZUS software with a variety of studies therein. HAZUS methods in evaluating damage to buildings is to assess the probability of damage to each building in an area using Fragility curve. Fragility curve is a curve that shows how much the level of vulnerability of buildings when the quake hit, both for the extent of the damage slight, moderate, extensive, and complete. The value of the probability of damage indicates the level of vulnerability (vulnerability) of the building due to earthquake shaking (ground shaking). With the Fragility curve can be used in an attempt to mitigate the disaster before the earthquake in the future.

Problem Formulation

Fragility curve in basic research, the problems to be solved include:
1. What is the probability of damage to five houses in the town of Bantul, which will be studied?
2. When compared with the HAZUS buildings, residential buildings in Bantul is close to what type of building?

Aim of Research

Comparing the calculated probability of damage to residential buildings in Bantul, with the calculated probability of HAZUS damage. By comparison it can be seen approaching the type of building whether residential buildings in Bantul when compared with HAZUS building.

Research Limitation

The study was limited to the description as follows:

1. Study sites located in Bantul district, because the area is the area most damaged houses, caused by the earthquake May 27, 2006
2. A case study using the same type of building that is housing
3. The building under study is assumed to have the same composition structure
4. Builders and construction methods are considered equal
5. PGA values are researched by our house mikrozonasi Bantul made by Pariatmono, 2008
6. Response spectrum is used as the reference is inelastic response spectrum based on research conducted MAE Center (Mid-America Earthquake Center), 2006 with a value of ductility
7. Seismic design code values are low seismic design code
8. Analysis of the damage probability studies using Fuzzy AHP
9. Verification carried out by the results of research in other areas but still within the city of Bantul.

Benefit of research

Benefits to be achieved in this study are:

1. For governments, this study can be used as one of the mitigation efforts when an earthquake occurred in the future.
2. For seismic research, this study can be used as a material consideration in bridging the research level of probability of damage (damage probability) in a wider area.

References review

Quake

Sarwidi (2002) interpreted the earthquake as a vibration/shock at the base or footing. Because human life on earth, then the basis is the foundation of the earth / ground. Widodo (2006) mentioned that the quake was tectonic earthquakes are generally large compared to most types of other earthquakes. Boen (2006) in his account of the earthquake May 27, 2006, mentioned that there are differences in the intensity and location of the epicenter of the earthquake that occurred in Yogyakarta, central reference seismic surveys used were the USGS (United State Geological Survey), NIED (National Institute for Educational Development) and BMG (Meteorological and Geophysical Agency).

Building vulnerability and loss estimation due to Earthquake

Dargush et al (2002) in his paper, research on the estimated losses in the area around the New York area. Tantala (2002) focused his research on high-rise buildings that are vulnerable due to earthquake loading. Gulati (2006) conducted a study on reducing the risk of losses caused by the devastating earthquake in the Indian city of Dehradun. Chang and Song (2006) in cooperation with the MAE (Mid-America Earthquake Center) conducted a study estimate losses caused by the uncertainty of the earthquake on the social and economic sectors within a region, using a numerical approach. Grossi (2006) conducted research on disaster risk reduction caused by the earthquake using the probability approach, case study research is the area of Oakland California. Sarwidi and Winarno (2006) studied the comparative study of earthquake losses May 27, 2006 in the residential sector between the estimate and the actual losses. BAPPEDA Bantul (2006) noted in its report losses arising from the earthquake on 27 May 2006 in terms of economic, social, educational, etc. complete. Bayudono (2007) in the general course of disaster management stated that due to the earthquake last May 27, 2006 a lot of losses in terms of both property and lives.

Analysis using HAZUS and Fragility Curve

NIBS (2002) makes an Earthquake Loss Estimation Methodology guide by the name of HAZUS 99 Service Release 2. Dargush (2002) using HAZUS software to find the probability of damage to buildings using Fragility curve. Tantala (2002), making the simulation of the losses caused by the earthquake, the values obtained using Fragility curve of probability of damage due to ground shaking (ground shake). Gulati (2006) using HAZUS software to help process the data obtained. Scenario earthquake is taken Chamoli earthquake in Dehradun (Uttaranchal) in 1999. Chang and Song (2006) in his research review of a scenario earthquake that causes damage to buildings, liquefaction and building damage level (damage states) using Fragility curve. Grossi (2006) conducted a study of vulnerability of buildings using HAZUS software, which relies on information technology and geographic information systems in the mapping space.

Analysis of Fuzzy Analytic Hierarchy using Process (FAHP)

Siswanto and Yudhanto (1999) analyzed the factors affecting the selection mode to campus using the method Analythic Hierarchy Process (AHP). Buldan (2001) in his thesis entitled "Housing Site Selection In Yogyakarta Special Region" examines the selection of the best locations of the five alternative sites in Yogyakarta, ie Dalkeith, Lahore; Tegalrejo, Yogyakarta, Depok Sleman; Banguntapan, Bantul, and Sewon, Bantul. Hsieh, et al (2004) selecting alternatives of development planning and implementation of public office using Fuzzy Analytic Hierarchy Process approach (FAHP). Setiyoko, Ciptomulyono and Gunarta (2005) conducted a study on the allocation of decision-making facility that involves many factors in nature and does not cause conflict.

Review of the literature in this study using the research literature from other people who've done as well as through relevant approaches tailored to conditions in Indonesia, particularly in the area of Bantul.

Authenticity of research

Differences in this study with a review-review of the literature in the next section is:

1. Research on the vulnerability of buildings in this thesis is the initial basic research that has never been in Indonesia for residential case study in Bantul in the scope of the same type of house. This study as an initial study Fragility curve creation in Indonesia.
2. In looking for the probability of damage to each house used Analytic Hierarchy Process Fuzzy method (FAHP). Research using FAHP to find the value of the probability of damage to buildings, have never encountered before both outside and inside the country.

Basis of Theory

HAZUS (Hazard United States)

Nibs (The National Institute of Building Sciences) developed the software with the name of HAZUS for the assessment of risk due to various disasters with a variety of studies included those Fragility curve. This software is issued by FEMA (the Federal Emergency Management Agency) in 1997 to estimate losses from earthquakes in the United States. The latest version of the software is launched in January 2005 with the name of the HAZUS MH MR-1 for risk assessmen earthquake disaster, including floods and hurricanes. HAZUS for earthquake disaster was launched in early 2003 as part of an analysis of disaster risks. With this software users can estimate the loss and damage to buildings and infrastructure caused by the earthquake.

Fragility Curve

One of the earthquake disaster risk reduction efforts in the USA (United State of America) is to develop Fragility curve at each building who were there, which is also contained in HAZUS. Fragility curve is a curve that shows how much the probability of the vulnerability of buildings when the quake hit. (Nibs, 2002).HAZUS Fragility curve divide method is different for the four state level of damage in each building, or it can be said that every building when the quake would have four categories of damage is slight (mild), moderate (moderate), extensive (severe) or complete (collapsed). With the Fragility curve can be determined how much the level of probability on the four categories of damage to each house. With known how much the probability of damage to each house studied, can be used in an attempt to mitigate earthquake disasters before they happen in the future.Example Fragility curve shape as shown in Figure 1.

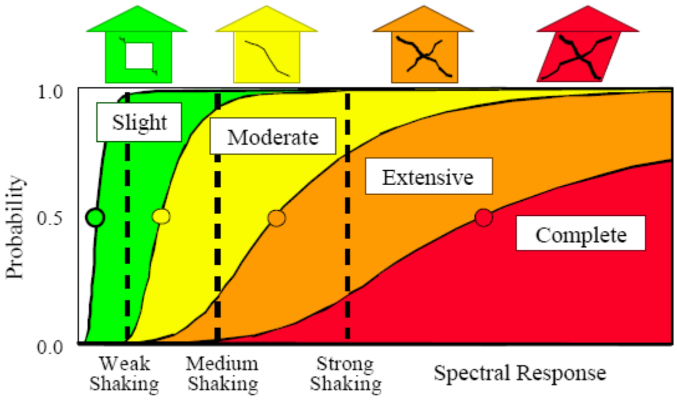


Figure 1 Fragility curve (NIBS, 2002)

Version of HAZUS Model Building and in Yogyakarta

In this study will be compared between the five houses in Bantul studied 16 types of buildings with the American version of HAZUS. To 16 types of buildings are distinguished as in Table 1 below:

Table 1 Model Building HAZUS (NIBS,2002)

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1 2	W1 W2	Wood, Light Frame (≤ 5.000 sq. Ft) Wood Commercial and Industrial (> 5.000 sq. Ft)		1 – 2 All	1 2	14 24
3	S1L	Steel Moment Frame	Low-Rise	1 – 3	2	24
4	S2L	Steel Braced Frames	Low-Rise	1 – 3	2	24
5	S3	Steel Light Frame		All	1	15
6	S4L	Steel Frame wit Cast-in Place Concrete Shear Walls	Low-Rise	1 – 3	2	24

7	S5L	Steel Frame With Unreinforced Masony Walls	Low-Rise	1 – 3	2	24
8	C1L	Concrete Moment Frame	Low-Rise	1 – 3	2	20
9	C2L	Cocncrete Shear Walls	Low-Rise	1 – 3	2	20
10	C3L	Concrete Frame with Unreinforced Masonry Infill Walls	Low-Rise	1 – 3	2	20
11	PC1	Precast Concrete Tile-Up Walls		All	1	15
12	PC2L	Precast Concrete Frames with Concrete Shear Walls	Low-Rise	1 – 3	2	20
13	RM1L	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms	Low-Rise	1 – 3	2	20
14	RM2L	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms	Low-Rise	1 – 3	2	20
15	URM L	Unreinforced Masonry Bearing Walls	Low-Rise	1 – 2	1	15
16	MH	Mobile Houses		All	1	10

The results of the team recconaisance CEEEDEDS UII (Center for Earthquake Engineering, Dynamic Effect, and Disaster Studies, Islamic University of Indonesia), it appears that the houses in Bantul area proved to have a wide range of typical, example is the bamboo house, gedek house, tembokan house without retrofitting , tembokan with retrofitting houses, and so forth. Almost all the buildings in Bantul, especially ancestral built using only buildings constructed without strengthening the structure, using only the reinforcement in the form of stacked bricks. Figure 2 is an example of pictures of the house in Bantul.

Figure 2 Houses in Bantul (BAPPEDA, 2007)

The houses in residential houses studied were tembokan with retrofitting. The purpose of this research is to investigate one of them when compared to the version of HAZUS building houses in the housing into what types of buildings

Figure 3 RM1 and URML USA Buildings (NIBS, 2002)

The probability of damage

The method used in this study is the method of Fuzzy Hierarchy Analythic PROCESS (FAHP). Most prominent difference between AHP and Fuzzy AHP is when calculating the matrix comparisons, AHP has a firm value (crisp), while the Fuzzy AHP has the vague (fuzzy), since in comparison calculations matris there dimungkingkan range (difference) in determining the comparative figures. For example: Linguistic scale Very Important (SAPs) by the AHP was assessed by the number 7 (crisp), but in Fuzzy AHP was assessed by (5,7,9) (fuzzy). It appears from these examples that the AHP is more assertive, in contrast to the Fuzzy AHP has a range, because the decision-making are no limits of tolerance, with a certainty value is 7

RESULTS

Comparison of the calculated probability of damage to the research and HAZUS type W1, W2, URML, and MH, when tabulated as in Table 2 below

Table 2 Comparison of the probability of damage

Research with W1, W2, URML, and MH

Type Building	Error				**AVERAGE**
	Slight	Moderate	Extensive	Complete	
W1	0.2660	0.2439	0.1530	0.0404	0.1758
W2	0.2084	0.1216	0.0752	0.0489	0.1135
MH	0.1956	0.1804	0.1127	0.0404	0.1323
URML	0.2657	0.3114	0.3321	0.1190	0.2570

In Table 2 can be concluded that the residential building types studied near W2 (Wood Commercial and Industrial) HAZUS. And when compared with tembokan building, close to typical buildings without retrofitting URML tembokan (Unreinforced Masonry Bearing Walls).

Comparison between the probability of damage to the building type W2 studies drawn as in Figure 4 below

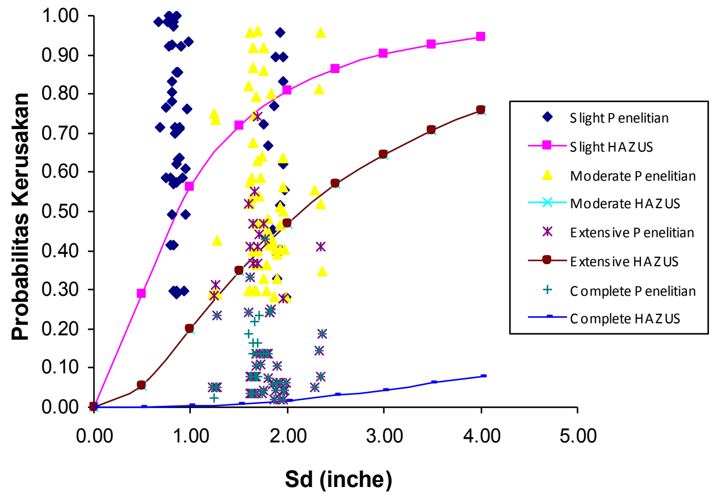


Figure 4 Probability of damage types W2 research and HAZUS all housing

Discussion

Discussion of test results of this study are as follows:

1. Inelastic response spectrum value is used as the reference (Elnashai, 2006) is higher than the value of the building capacity curve. Thus, not all buildings have a peak value of spectral displacement (Sd).
2. Research capacity value curve curve imposed in accordance with the capacity building in America, because Indonesia does not have the capacity curve of the building.
3. The study appears in the spectral displacement accumulate a very short, between 1-4 inches.
4. In this study can not form a graph Fragility curve, because in making a graph Fragility curve requires data very much. Data needed to make Fragility curve not only in one district area only, but possibly up to an island.
5. The houses which have been studied which are above and below the HAZUS Fragility curve but tends to be above Fragility curve, which means that the typical buildings studied had the probability of damage for each category tend to be larger than the HAZUS, so it may mean that more buildings in Indonesia worse than building in America.
6. When compared with all versions of HAZUS building types, housing types surveyed close to W2 (Wood Commercial and Industrial). And if only in comparison with typical tembokan buildings, residential buildings in residential-type approach URML Bantul (Unreinforced Masonry Bearing Walls).

Conclusion

Based on the results of research conducted at the residential-housing in the area of Bantul with models of buildings and building age were obtained conclusions based on the results of the analysis and discussion. The conclusion is that the probability of damage to each house is different, this is because the distance from the epicenter, the condition of the soil geology, topography, soil, and soil type are listed below each house. Value of the probability of damage are differentiated based on differences in the criteria of damage to each house.

When compared with tembokan version of HAZUS building, building diteiti in this study approached the building types without retrofitting HAZUS is tembokan or URML (Unreinforced Masonry Bearing Walls).

Recommendation

To develop this study in further studies, the suggestions of the researchers are:

1. Area of the study area be expanded in order to obtain a graph like the graph intact Fragility curve HAZUS Fragility curve.
2. Determination of criteria for each category of damage to the damage should be more didetailkan that when determining the probability of damage is closer to the results obtained with the probability of damage to HAZUS version.
3. Expert judgment should involve some experts really expert and familiar in the field of earthquake resistant buildings such as the professor of seismicity, and earthquake experts in Indonesia which already has a good track record.
4. Analysis of the probability of damage to each house, could use other methods, as efforts to improve the methods used now (Fuzzy AHP).
5. Need for research on building capacity curve in Indonesia, as a standardization in the building, as in America already has a standard curve values for each type of capacity building.
6. Seismic data should be collected in the collection and become a complete database in order to be used for research or other interests.
7. Preparation of the response spectrum by the earthquake in Indonesia need to be studied and researched further as a research effort for the benefit of our country.
8. Need for research on building capacity curve in Indonesia, as a standardization.
9. Can be selected for further study other types of buildings, a model of the building is different from the present study.
10. For further research can be developed to calculate the cost (cost) loss.

Acknowledgement

The autor say thanks to Prof. Mochammad Teguh, MSCE, Ph.D, Ir. Suharyatmo, MT, Prof. Widodo, MSCE, Ph.D, Ir. Setya Winarno, Ph.D, Ir. Akhmad Suradji, Ph.D, Prof. Sarwidi, MSCE, Ph.D, Ir. Albani Musyafa. Ph.D, Earthquake Engineering Management Concentration of Universitas Islam Indonesia, CEVEDS International (Center for Earthquake and Volcano Engineering and Disaster Studies), CEEDEDS UII (Center of Earthquake Engineering, Dynamic Effect and Disaster Studies Universitas Islam Indonesia), ICSBE UII (International Conference on Suistanable Built Environment) and Department of Civil Engineering Universitas Teknologi Yogyakarta.

References

Arikunto, S., (2006), *Prosedur Penelitian Suatu Pendekatan Praktik*, PT Rineka Cipta, Yogyakarta.

Arikunto, S., (2008), *Presentasi Kuliah Metodologi Penelitian dan Statistika Terapan*, Manajemen Rekayasa Kegempaan, Universitas Islam Indonesia, Yogyakarta.

BAPPEDA Bantul (Badan Perencanaan Pembangunan Daerah), (2008), *Laporan Perkembangan Monitoring Dan Evaluasi Kegiatan Rehabilitasi Dan Rekonstruksi Kabupaten Bantul Sampai Dengan Desember 2007*, BAPPEDA, Bantul.

BAPPEDA DIY (Badan Perencanaan Pembangunan Daerah), (2007), *Profil Daerah Istimewa Yogyakarta*, BAPPEDA, Yogyakarta.

BAPPENAS (Badan Perencanaan Pembangunan Nasional), (2006), *Buku Utama Rehabilitasi Dan Rekonstruksi Wilayah Pasca Bencana Gempa Bumi Di Provinsi Daerah Istimewa Yogyakarta Dan Provinsi Jawa Tengah*, BAPPENAS, Jakarta.

Bayudono, (2007), *Kuliah Umum Manajemen Kebencanaan S2 Manajemen Rekayasa Kegempaan*, Universitas Islam Indonesia, Yogyakarta.

BMG (Badan Meteorologi dan Geofisika), (2006), *Teori Seismologi, Balai Besar Meteorologi & Geofisika Wilayah II Ciputat, Jakarta*, www.bbmgwil2.bmg.go.id/penyebabgempabumi.php; akses tanggal 6 Februari 2009.

BMG (Badan Meteorologi dan Geofisika), (2008), *Presentasi BMG Informasi Dini Dan Kesiapsiagaan Masyarakat Terhadap Terjadinya Bencana, Forum Dialog Publik (FDP) "Membangun Gerakan Bersama Dalam Pencegahan Dan Penanganan Bencana"*, Yogyakarta.

Boen, T., (2006), *Yogya Earthquake 27 May 2006, Structural Damage Report*, EERI Report, USA.

Buldan, H., (2001), *Thesis Pemilihan Lokasi Perumahan Di Daerah Istimewa Yogyakarta*, Magister Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

CEEDEDS UII (Center for Earthquake Engineering, Dynamic Effect, and Disaster Studies) Universitas Islam Indonesia, (2006), *Manual Bangunan Rumah Rakyat Tahan Gempa (BARRATAGA) Edisi 04 Revisi 00*, Kerjasama CEEDEDS UII dengan Pemerintah Jepang, Yogyakarta.

Chang, L, Song, J., (2006), *Systematic Treatment Of Uncertainty In Consequence-Based Risk Management Of Seismic Regional Losses,* A Report of the Mid-America Earthquake Center, Mid-America Earthquake Center1241 Newmark Civil Engineering Laboratory 205 North Mathews AvenueUniversity of Illinois at Urbana-ChampaignUrbana, Illinois 61801.

Dargush, Andrea, S., Augustyniak, M., Deodatis, G., Jacob, H, K., McGinty, L., Mylonakis, G., Nordenson, G,J,P., O brien, D., Stanford, S., Swite, B., Tantala, M, W., Wear, S,. (2002), *Estimating Earthquake Losses for theGreater New York City Area, page 173 – 184*, Department of Finance, and Dr. A. N. Shah, Metropolitan Transportation Authority/New York City Transit Agency, for their generous assistance.

Douglas, J., (2001), *A comprehensive worldwide summary of strong-motion attenuation relationships for peak ground acceleration and spectral ordinates (1969 to 2000)*, ESEE Report No. 01-1 January 2001, Engineering Seismology and Earthquake Engineering, Imperial College of Science, Civil Engineering Department London.

DPU (Departemen Pekerjaan Umum), (2006), *Laporan Penanganan Bencana Gempa Bumi Yogyakarta Dan Jawa Tengah*, DPU Jateng.

Elnashai, A, S., Kim, S, J., Yun, G, J., Sidarta, J., (2006), *The Yogyakarta Earthquake of May 27, 2006*, Mae Center Report No.07-02, Mid-America Earthquake Center.

FEMA 154, 2002, *Second Edition Rapid Visual Screening Of Buildings For Potential Seismic Hazards: A Handbook*, Federal Emergency Management Agency 154/ March 2002, Washington DC.

FEMA 306, 1998, *Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings*, Federal Emergency Management Agency, 1998, Washington DC.

Gulati .B, (2006), *Earthquake Risk Assessment of Buildings: Applicability of HAZUS in Dehradun, India*, International Institute For Geo-Information Science And Earth Observation Enschede, The Netherlands.

Grossi, P, A, (2006), *Quantifying The Uncertainty In Seismic Risk And Loss Estimation*, Department of Operations and Information Management,The Wharton School, Philadelphia, PA, USA.

Hsieh, TY., Lu, ST., Tzeng, GH., (2004), *Fuzzy MCDM Approach for Planning and Design Tenders Selection in Public Office Buildings*, International Journal of Project Management 22 (2004) 573-584: 573-583, ELSEVIER Ltd and IPMA.

Irwansyah, (2007), *Kegunaan Teknologi GPS Dalam Berbagai Aspek Kehidupan*, http://www.waena.org/wiki/Sistem_Informasi_Geografis; akses 20 Januari 2008.

Kusumadewi, S., Purnomo, H., (2004), *Aplikasi Logika Fuzzy Untuk Pendukung Keputusan*, Penerbit Graha Ilmu, Yogyakarta.

Kusumadewi, S., Hartati, S., Harjoko, A., Wardoyo,. R, (2006), *Fuzzy Multi Attribute Decision Making (Fuzzy MADM)*, Penerbit Graha Ilmu, Yogyakarta.

Kusumadewi, S., (2008), *Presentasi Kuliah Sistem Informasi Kebencanaan, Manajemen Rekayasa Kegempaan*, Magister Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

NIBS,(2002). HAZUS (Hazard US), 1999: *Earthquake Loss Estimation, National Institute of Building Sciences*, Washington DC.

Pariatmono,(2008), *Science and Technology Role in Earthquake Mitigation,* Workshop on Housing Construction on the High-Risk Earthquake Zone, Jakarta, March 18, 2008.

Porter, K. A., (2003), *Earthquake Engineering Handbook*, California Institute of Technology Pasadena, CA.

Saaty, T., (1991), *Pengambilan Keputusan Bagi Para Pemimpin*, Pustaka Binaman Presindo, Jakarta.

Sarwidi, (2002), *Diktat Kuliah Dasar – Dasar Kegempaan*, Jurusan Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

Sarwidi, Winarno S., (2006), *Laporan Penelitian. Kajian Perbandingan Kerugian Bencana Gempa 27 Mei 2006 Pada Sektor Rumah Tinggal Di Kota Yogyakarta Antara Kerugian Hasil Estimasi Dan Kerugian Aktual*, Jurusan Teknik Sipil, Fakultas Teknik Sipil Dan Perencanaan, Universitas Islam Indonesia, Yogyakarta.

Satrio, R.P, (2005), *Perilaku berbagai tipe rangka beton bertulang dengan dinding pengisi pasangan bata merah pada portal rumah sederhana,* Thesis Program Pasca Sarjana, Universitas Gajah Mada, Yogyakarta.

Setiyoko, AS., Ciptomulyono, U., Gunarta,. K, (2005), *Prosiding Seminar Nasional Nasional Manajemen Teknologi* I B 16, Program Studi Magister Manajemen Teknologi, Institut Teknologi Sepuluh November, Surabaya.

Setyawati, (2005), *Karakteristik pasca elastik dinding bata merah pejal dengan tulangan horizontal akibat beban statik,* Thesis Program Pasca Sarjana, Universitas Gajah Mada, Yogyakarta.

Siswanto, H., Yudhanto, S.A, (1999), *Penggunaan Metode Analytic Hierarchy Process dalam Menganalisa Faktor-Faktor yang Mempengaruhi Pemilihan moda ke kampus*, Dimensi Teknik Sipil Volume 1, No. 1 Maret 1999.

SNI (Standar Nasional Indonesia), (2002), SN-03-1726-2002 Tata Cara Perencanaan Ketahanan Gempa Untuk Bangunan Gedung, Badan Standarisasi Nasional (BSNI), Indonesia.

Suryadi, K., Ramdhani, A., (2002), *Sistem Pendukung Keputusan*, PT Remaja Rosdakarya, Bandung.

Tantala, W, M., Deodatisz, G., (2002), *Development Of Seismic Fragility Curves For Tall Buildings, 15th Asce Engineering Mechanics Conference*, Columbia University, New York, NY.

Universitas Muhammadiyah Yogyakarta, (2006), *Overview Gempa Jogja 27 Mei 2006*, Www.Elcom.Umy.Ac.Id; akses tanggal 12 Desember 2007.

USGS (United States Geological Surveys), (2006), *Magnitude 6,3-Java Indonesia*, http://earthquake.usgs.gov/eqcenter/eqinthenews/2006/usneb6/index.php; akses tanggal 12 Desember 2007.

Widodo, (2001), *Respons Dinamik Struktur Elastik*, UII Press, Yogyakarta.

Widodo, (2006), *Diktat Kuliah Teknik Gempa S1*, Jurusan Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

Widodo, (2008), *Presentasi Kuliah Evaluasi Struktur, Rehabilitasi dan Rekonstruksi*, Manajemen Rekayasa Kegempaan, Magistek Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

Winarno, S., (2007), *Disertasi chapter VI Research Methodology Seismic Risk Management of Non-Engineered Buildings, Inggris.*

Winarno, S., (2008), *Presentasi Kuliah Assessmen Resiko Kegempaan*, Manajemen Rekayasa Kegempaan, Magistek Teknik Sipil, Universitas Islam Indonesia, Yogyakarta.

The Importance of Equilibrium Beach Principle As A Protection Infrastructure for Coastal Area

Mochammad Meddy Danial

Lecturer

Faculty of Engineering, Tanjungpura University, Pontianak

Abstract

Shoreline is always change dynamically, very vulnerable and tend to experience erosion. Recently, structure of coastal protection is not only used as a protection structure from wave action and erosion merely, but also used for creating a stable dynamic equilibrium coastline.

The aim of this paper is to design of coastal protection strurcture that is not only used as a coastal protection, but it can also be used as an protection infrastructure of coastal area based on the principle of stable dynamic equilibrium coastline. The simulation of coastline change due to coastal protection structure by using GENESIS software is conducted to know the effect of coastal structure on coastline change and to find out about how long it takes to reach a stable dynamic equilibrium coastline condition. There are four types of coastal defence structure, namely groin T, groin I, and parallel and inclined offshore breakwater. Each type is simulated to find out the impact on coastline change and to find out which types of coastal structure that can shape a stable dynamic equilibrium coastline, effectively.

In general, the results are quite successful in modeling coastline change due to coastal protection structure. Among the four of coastal structure types, T groyne type is better than other types because it can efectively create a stable dynamic equilibrium coastline. Furthermore, the shape of coastline created by T groin is very natural, beautiful and more aesthetic. The equilibrium point of coastline change can be reached around five years. The coastline still change around 4 m/year from one to five years.

***Keywords**: coastline change, stable dynamic equilibrium coastline, coastal protection infrastructure, coastal area.*

Background

Coastal erosion is a major problem that is often experienced on coastal areas in many places in the world. In the past and even in recent years, we have often seen that handling of coastal erosion is only viewed in narrow aspect and sometime only have one function merely, namely just build such a coastal protection structure without another function. This concept should not be applied again in the future.

A new concept with several methods have already been developed to handling coastal erosion problem with several functions, not only one function merely. In principle, all these methods only have one goal, namely for creating a stable dynamic equilibrium coastline condition by using the hard solution.

In the world, there are a lot of examples that can reflect the condition of stable dynamic equilibrium coastline using hard solution. For example are the East coast park in Singapore and Nusa Dua Beach in Bali island are such a good example for understanding the philosophy of stable dynamic equilibrium coastline condition. East coast park is a reclamation area protected by artificial headland breakwater along the coastline. The shape of coastline is similar to parabolic form or commonly known as crenulate shape or bay shape. In Nusa Dua Beach Bali, there are several groins along the coast that not only functioned as coastal protection structure but also functioned as an infrastructure that cannot be separated as unity of area.

Another important concept besides the stable dynamic equilibrium coastline is that the coastal area must be seen as an infrastructure. The concept of coastal protection infrastructure cannot be separated in the context of coastal area development. Thus, coastline as an integral part of coastal area must also be seen as an infrastructure. Based on the physical aspect, along coastal area usually is consists of sand, mud or rock, mangrove, etc, and therefore, the coastal area has a very high value and every lost of them must be taken into account and cannot be neglected.

The concept that a coastal area can also be regarded as an infrastructure is very important think, but unfortunately, many people including stakeholders don't realize about it. Essentially, the coastline is a borderline that separates the sea area and the land area that become such a benchmark for the existence of coastal area it self. If borderline or coastline has experienced such a retreat of land or erosion problem, then the consequence is that it can cause some parts of the coastal area diminished. This occurrence can cause such a severe damage condition for coastal area if the erosion problem cannot be overcome.

This paper tries to design such a protection structure that not only functioned as a coastal protection, but it can also functioned as a coastal protection infrastructure for coastal area. Need to notice, although a soft solution is better than such hard solution from environment aspect, it must be atmitted that almost all country have built up coastal protection using hard solution method. In Europe, for example, there are about 70% of coastal protections using hard solution [1].

Objective

The objective of this paper is to design of coastal protection structure that can fulfill the condition of stable dynamic equilibrium coastline.

Methodology

Four different types of coastal structure is simulated using Genesis software for knowing the change of coastline due to the coastal protection structure. For running the simulation by using the genesis software, several data is required, namely, daily wind data, bathymetry, wave height and periods, coastline and sediment parameter such as grain size d_{50}, density ρ and porosity p.

Because there is no calibration with respect to numerical model, several simulations are conducted to see the behaviour for each simulation. The sensitivity of the models for each simulation can be seen from their behaviours.

Each type of coastal structure is simulated and then the result of coastline change is analyzed and depicted graphically using excel data sheet in order to be able to see the influence of structure with respect to coastline change.

For the simplicity of the analysis, the dominant wave direction is limited only from the North direction. The length of time of simulated coastline change is for 10 years, namely from 2011 to 2021. The significant wave height (H_S) is varied from 0.1 m to 3.0 m and the periode (T) from 3s to 8 s. Grain size diameter (d_{50}) is 0.004 mm, the density (ρ) is 2660 kg/m^3, the porosity (*p)* is 0.624 %.

Equilibrium coastline

The equilibrium coastline is a unique shape and naturally this type already exist along time ago prior to the human intervention in the coastal managament [2]. The shape of the equilibrium coastline is similar to such a pocket beach, or so-called as headland bay beaches or crenulate-shaped bays. Due to this type, a coastline is allowed to retreat until it reaches an certain equilibrium condition.

The shape of equilibrium coastline in nature is then adopted by some experts of coastal engineer to manage the coastal erosion in order to stabilize the coastline dynamically. Such a type of equilibrium coastline have an interesting features, such as beautiful and attractive form, and can blend with nature, so that this type is quite popular to be applied in country around the world. The equilibrium coastline can be created by built such a coastal protection structure like artificial headland, groin type T or type Y and also offshore breakwater.

Software of coastline change

In principle, coastline change is natural process occurred in the time scale and space scale. But, coastline change, especially for erosion phenomena can experience accelerated erosion due to two main factors. The first factor is because of man activity such as sand mining, shrimp farming. The second factor is because of natural activity such as regular wave action, storm wave, longshore sediment transport, combination of several individu factors, etc.

Genesis is widely used for engineering use in order to predict the shorline change based on the one-line theory. Genesis is a usefull tool for planning process especially for detemining the efectiveness of coastal protection structure associated with shoreline change. The governing equation within genesis software consists of two main equations, namely the empirical sediment transport formula and the conservation of sand volume equation, which can be written below [3].

$$\frac{\partial y}{\partial t}+\frac{1}{\left(D_B+D_C\right)}\left[\frac{\partial Q}{\partial x}-q\right]=0 \quad \text{(conservation of sand equation)}$$

$$Q=\left(H^2 C_g\right)_b\left[a_1\sin 2\theta_{bs}-a_2\cos\theta_{bs}\frac{\partial H}{\partial x}\right]_b \quad \text{(sediment transport formula)}$$

$$a_1=\frac{K_1}{16\left(\rho_s/\rho-1\right)\left(1-p\right)\left(1.416\right)^{5/2}}$$

$$a_2=\frac{K_2}{8\left(\rho_s/\rho-1\right)\left(1-p\right)\tan\beta\left(1.416\right)^{7/2}}$$

where Q : longshore sediment transport rate, ρ: density of water (*kg* / *m*^{3}), H_b: breaking wave height (m), c_g: wave group velocity K: nondimensional empirical constant, ρ_s: density of sand (*kg* / *m*^{3}), p: porosity of sand.

Location of erosion

Condition of severe coastal erosion is located between beach of Kalimantan village to beach Arung Parak village, with 3 km long. Arung Parak and Kalimantan beach dominated by sand beach and their common vegetation is coconut tree. According to the people of Arung Parak-Kalimantan beach, this coast has eroded with the erosion rate is approximately 4-8 m a year and causes two rows of coconut trees along the coast vanished (See Figure 1).

Figure 1. Common vegetation at Arung Parak-Kalimantan Beach is coconut tree and vanished due to wave action.

Figure 2 indicates the net longshore sediment transport occurs from the North to the South along the coast. The physical evidence is a morphology trend of the river mouth along the coast from North to South which indicate that sand spit pattern is pointing downward or to the South direction

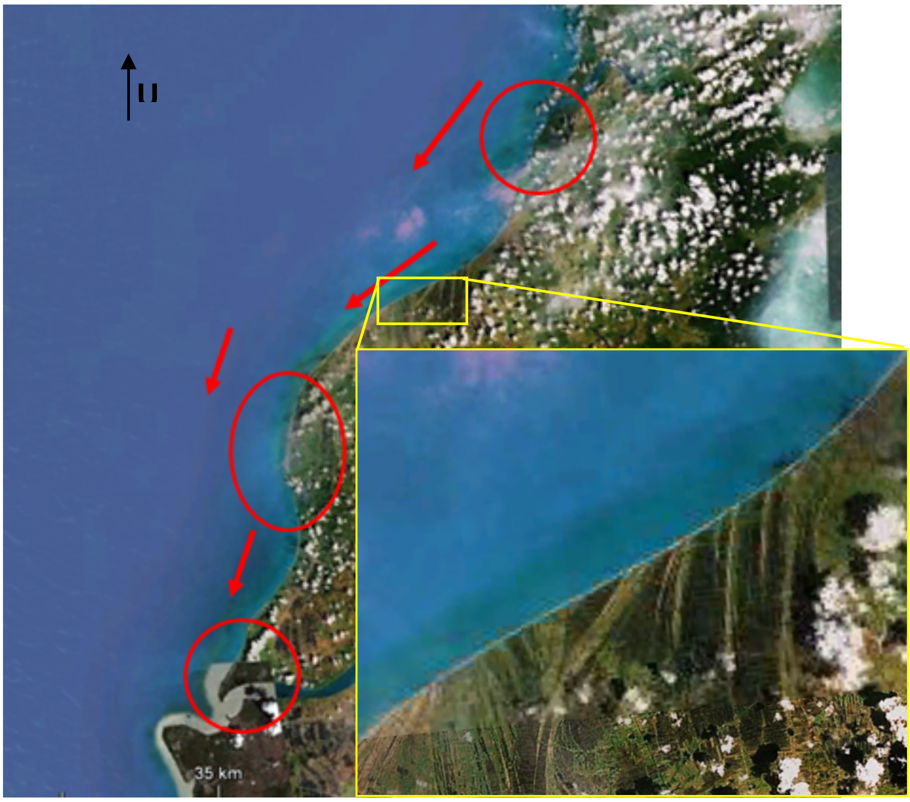
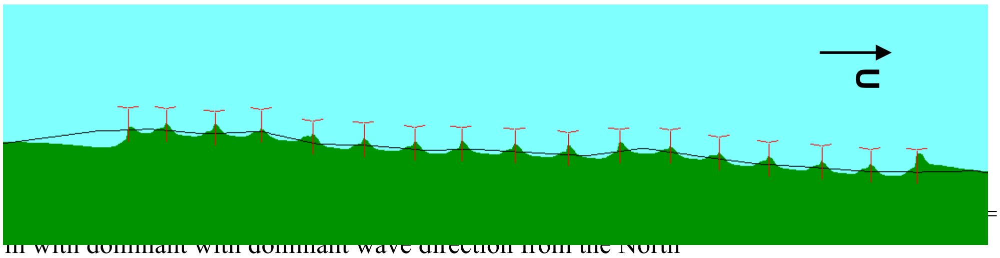


Figure 2. Morphology pattern of the net sediment transport from the North to the South along the coast

Results

First alternative is groin type T with the length of groin from shorline is 100 m and gaps width between groins (center to center) is 250 m. The length of the protected coastal area is about 3 km, which means there are about 14 units of coastal protection that will be built along the coast.



= 100
m with dominant with dominant wave direction from the North

Figure 3 shows that the dominant wave is propagating from North to South which mean that the sediment transport also move from North to South. From the results, the groin type T has the ability to form pocket beach between groins, which means it can produce stable equilibrium coastline where the salient process is also depicted along the coast. Nevertheless, at the most left of groin (at south side) will always experience erosion significantly.

Figure 4 shows the simulation of shoreline change for 10 years after construction, where the performance of groin type T is quite able to form equilibrium beach. The salient (protuding area) is formed from 20 m to 90 m with 40 m of average. The equilibrium pocket beach resulted from this model is reduced less than 20 m from existing coastline. But the left-most of groin T (downdrift area) need to be maintenance due to the significant erosion. The erosion at the left-most of groin area can reach about 70 m to the land.

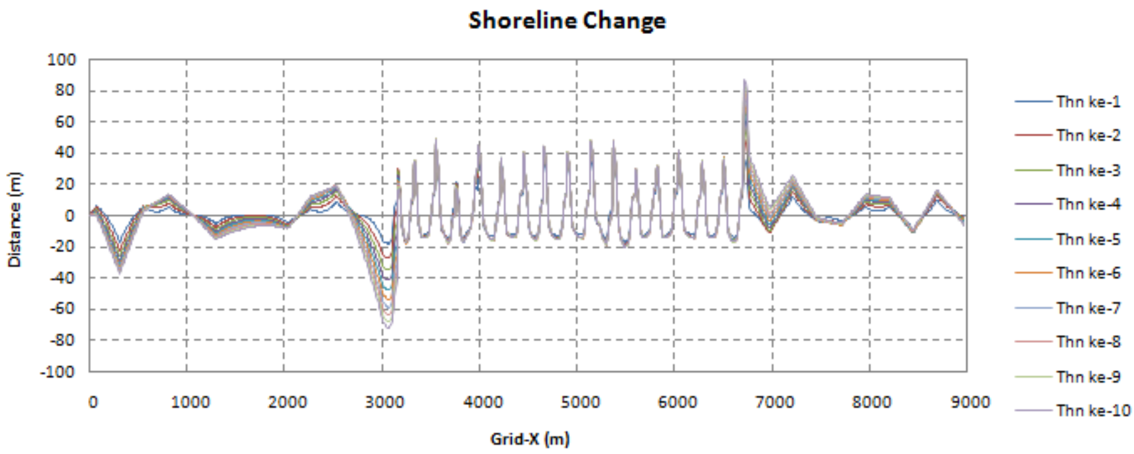


Figure 4. Shoreline change simulation from 1 year to 10 years for groin type T with dominant wave direction from the North

The second alternative of coastal protection is groin type I with 100 m long. The gap between groins is about 250 m. The reason for the use of this type is due to the evidence of coastal physical morphology behavior where the dominant wave direction from the North led to the sand spit pattern to the South along the coast. In addition, this type is choosed due to the reason of reduction of construction material and cost.

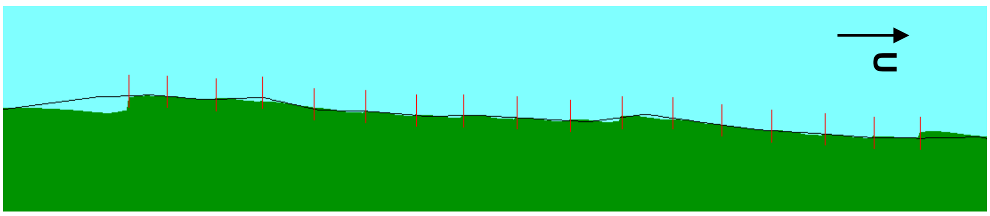


Figure 5. Pattern of oastline change of groins type I with the length = 100 m and dominant wave direction from the North.

Figure 5 shows that although the coastline is quite stable, the equilibrium coastline can not be created and the rythmic patterns of the coastline change can not quite appear. Figure 6 is the result of comparison for coastline change simulation during 10 year. It can be seen that the down drift area, the left-most of groin, suffers significant erosion due to the lack of sediment suplay to downdrift area as a result of the effect of multiple groins. The erosion impact of the left-most of groin area can reach about 70 m to the land.

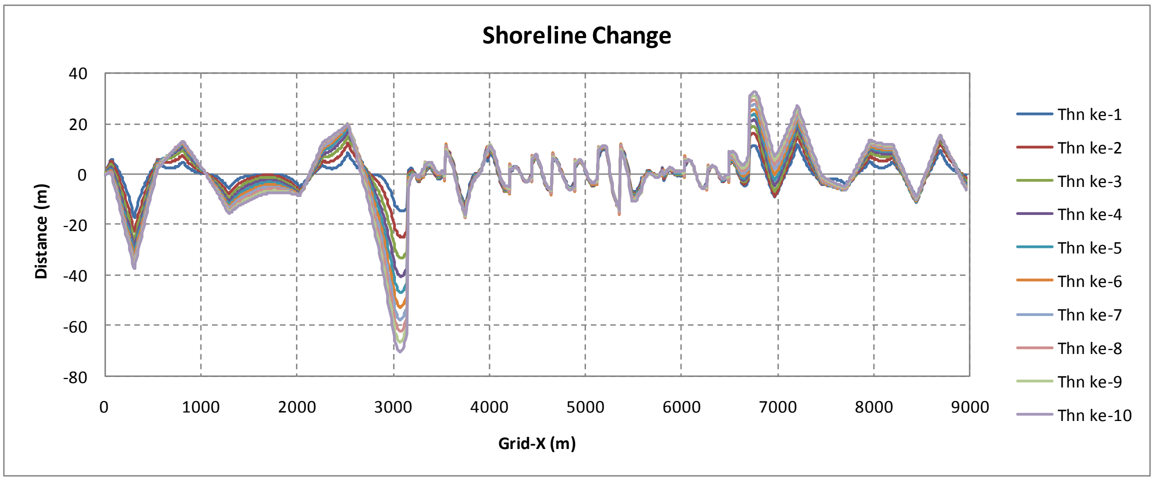


Figure 6. Coastline change simulation of groin type I and comparison of coastline change simulation during 10 years

In Figure 6, groin type I, due to the shape of groin which perpendicular with respect to the coastline, without headland at the outer end of groin, do not have the ability to withstand the wave propagation from the front direction (north-west direction). In this case, groin is only functioned as obstacle with respect to longshore sediment transport from side direction (parallel to the coastline).

The third alternative of coastal protection is parallel breakwater type. The main purpose of this model is to protect the coastal area from several direction, namely from the North, the West and the North-West. Figure 7 shows the simulation is conducted by using the dominant wave direction from North to South.

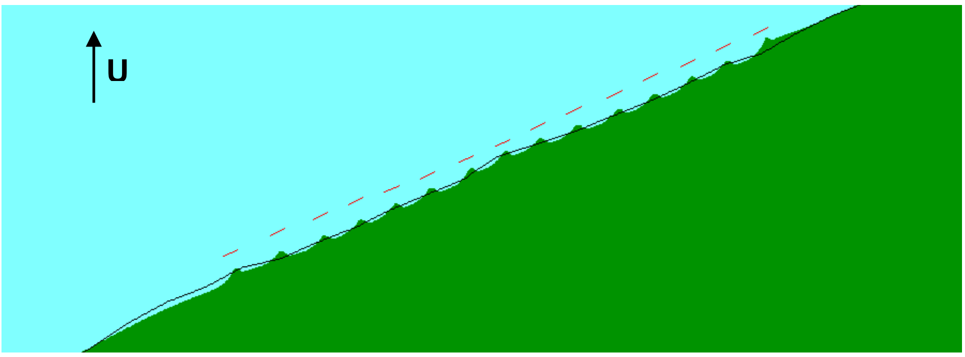


Figure 7. The pattern of coastline using parallel offshore breakwater with the distance from coastline y = 100 m and dominant wave direction from the North.

Figure 8 shows simulation of coastline change in 10 years, which indicates that the performance of parallel breakwater is quite good. However, the salient varies between 20 m – 40 m with 30 m of average and the shoreline retreat which form equilibrium pocket beach is around 15 m – 25 m. The erosion impact at the leftmost of parallel offshore breakwater area can reach about 40 m to the land.

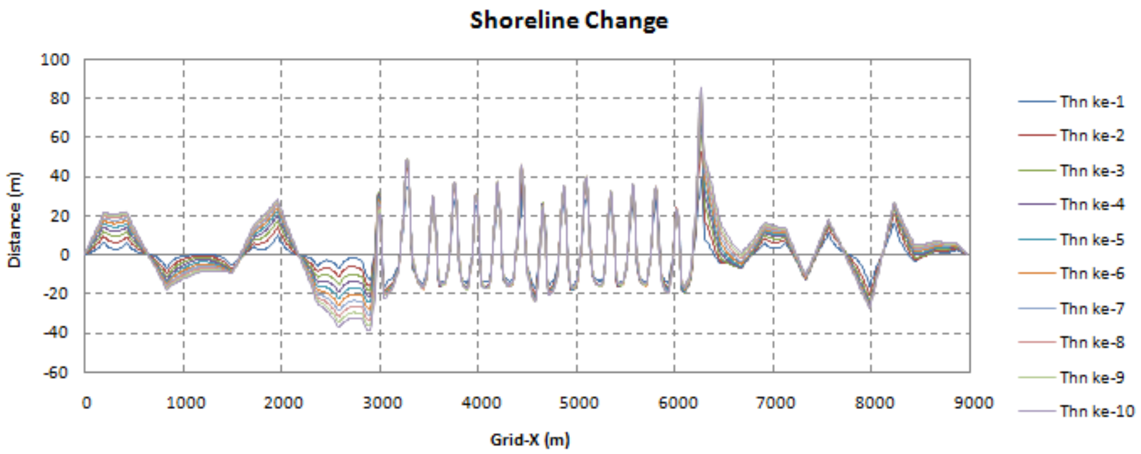


Figure 8. Coastline change simulation of parallel offshore breakwater with the distance from coastline y = 100 m and dominant wave direction from the North.

Fourth alternative of coastal protection is an inclined breakwater or can be called as North-facing breakwater. The main purpose of this model is to cope the direction of dominant wave from the North. Generally, the result at Figue 9 shows that the pattern of coastline is quite similar to the parallel breakwater, and the erosion impact at the left-most of inclined breakwater area is also about 40 m to the land.

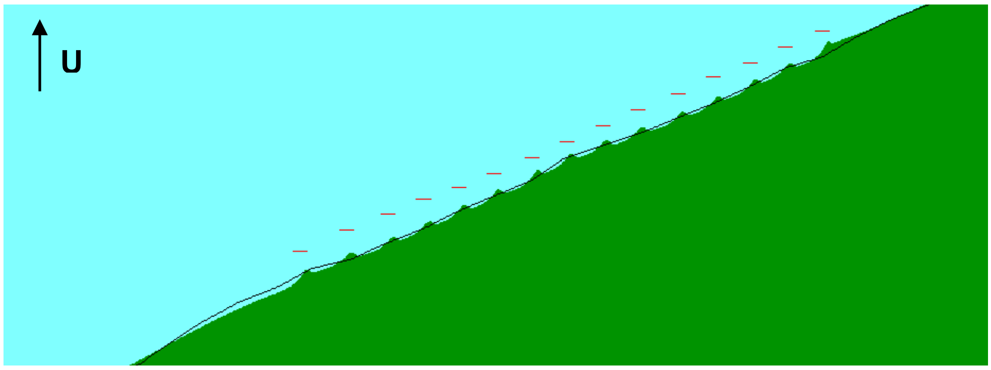


Figure 9. Coastline change pattern of inclined offshore breakwater with the distance from coastline y = 100 m and dominant wave direction from the North

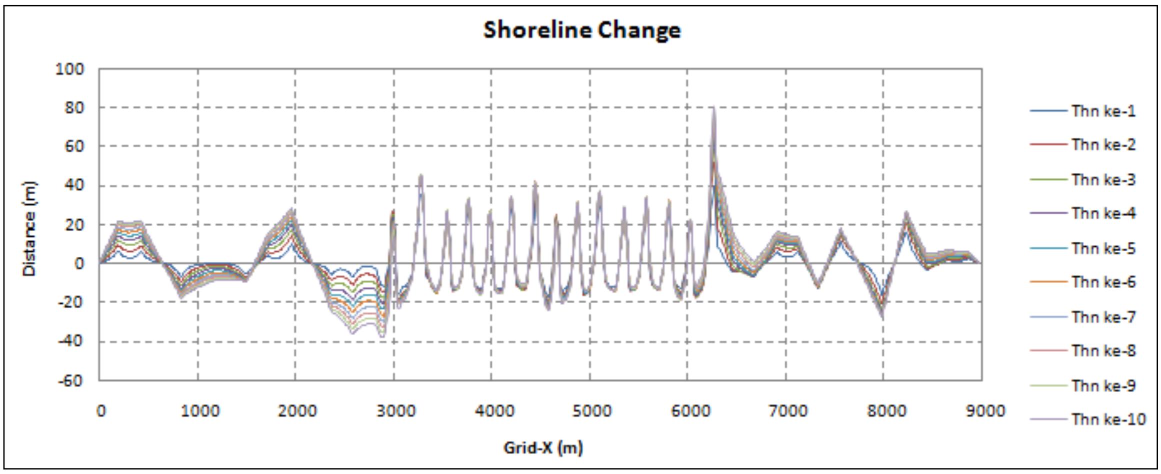


Figure 10. Coastline change simulation of inclined offshore breakwater with the distance from the coastline y = 100 m and the dominant wave direction from the North

Conclusion

Based on the result of coastline change analysis using four alternatives of coastal protection, it can be concluded as follows,

a. From four alternatives of coastal protection, the groin type T is more adequate than another three alternatives in term of equilibrium beach form. The pattern of equilibrium beach is very appear and very attractive than others.
b. Among the four alternatives of coastal protection, the groin type I is not able to form equilibrium beach pattern.
c. In term of erosion impact, the type of groin (I and T) is more severe (about two times) than the type of parallel and inclined breakwater.
d. The equilibrium point of coastline change can be reached around five years and the coastline still change around 4 m a year from one to five years after construction.

Reference

[1] http://en.wikipedia.org/wiki/Coastal_management

[2] Hsu, J. R. C., et all, 2008, *Appreciation of Static Bay Beach Concept for Coastal Management and Protection*, Journal of Coastal Research, 24(1), 198–215. West Palm Beach (Florida), ISSN 0749-0208.

[3] Hanson, H., Kraus, N. C., 1989, Genesis: Generalized Model For Simulating Shoreline Change, Department of The Army, US Army Corps of Engineering, Washington.

Utilization of Waste Ash from Palm Oil Empty Bunches to Improve Strength, Stiffness and Structural Performance of Asphalt Mixture

Miftahul Fauziah

Department of Civil Engineering, Universitas Islam Indonesia, Yogyakarta, Indonesia

Email: miftahul_fauziah@yahoo.com.au, miftahul.fauziah@uii.ac.id

Abstract

Waste ash from palm oil empty bunches (WAPOEB) is one of the residual waste of palm oil industry from the combustion of oil palm bunches which usually was disposed. Utilization of these waste materials in the development of sustainable civil engineering materials then is essential, as an attempt waste of palm oil bunches recycling and environmental awareness. The main purpose of using additive in the mixture is increasing the strength and stiffness of asphalt mixture. This experimental laboratory was aim to investigate the possible usage of an WAPOEB to increase performance of asphalt concrete mixture, in particular to their strength, stiffness and structural number. Research was conducted in three steps. First step was to obtain an optimum asphalt content of the mixture, next stage was to find an optimum content of WAPOEB. An investigation of the strength, stiffness and structural number of the mixture then was conducted in stage III. Stiffness modulus and relative strength coefficient of the specimen then are calculated. Results demonstrate that utilizing WAPOEB as an additive for asphalt concrete mixture at certain content was able to improve its strength, stiffness modulus and structural properties.

Keywords: Waste ash, palm oil empty bunches, additive, strength, stiffness and structural number

Introduction

One of the most important agroindustries in Indonesia is palm oil industry. Besides the production of crude palm oil, a large amount of solid waste is also an output from the palm oil industry such as palm fiber, shells, and empty fruit bunches. Waste ash from palm oil empty bunches (WAPOEB) is a solid residual waste from the combustion of palm which was burn to ashes. They were mostly disposed in the fields around the vicinity of the palm oil industry or disposed to landfill. However, the ash recycling is receiving more and more attention recently because of its potential to improve economic benefits and environmental awareness.

In Indonesia, the palm plantation produced 2700 ton of fresh palm fruit per year. The palm plantation with the capacity of 1200 ton of fresh palm fruit will produce WAPOEB of about 10.8% (Ditjendbun, 2006). Kalium and silika were the main chemical component of WAPOEB. Yoeswono and Iqmal (2007) investigated WAPOEB contains of 29.82 % Kalium (K), 14.24 % Silika (Si), 6.72% Calsium (Ca), 4.34% Magnesium (Mg), 2.37% Natrium (Na), 0.31% Ferum (Fe), 0.17% Mangan (Mn), 0.02% Cu, 19.63 % CO3, and 3.21% HCO3.

Asphaltic concrete mixture is a dense gradation agregate mixture so that intergranular void space between the agregate particles are almost filled, only remain little space for asphalt. Asphalt is commonly used as a binder in bituminous mixture for surfacing layer of the road. Because of its rheology characteristics give a complex phenomenon on deformation and flow (Fordyce, D. and O'Donnel, E, 1994), choosing appropriate asphalt and modified asphalt are still prominet for researcher. The influence of viscosity changes and temperature susceptibility of asphalt on resistance to deformation of pavement mixture is significant. Brien, D. (1978) concluded that deformation of bituminous mixture using higher penetration value was relatively greater than that of deformation of the mix with lower penetration value. He also stated that the mix having lower temperature susceptibility showed less deformation value than those with higher temperature susceptibility.

To elevate performance, to reduce the frequency of maintenance required and to provide much longer service life for maintenance treatments at difficult sites, asphalt modified was widely used. In most cases an additive is mixed with bitumen to modify its properties. One of the main purposes of using additive in the mixture is increasing the resistance to permanent deformation of asphalt mixture at high temperature without losing its properties. This is achieved by either stiffening the bitumen so that the visco-elastic response of the asphalt is reduced or by increasing the elastic component of the bitumen, thereby reducing the viscous component, which results in a reduction in permanent strain (Brown, 1990).

Utilizing WAPOEB as a material in pavement such the case in subgrade stabilization material (Yuheni, et al., 2010) and the use of WAPOEB in wall concrete (Sari, D T, 2010) and the use of oil palm ash in concrete blocks (Kaosol et al., 2010) had reported very recently. However, WAPOEB used as a material in bituminous mixture for surfacing layer of the road was very limited (Fauziah and Saleh 2011). This paper presents results of some experimental laboratory to investigate strength, stiffness and structural performance of asphaltic concrete specimens utilizing the waste of empty fruit bunches of palm ash. Specimen preparation, procedures, data evaluation and discussion will be presented in the following discourse.

Strength, Structural Performance, And Stiffness

Strength of the asphalt mixture could be represented as its ability to support the traffic load with the absence of deformation, known as a stability value. The Asphalt Institute, MS-2 (1991) defined that stability is a resistance to permanent deformation of asphalt mixture due to a traffic load. The stability value of asphalt mixture is affected by frictional resistance and interlocking between aggregates particles and cohesion of the mixture. On the Marshall test it demonstrates as a maximum load that the specimen can restrained at the temperature of 140 0F with the consistence loading velocity of 2 inch per second.

AASHTO (1982) declared that structural performance of the material could also be indicated by the value of relative strength coefficient (a), which is correlated with the value of Marshall stability. A quantitative indicator of structural number of the pavement related to the thickness of pavement layer is shown in equation 1 (AASHTO, 1996)

$$SN = a_1.D_1 + a_2.D_2 + a_{3.D_3} \qquad (1)$$

in which:

S : stability of the mixture (lbs)
SN : structural number
a1, a2, a3 : relative strength coefficient of each layer
D1, D2, D3 : thickness of each layer
Index of 1, 2 or 3 is shown as surface course, base course and sub base course respectively.

Elastic modulus or stiffness modulus of asphalt mixture is one of the importance structural performance parameter of flexible pavement. It defines as a value of stress per strain of the pavement at certain temperature and time of loading due to the effect of dynamic loading of the vehicle. Stiffness of the binder (asphalt and bitumen) and the value of voids in mixed aggregate (VMA) are the main factors establishing it. The bitumen stiffness depends on loading time, recovered softening point of bitumen and recovered penetration index of bitumen. Stiffness modulus of the mixture is formulated by Brown and Brunton (1984) as shown in Equation 2.

$$Sm_e = S_b\left(1 + \frac{257.5 - 2.5VMA}{n.(VMA - 3)}\right)^n \qquad (2)$$

$$n = 0.83.\log\left(\frac{4.10^{10}}{S_b}\right) \qquad (3)$$

in which:

Sme : stiffness modulus of the mix (MPa),
VMA : voids in mixed aggregates,
Sb : stiffness modulus of asphalt (MPa),

while:

$$S_{bit} = 1.157.10^{-7}.t^{-0.368}.2.718^{-PIr}.(SP_r - T)^5 \qquad (4)$$

In which:

Pir : recovered penetration index,
Pr : recovered penetration,
SPr : recovered softening point (^{o} C),
t : time of loading, and
T : air temperature (^{o}C).

while

$$PI_r = \frac{195.4 - 500.\log pen - 20.SP_r}{50.\log(P_r) - SP_r - 120.14} \qquad (5)$$

$$SP_r = 98.4 - 26.35\log(P_r) \qquad (6)$$

$$P_r = 0.65 P_i \tag{7}$$

$$t = 1 / v \quad \text{(sec)} \tag{8}$$

in which

P : value of stability reading of the marshall device (lbs)

Pi : innitial penetration at 25 ^{o}C (0.1 mm)

V : speed of loading (km/h)

l : area of wheel contact to pavement

Research Method

A series of each individual material as a component of the mixture which consists of aggregates, asphalt and waste ash from palm oil empty bunches (WAPOEB) were firstly conducted. The aggregates consisted of crushed gravel coarse, fine aggregates and filler were obtained from Clereng, Yogyakarta Indonesia. The individual sizes of aggregate were separated first and then recombined to meet the Binamarga specification at middle of the grading as shown in Table 1.

Table 1 Aggregate Grading Type of IV Bina Marga

Sieve size		Percent Passing (%)	
Inch	mm	Specification	Middle of grading
# ¾	19,10	100	100
# ½	12,70	80 – 100	90
# 3/8	9,250	70 – 90	80
# 4	4,760	50 – 70	60
# 8	2,380	35 – 50	42,5
# 30	0,590	18 – 29	23,5
# 50	0,279	13 – 23	18
# 100	0,148	8 – 16	12
# 200	0,074	4 – 10	7

Source: Bina Marga (1987)

The Asphalt Cement (AC 60/70) was used in this experimental study and it was provided by PT Pertamina Cilacap. (WAPOEB) were made from the newly captured and burned to ashes passed sieve # 200, which were produced of Palm plantation in Pelalawan, province of Riau.

Three specimens were then prepared for each of five asphalt contents from 4 to 6 percent, with the interval of 0.5 %, by total weight of the mixture to obtain optimum asphalt content. The mixture mixing process was followed The AASHTO T 245-82 and ASTM D 1559-89 procedure. The specimens test based on Marshall criterion then were run. Next, five types of specimens with different WAPOEB (from 0 to 4 percent, with the interval of 1 %, by total weight of asphalt content) were prepared and tested at optimum asphalt content in order to find their performace at different WAPOEB content.

Data from the Marshall test which were represented strength of the mixture then were obtained by Marshall stability and then they were used to calculate structural number using AASHTO method (equation 9) as well as thickness of layer (equation 10) . Following this stiffness of the mix was also calculated based on value of VMA and stiffness modulus of asphalt which was also derived from Marshall testing results. Specimen of asphalt with optimum WAPOEB content was prepared. From the data obtained the value of stiffness modulus of asphalt could be carried out and the stiffness of bitumen is reckoned using the formula derived by Brown and Brunton (1984). In this study stiffness of bitumen and asphalt mixture were calculated at air temperature of 30°C and vehicle speed of 30 km/h, 40 km/h, 50 km/h and 60 km/h.

Results, Analysis And Discussion

Five types of specimen at different WAPOEB content of 0%, 1%, 2%, 3%, and 4% respectively will be discussed in the following discourse. Marshall stability, VMA and relative strength coefficient (a) as well as layer thickness of the asphalt mixture at optimum asphalt content are presented in Table 2, while stiffness modulus of asphalt and asphalt mixture at different vehicle speed are summarised and presented in Figure 3 and Figure 4 respectively.

Table 3. Strength, VMA and Relative Strength Coefficient (a) *)

Parameter	EFBPOA (%)				
	0.0	1.0	2.0	3.0	4,0
Marshall Stability (lbs)	3380.2	3417.3	3501.9	3511.3	3596.6
VMA (%)	15.3	15.5	15.5	16.7	18.4
Relative strength coefficient (a)	0.490	0.492	0.496	0.496	0.501
Layer thickness (cm)	9.188	9.153	9.075	9.067	8.991

*) Average of three specimen

Figure 1 presents the effect of WAPOEB content on the stability of the specimen. As can be seen from the graph stability was rising with the increasing of WAPOEB content. The specimen containing WAPOEB have a higher stability than those of without it. Since the stability represents strength of the mixture, this means that the strength of the mixture was strongly affected by WAPOEB content. As stated by Brown (1990), improving stability or resistance to deformation of asphalt mixture can be achieved by either stiffening the bitumen so that the visco-elastic response of the asphalt is reduced or by increasing the elastic component of the bitumen, thereby reducing the viscous component, which results in a reduction in permanen strain.

Results shows that the higher WAPOEB content provides higher mixture strength. This occurrence was likely because of the hardness of bitumen changes. The use of WAPOEB as an additive provides the higher hardness in the bitumen, as supported by the result penetration test (Fauziah and Saleh, 2011). Higher penetration asphalt provides higher stability of the mixture. This is consistence with the findings of Subarkah (2001), which is showed that the mixture made with the lower penetration asphalt gives higher stability.

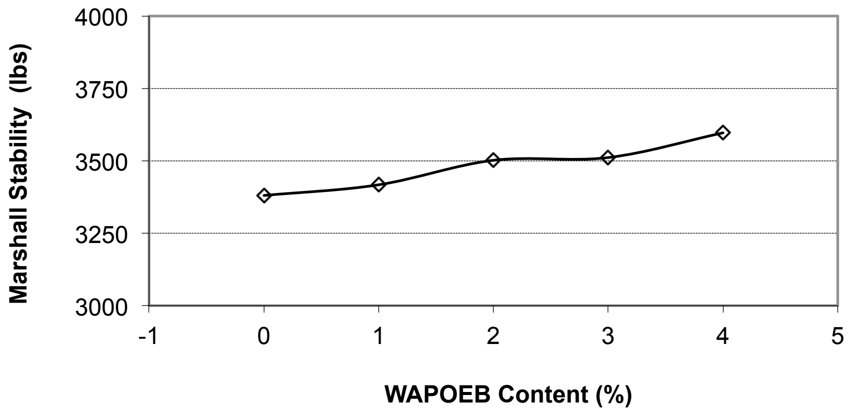


Figure 1. Relationship Between WAPOEB Content and Stability

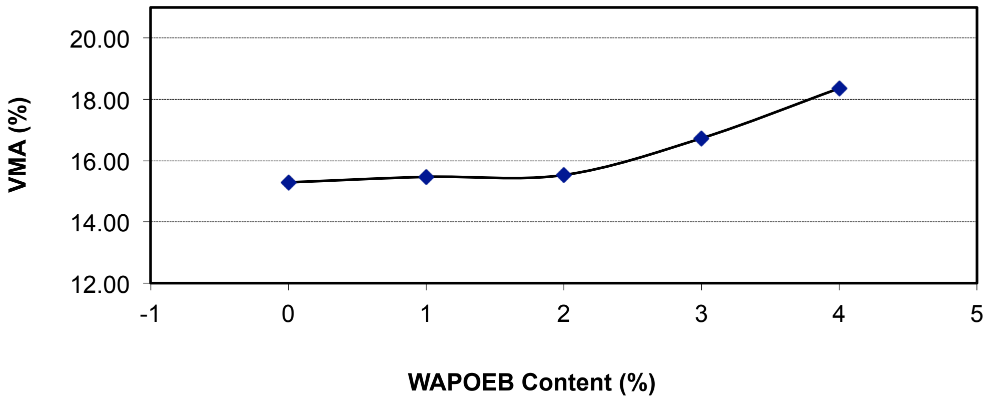


Figure 2. WAPOEB Content Corresponding with VMA

A relationship between Voids in Mineral Aggregates (VMA) and WAPOEB content at optimum asphalt content is depicted in Figure 2. As shown fom the graph that VMA value of the mixture is rising with the increasing of the WAPOEB content. This was occurred because asphalt containing WAPOEB had a lower penetration value compared with that of original asphalt, as mentioned in the previous paragraph. An added of WAPOEB on the asphalt provides a more hardness on it. The declining penetration asphalt caused by rising of WAPOEB content led to a rising its viscosity so that it was more hardly to penetrate to the voids in the aggregate framework, resulting an increasing voids in mineral aggregates. This means that the specimen made with higher content of WAPOEB had a more spaces between the aggregates than that of those with lower content of WAPOEB. The VMA value and stiffness modulus of asphalt were significant parameters affecting stiffness modulus of the mixture.

Table 1 shows that the coefficient value increase with the addition of WAPOEB. This indicates that structural performance of the mixture, which is correlated to the thickness of pavement layer, improved with the addition of WAPOEB, therefore thickness of pavement layer is reduced, as shown in Figure

3. Thickness of pavement layer is correspondingly decreased with the greater WAPOEB amount.

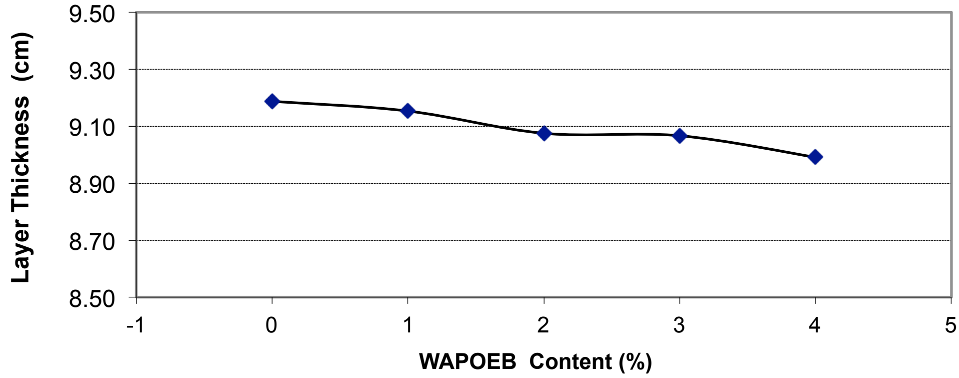


Figure 3. Thickness of Pavement Layer Correspond to WAPOEB Content

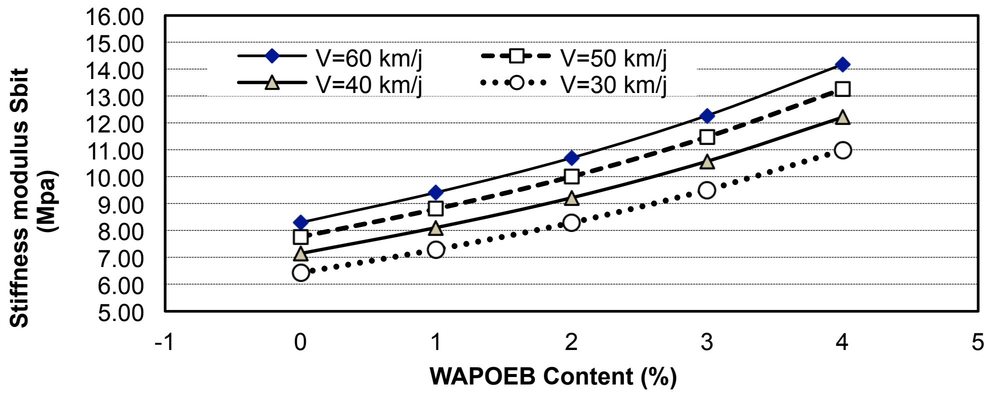


Figure 4. Correlation of Stiffness Modulus of Asphalt with WAPOEB Content

Figure 4 plots stiffness modulus of asphalt at different WAPOEB content and vehicle speed. It is observably from the graph that stiffness modulus of asphalt was climbing with the rising of EWAPOEB content and the vehicle velocity. This case was likely because of the changes of asphalt hardness and loading time on the pavement. The use of WAPOEB as an additive provides the higher hardness in the bitumen, as supported by the result of penetration test (Fauziah M and Saleh A, 2011). Higher penetration asphalt provides higher stiffness of asphalt. These results seem consistence with the theory of Brown and Brunton (1984) which stated that the bitumen stiffness depends on loading time and the hardness of bitumen. The loading time on the pavement was affected by vehicle speed. The greater the vehicle speed the lower the loading time. As can be seen from the graph stiffness modulus of asphalt was increasing with the rising of the vehicle velocity. This is because of the increasing of vehicle speed will lead to decrease the loading time.

A relationship between VMA and stiffness modulus of asphalt mixture is provided in Figure 5, while Infuence of WAPOEB content on the stiffness modulus of asphalt mixture at different velocity of the vehicle is described in

Figure 6. As stated in the previous section, stiffness modulus of asphalt mixture is the function of VMA and stiffness of bitumen.As shown from Figure 5 stiffness modulus of the mix tends to decrease with the increasing of the VMA value. The mixture with less voids mineral aggregate will have a higher stiffness.

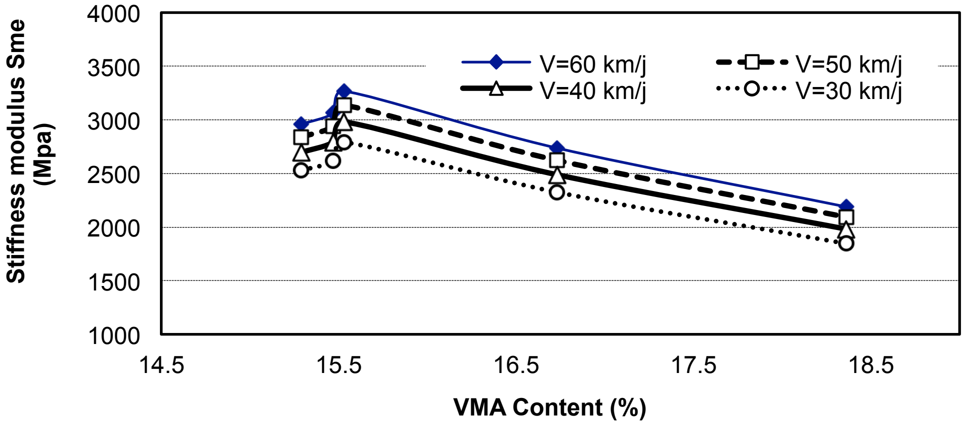


Figure 5. Relationship of VMA and Stiffness Modulus of Mixture

As observably from Figure 6, stiffness modulus of asphalt mixture went up along with the increasing of WAPOEB content until it reach the maximum value at the WAPOEB content of 2%, then it went down. The rising of the curve seems is caused by effect of bitumen stiffness modulus. As mention earlier, an increasing of bitumen hardness resulting from an addition of WAPOEB is led to increment asphalt stiffness modulus. However, the rising of asphalt hardness caused by additional of WAPOEB content led to its viscosity rising so that it was more hardly to penetrate to the voids in the aggregate framework, resulting an increasing voids in mineral aggregates. The stiffness then was felt down due to the fall of its VMA. It is evident that utilizing waste ash from palm oil empty bunches elevates strength and performance of the pavement structure, as well as its stiffness modulus at the precise content of WAPOEB.

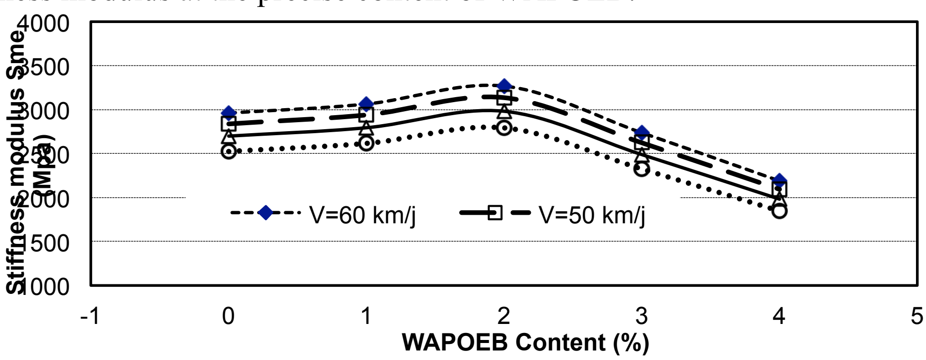


Figure 6. Stiffness Modulus of Mixture versus WAPOEB Content

Conclusion

Based on the data obtained and analyses carried out following conclusion might be drawn from this experimental study.

- Utilizing WAPOEB as an additive on the asphalt mixture specimen was proven increasing their strength. The higher the WAPOEB content the higher the mixture strength. Structural performance of asphalt mixture indicated by the coefficient value of relative strength is better than those without WAPOEP. The higher the WAPOEB content the greater the value of relative strength coefficient of specimen obtained.
- The stiffness modulus of asphalt was climbing with the increasing of WAPOEB content, while stiffness modulus of asphalt mixture was going up along with the addition of WAPOEB until its reach maximum value then it was falling for the next extra amount of WAPOEB. To reach maximum stiffness of the mixture the optimum content of WAPOEB was obtained at the value of about 2 % of asphalt content. Results verify that utilizing WAPOEB as an additive of asphalt at the precise amount were improving strength, structural performance and stiffness of asphalt mixture.

References

AASHTO. 1996. Standard Specifications for Transportation Material and Methods of Sampling and Testing. Part I, 13 th Edition. Washington D.C.

Bina Marga. 1987. Petunjuk Pelaksanaan Lapis Aspal Beton Untuk Jalan Raya. Jakarta: Penerbit Yayasan Penerbit PU.

Brien, D. 1978. Asphalt Mix Design, Development in Highway Pavement Engineering. London: Brown, Stephen. 1990. The Shell Bitumen Handbook. UK: University of Nottingham.

Fauziah, M and Saleh, A. 2011. Characteristics of Asphalt Concrete Containing Empty Fruit Bunches of Oil Palm Ash. Proc.of International symposium of FSTPT (Forum Studi Transportasi Perguruan Tinggi). Pekanbaru, Riau.

Fordyce, Derek and O'Donnel, Eric. 1994. Bituminous Mixture in Road Construction. London: IRE-TRRL.1990. Research on Hot Rolled Sheet in Indonesia: Design and Imlpementation of Studies of Existing Overlays, Collaboration Research Project, Instititute of Road

Kaosol, T. 2010. Recycling of Oil Palm Ash as Partial Replacement of Cement of Cement in Concrete Block Productions. Proc. of The 8th Asian-Pacific Regional Conference on Practical Environmental Technologies (APRC2010), Ubon Ratchathani University, Ubonratchathani, Thailand.

The Asphalt Institute. 1991. Mix Design Methods of Asphalt Concrete and Other Hotmix Types. Manual Series No.2 (MS-2) Sixth edition. Maryland, USA.

Sari, D. T. 2010. Pembuatan dan Karakterisasi Batako menggunakan Abu Tandan Kosong Kelapa Sawit. Medan: Universitas Sumatera Utara.

Subarkah. 2001. Effect of Bitumen Hardness on Characteristics of Gap Graded Pavement Mixture. Yogyakarta: Jurnal Teknisia FTSP UII.

Yoeswono, I. . 2007, Pemanfaatan Abu Tandan Kosong Sawit. Yogyakarta (http://iqmal.staff.ugm.ac.id/wp-content/manling-2007-iqmal- yoeswono3.pdf)

Yuheni, Cecen, Mawardi, dan Bahri, Samsul. 2010. Stabilisasi Tanah dengan Menggunakan Abu Tandan Kosong Kelapa Sawit (Studi Kasus pada Ruas Jalan Basuki Rahmat). Bengkulu: Fakultas Teknik Universitas Bengkulu.

Low and Medium strain level relationship on SASW and FWD Tests Method before and after disaster (Case Study Soekarno-Hatta and Cikampek-Purwakarta Highway)

Sentot Hardwiyono

Department of Civil and Structural Engineering, Universitas Muhammadiyah Yogyakarta Indonesia

Email: raharjo@uii.ac.id

Abstract

Traditional methods of determining stress maximum of sub grade flexible pavment involving soil parameters collected from field by Destructive Test (DT) method and laboratory test are quite established. Two methods Non Destructive Test (NDT) based on deflection bowls (Falling Weight Deflectometer, FWD), shear wave velocity (Spectral Analysis of Surface Wave, SASW), and damping measurements is proposed in this study, aimed to reduce the problem inherent in the traditional tests (before and after desaster). Analysis the hyperbolic shear stress to shear strain relationship of sub grade is proposed by Hardin and Drnevich (1972) equation and the viscoelasticity model of soil proposed by Abbiss (1983). In this study, the results of the equation are compared to the FWD and SASW test results. The seismic model derived from the equation was able to produce an initial stress-deformation curve close to the stress-deformation curve of the FWD-SASW test, but the accuracy was found to deviate slightly as the deformation increase above about 10 % strain. However, the predicted ultimate stress of sub grade flexible pavement from the seismic and deflection bowl is better than other traditional methods.

Keywords: FWD, SASW, sub grade pavement, strain, damping

Introduction

Sub grade is defined as the last layer from the layers pavement structure where load of traffic and environment undergo continuous destruction from the time it is open for use. Sub grade is chose from soil selection by laboratory test or in situ test. There are two methods to determine the performance of sub grade structures (clay, sandy-clay, etc.) i.e. the destructive testing (DT) and the non-destructive testing (NDT). The DT method (i.e. resilient modulus test, CBR test) called traditional method where is more time consuming, destructive (coring required) and costly if applied in routine monitoring sub grade on road works (*Asphalt Institute* 1986, *AASHTO* 1993).

On the other hand, the NDT method is more economic and fast. The FWD is an NDT method that measures the pavement modulus based on the concept of deflection bowl (Ullidtz 1987, Brown 1986, Choi et al. 2010). The method can be evaluating to the modulus of the sub grade structure. The SASW method is also NDT method based on the velocities of the seismic waves (primary, shear, Rayleigh and Love waves) that propagate in the media for determining of that sub grade structure (Heisey et al. 1982, Röesset 1990, Joh 1996, Rosyidi 2004).

The sub grade parameters (from FWD and SASW test result: shear wave velocity, modulus, damping) used in their calculation are the stress maximum or effective shear strength parameters obtain from analysis the hyperbolic shear stress to shear strain relationship is proposed by Hardin and Drnevich (1972) equation and the viscoelasticity model of soil (sub grade) proposed by Abbiss (1983). Comparison with the FWD and SASW test versus stress-strain relationship plotes are also presented at two locations of sub grade in Soekarno-Hatta and Cikampek-Purwakarta highway road, Bandung, Indonesia, since its elastic modulus and strain characteristic is known to give the stress maximum of sub grade.

Theory

In soil dynamic the behavior of soil (sub grade) under loading is normally assumed to have viscoelastic properties. In many studies the analysis of the dynamic soil properties has been done under different constitutive models such as: the elastic-, Kelvin-Voigt- and Maxwell-model. Hall and Richart [1963], Hardin [1965], and Hardin and Scott [1966] have used the Kelvin-Voigt model to represent the behavior of dry sand subjected to small cyclic vibration amplitudes, over a large frequency range. The modified spring and dashpot Kelvin-Voigt- and Maxwell-model can be assumed, where a linear spring element and a linear dashpot element are connected in combination parallel-series (Carlos 2002). Under instantaneous loading the load is initially transferred to the elastic skeleton, some being transferred to the pore water. It is then shared between the soil and the water, and finally the entire load is transferred to the soil skeleton. The model assumes physically that the spring property can be measured by the shear wave velocity and dashpot properties by the damping parameter of the soil. This model has been successfully adopted by Abbiss (1983) in the calculations of settlement and has been able to predict both to the short and long term settlement behavior of sites in stiff clay, chalk, landfill and soft clay. The result viscoelastic models have also been compared, with good agreement, to the very long term settlement data of the tilting of Pisa tower. Soil tests under cyclic loading, both in normal triaxial or shear test, have shown common hysteretic behavior.

The skeleton or the backbone curve of the hysteresis is known to follow the form of the curve as shown in Figure 1. This curve is defined by Hardin and Drnevich (1972) and can be expressed in the form of hyperbolic stress strain soil model.

$$\tau = \frac{G_{max}\,\gamma}{1+\frac{\gamma}{\gamma r}} \qquad (1)$$

Where:

G_{max}= low strain shear modulus, where maximum Young's modulus =2G_{max} (1+ν)

γ = shear strain

γ_r = characteristic shear strain

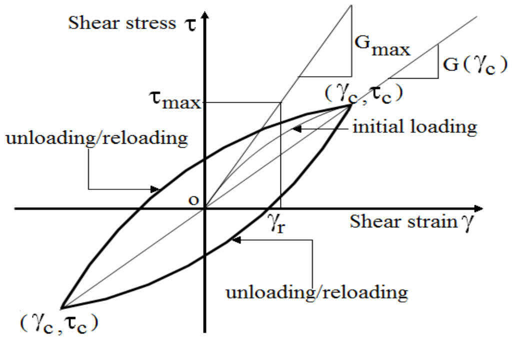


Figure 1. Stress-strain loops for Hardin-Drnevich model

This relationship of the skeleton curve can also be presented in the form of Figure 2 and can be simplified in the form of equation 1.

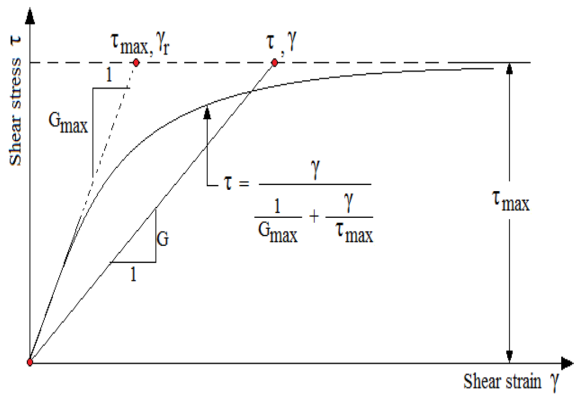


Figure 2. Stress-strain skeleton curve for Hardin-Drnevich model

The skeleton curve is relationship shear stress versus shear strain where shear stress maximum can be obtained by initial tangent G_{max} and shear strain characteristic. From the Hardin and Drnevich equation (1972) by multiplying top and bottom of the right hand side of equation 1 by γ_r:

$$\tau = \frac{G_{max}\,\gamma\gamma_r}{1+\gamma_r} \qquad (2)$$

As γ increases and tends to infinity and in the limit we get:

Maximum stress $\tau_{max} = \frac{G_{max}\,\gamma\gamma_r}{\gamma}$ *(3)*

Because in the denominator γ_r is now very small in comparison with γ, the ratio $\frac{\gamma_{max}}{\gamma_{max}}$ is unity and thus the formula reduces to:

$$\tau_{max} = G_{max}\gamma_r \qquad (4)$$

The strength is the product of the low strain shear modulus maximum and the characteristic strain. Under axial cyclic loading, the stress strain loop of soil is similar to the loop of the cyclic shear loading of Figure 1 and similar relationship is hereby proposed and may be expressed by:

$$\sigma = \frac{E_{max}\,\varepsilon}{1+\frac{\varepsilon}{\varepsilon_r}} \qquad (5)$$

Where:

E_{max}= low strain maximum shear modulus

ε = strain

ε_r = characteristic strain

Under low strain condition of less than $1x10^{-4}$ the following conditions expressed by equation 5 can be employed:

$$\varepsilon = \gamma\ (1+\nu) \qquad (6)$$

An assumption is also made where the characteristic shear strain (γ_r) is assumed to be equal to characteristic axial strain (ε_r), thus similarly:

$$\sigma_{max} = E_{max}\varepsilon_r \qquad (7)$$

To plot equation 4 in terms of normal stress (σ) versus strain (ε), the unknown parameter characteristic axial strain (ε_r) can be determined from the relationship of damping and strain derived by Abbiss (1983) to be as in equation 8.

$$\varepsilon_r = [2\varepsilon]\left[\left\{\frac{e^{\left(\frac{Dm}{D}-1\right)}-1}{(e-1)}\right\}\right] \qquad (8)$$

Where:

D_m = maximum damping = 33%

D = damping at elastic strain obtained from equation

ε = strain at which D is measured

ε_r = characteristic strain as shown in Figure 3

A typical damping against shear strain relationship can be illustrated by Figure 3 below for clays.

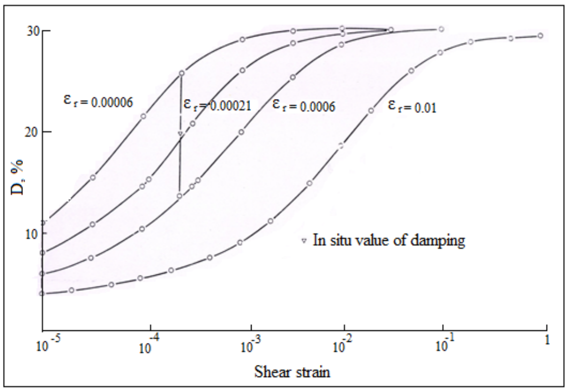


Figure 3. Theoretical curves of damping against shear strain

The value of damping D may either be calculated from the hysteresis loop of the normal and shear stress envelope or it may be calculated by other methods (in situ tests, FWD and SASW tests method) proposed by Abbiss (1986). Based on theory and in situ tests (FWD and SASW methods) prediction and calculation E_{max} (low strain maximum shear modulus), ε (strain), ε_r (characteristic strain) and life time and cumulative damage pavement (crack and rutting) can be obtained before and after disaster.In his seminal work 'Planet of Slum', Mike

Davis (2007) portrayes how the urbanization has turned the built environment in most cities of the global-South into slum. Davis' claim is not an exagreation, as almost ten years ago the UN had estimated the world population of slum dwellers was almost one billion, i.e., 32 percent of the world's urban population (UN Habitat, 2003). Caracas is an example of a city with striking division between 'chaotic' and 'well-ordered' built environment (refer to Figure 2). The former is often called 'informal city', which has been formed and shaped by the growth of informal settlements over time (Brillembourg, et al, 2005).

FWD and SASW test result

In falling weight deflectometer (FWD) test an impulsive load is applied on the road surface. The magnitude of the load, duration and area of loading is so adjusted that it corresponds to the effect of loading due to standard axle on in-service pavement including sub grade (Ullidtz 1987, Sebaaly et al. 1991). Figure 4 presents a schematic diagram of a FWD.

The instantaneous of the road surface deflections is measured at a number of points at different distances (0 to 1500 mm, and 7 geophones in this study) radials outward from the centre of the falling weight. Thus, the shape of deflection bowl is obtained. Information on structural health condition (Sub-grade) can be extracted from analysis (by back calculation, i.e. software ELMOD) of the FWD data. The result of the deflection data and calculation modulus sub-grade and strain characteristic is presents in Table 1a and 1b. Average elastic modulus and strain characteristic sub grade on both site FWD test are 148 MPa and 0.2765%.

The spectral analysis of surface waves (SASW) method is an in situ seismic method for determining the shear wave velocity (or maximum shear modulus) profile of a site (Heisey et al. 1982, Nazarian & Stokoe 1985, Nazarian & Stokoe 1986). The SASW method is based on dispersive characteristics of surface waves. Most of the surface wave energy exists within one wavelength of depth and in layered media, the propagation velocity of surface wave depends on the frequency (or, wavelength) of the wave because waves of different wave lengths sample different parts of the layered medium.

The SASW test consists of three steps; field testing, evaluation of dispersion curve by phase unwrapping method, and determination of shear wave velocity profile by inversion process. In general, field testing and dispersion curve evaluation are regarded as simple work. However, under some field conditions, particularly, when various noises exist in the field and/or the shifting of dominant propagation mode with frequency exists, the usual phase unwrapping method can lead to erroneous dispersion curve (Hunaedi 1993, Joh 1996). The general configuration of accelerometer, source, spectrum analyzer and notebook computer in the SASW test is shown in Figure 5.

Two vertical accelerometers were placed on the ground at an equal distance from a fixed centerline. Impulsive or random-noise load was used to apply vertical excitation in the line with the two accelerometers at a distance, *d*, away from the near accelerometer. A spectrum analyzer used to record the accelerometer signals and then to transform them into a frequency domain. A reverse test was also performed with a source on the opposite side of the receiver array. Testing continues by progressively moving the receivers away from the fixed centerline. Phase information of the cross-power spectrum, which represents the phase difference between two receiver signals as a function of frequency, was obtained. From the cross power spectrum, time delay between receivers is obtained for each frequency by:

$$t(f) = \frac{\theta_{XY}(f)}{2\pi f} \qquad (9)$$

where θ_{XY} is the phase shift of the cross-power spectrum in radian and the frequency, f, is in cycles/s. The surface wave phase velocity, V_R, is then calculated using equation 10.

$$V_R(f) = \frac{d}{t(f)} \qquad (10)$$

Where d is the distance between two accelerometers. The corresponding wavelength of the surface wave, λ_R, is:

$$\lambda_R(f) = \frac{V_R(f)}{f} \qquad (11)$$

In general, Heisey's criterion (Heisey et al. 1982, Joh 1996, Rosyidi 2004) is widely used in the SASW method. The long accelerometer distances (64, 100 cm) with a set of low frequencies sources (a set of hammers) were used to sample the sub grade layers. Damping and attenuation can be calculated by Bornitz equation (Yang 1995, Woods 1997 and Athanasopoulos, et al. 2000) as below:

$$\frac{w_2}{w_1} = 0.5^{0.5} e^{-\alpha_0 f} \qquad (12)$$

Where w_2 is amplitude ratio after amplitude w_1 against frequency and α_0 by trial method and f is frequency. Calculation strain characteristic used Equation 8 where D_m is 33% and elastic strain ε is 10^{-4}.

The SASW testing was carried out at 45 sites on an existing flexible pavement of Soekarno-Hatta and Cikampek – Purwakarta State (Province) Road, Indonesia. The result of the elastic modulus sub grade and damping ratio in SASW test is presents in Table 2.

Averages elastic modulus and strain characteristic sub grade on both site SASW test are 160 MPa and 0.5855%.

Prediction of stress maximum at subgrade using graphic method

Using Equation 5 where E_{max} is elastic modulus and ε_r is strain characteristic from SASW and FWD test result, than strain ε is trial value from 0 to ∞. Prediction of stress maximum (σ_{max}) at sub grade can be plotting by graphic. First plot point 0 at initial (σ=0, ε=0) and second plot point $\varepsilon=10^{-7}$, elastic modulus sub grade E_{SASW}=160 MPa, Characteristic strains ε_r=0.5855% and by Equation 5 can be plotting graphic as shown in Figure 6.

Continuous trial by value strain ε and all the parameter and equation is same, can be made graphic by initial tangent elastic modulus E_{max} (SASW) crossing with in a straight line of strain characteristic ε_r from the strain axis at a point and we called stress maximum point. Plotting graphic shown in figure 7.

By similar method prediction of the maximum stress from FWD test can be plotting where elastic modulus subgrade E_{FWD} = 148 M.Pa, characteristic strain ε_r = 0.2765% shown in figure 8. Why subgrade are important in this study, because pavement layers spreading on the last layers e.i. subgrade where early strain damage can be obtained caused by traffic, climate condition or disaster.

Table 1a. Elastic modulus sub-grade and strain characteristic FWD test result

FWD test result in Cikampek - Purwakarta:												
			Deflection bowls (di) (0.001 mm) and time (ti) (second)								**Subgrade**	
No	**Sta**	**(σ)**	**d_1**	**d_2**	**d_3**	**d_4**	**d_5**	**d_6**	**d_7**	**Es**	**ε_r**	
		(kPa)	**t_1**	**t_2**	**t_3**	**t_4**	**t_5**	**t_6**	**t_7**	**(MPa)**	**(%)**	
1	0+000	568	189	139	125	106	88	64	38	191	0,0677	
			0,0234	0,0242	0,0267	0,0288	0,0306	0,0321	0,0356			
2	0+010	565	237	163	141	118	98	69	42	176	0,0582	
			0,0241	0,0276	0,0293	0,0301	0,0323	0,0340	0,0354			
3	0+020	579	178	130	118	103	89	66	43	188	0,1015	
			0,0237	0,0259	0,0274	0,0297	0,0311	0,0337	0,0367			
4	0+030	574	168	137	122	109	96	75	49	164	0,0722	
			0,0232	0,0257	0,0275	0,0297	0,0319	0,0339	0,0361			
5	0+040	584	211	162	145	125	107	79	48	159	0,0555	
			0,0229	0,0258	0,0280	0,0297	0,0311	0,0346	0,0358			
6	0+050	571	221	162	145	128	111	82	51	150	0,0666	
			0,0240	0,0258	0,0280	0,0305	0,0322	0,0359	0,0380			
7	0+060	565	220	166	150	131	113	84	50	144	0,1050	
			0,0239	0,0265	0,0290	0,0312	0,0328	0,0368	0,0373			
8	0+070	574	267	192	163	135	111	79	47	156	0,3139	
			0,0252	0,0262	0,0277	0,0289	0,0303	0,0324	0,0344			
9	0+080	564	300	222	189	150	121	84	50	144	0,7031	
			0,0247	0,0259	0,0281	0,0302	0,0324	0,0337	0,0360			
10	0+095	557	270	209	183	156	130	91	55	131	0,0358	
			0,0255	0,0261	0,0288	0,0323	0,0344	0,0350	0,0380			
11	0+105	564	377	248	214	179	148	103	63	118	0,0786	
			0,0258	0,0278	0,0297	0,0320	0,0332	0,0341	0,0365			
12	0+115	576	325	232	196	158	128	88	55	141	0,0625	
			0,0257	0,0260	0,0281	0,0308	0,0322	0,0342	0,0363			
13	0+145	580	199	151	135	118	103	79	50	158	0,0505	
			0,0247	0,0263	0,0288	0,0321	0,0358	0,0371	0,0390			
14	0+165	577	249	164	145	124	105	78	48	159	0,0380	
			0,0245	0,0268	0,0280	0,0296	0,0326	0,0343	0,0375			
15	0+175	591	217	150	133	117	102	77	49	165	0,0432	
			0,0236	0,0239	0,0257	0,0278	0,0296	0,0337	0,0366			
16	0+185	580	251	161	143	123	105	78	47	160	0,0424	
			0,0256	0,0273	0,0277	0,0314	0,0346	0,0373	0,0397			
17	0+195	588	228	173	152	130	109	81	46	156	0,0385	
			0,0238	0,0256	0,0274	0,0312	0,0339	0,0359	0,0367			
18	0+205	590	192	143	129	113	97	73	44	174	0,0570	
			0,0228	0,0258	0,0285	0,0326	0,0356	0,0389	0,0396			
19	0+215	593	159	106	94	83	73	57	39	223	0,0423	
			0,0229	0,0245	0,0258	0,0280	0,0288	0,0334	0,0351			
20	0+225	588	194	141	124	106	89	65	40	194	0,0377	
			0,0231	0,0255	0,0274	0,0306	0,0327	0,0347	0,0360			
21	0+235	577	224	155	139	119	100	70	41	177	0,0440	
			0,0243	0,0247	0,0269	0,0304	0,0330	0,0379	0,0390			
22	0+380	576	350	285	251	212	169	110	50	193	0,6686	
			0,0253	0,0259	0,0276	0,0285	0,0292	0,0331	0,0342			
									Avarage	165	0,1265	

Table 1b. Elastic modulus sub-grade and strain characteristic FWD test result

FWD test result in Soekarno-Hatta:

No	Sta	(σ)	Deflection bowls (d_i) (0.001 mm) and time (t_i) (second)							Subgrade	
			d_1	d_2	d_3	d_4	d_5	d_6	d_7	Es	ε_r
		(kPa)	t_1	t_2	t_3	t_4	t_5	t_6	t_7	(MPa)	(%)
1	0+000	582	237	172	135	99	75	52	38	240	0,4176
			0,0210	0,0237	0,0250	0,0277	0,0297	0,0322	0,0348		
2	0+020	580	396	283	229	170	125	81	52	154	0,5189
			0,0216	0,0240	0,0255	0,0280	0,0300	0,0329	0,0355		
3	0+040	569	331	248	209	163	123	78	50	157	1,6857
			0,0212	0,0233	0,0250	0,0270	0,0295	0,0324	0,0353		
4	0+060	578	391	291	232	170	121	74	48	153	0,2435
			0,0219	0,0234	0,0258	0,0289	0,0308	0,0325	0,0342		
5	0+080	587	395	271	215	157	116	79	51	160	0,3799
			0,0211	0,0238	0,0250	0,0280	0,0298	0,0324	0,0350		
6	0+100	578	428	328	269	203	147	85	54	134	0,6634
			0,0230	0,0271	0,0302	0,0328	0,0345	0,0360	0,0367		
7	0+120	580	406	318	254	184	129	74	45	149	0,4679
			0,0219	0,0263	0,0285	0,0297	0,0303	0,0338	0,0359		
8	0+140	578	391	283	229	174	130	80	50	145	0,3577
			0,0209	0,0218	0,0235	0,0255	0,0277	0,0297	0,0336		
9	0+160	583	395	304	251	192	143	89	53	132	1,0924
			0,0211	0,0234	0,0257	0,0281	0,0305	0,0331	0,0356		
10	0+180	574	411	295	236	177	132	89	55	139	0,2120
			0,0221	0,0244	0,0265	0,0286	0,0310	0,0335	0,0337		
11	0+200	574	386	296	242	182	135	86	54	142	0,3485
			0,0219	0,0234	0,0250	0,0272	0,0295	0,0325	0,0357		
12	0+220	584	525	365	287	212	160	107	64	117	0,2104
			0,0231	0,0233	0,0240	0,0250	0,0274	0,0320	0,0352		
13	0+240	588	462	354	290	221	162	100	57	115	0,1409
			0,0238	0,0256	0,0264	0,0270	0,0282	0,0320	0,0334		
14	0+260	578	535	381	302	222	165	104	66	118	0,0953
			0,0236	0,0243	0,0253	0,0262	0,0282	0,0311	0,0341		
15	0+280	585	478	367	306	236	177	110	64	106	0,3638
			0,0224	0,0266	0,0273	0,0284	0,0310	0,0330	0,0336		
16	0+300	576	539	402	327	248	180	111	63	101	0,2189
			0,0232	0,0244	0,0254	0,0263	0,0284	0,0312	0,0341		
17	0+320	584	497	382	311	235	174	108	63	108	0,2385
			0,0234	0,0274	0,0288	0,0295	0,0310	0,0336	0,0343		
18	0+340	586	499	375	307	232	173	109	64	109	0,1979
			0,0238	0,0272	0,0290	0,0293	0,0311	0,0338	0,0343		
19	0+360	587	838	517	366	251	187	122	68	95	0,0527
			0,0275	0,0285	0,0300	0,0315	0,0336	0,0354	0,0375		
20	0+380	582	430	331	273	207	157	96	62	127	0,2884
			0,0222	0,0240	0,0249	0,0253	0,0273	0,0307	0,0332		
21	0+400	577	548	422	347	258	188	115	65	97	0,2352
			0,0237	0,0243	0,0251	0,0267	0,0287	0,0315	0,0346		
22	0+500	580	612	335	161	121	97	74	61	122	0,9658
			0,0230	0,0268	0,0282	0,0292	0,0304	0,0334	0,0368		
23	1+000	578	694	337	177	139	115	92	77	100	0,5731
			0,0261	0,0284	0,0295	0,0335	0,0348	0,0365	0,0372		
									Avarage	131	0,4334

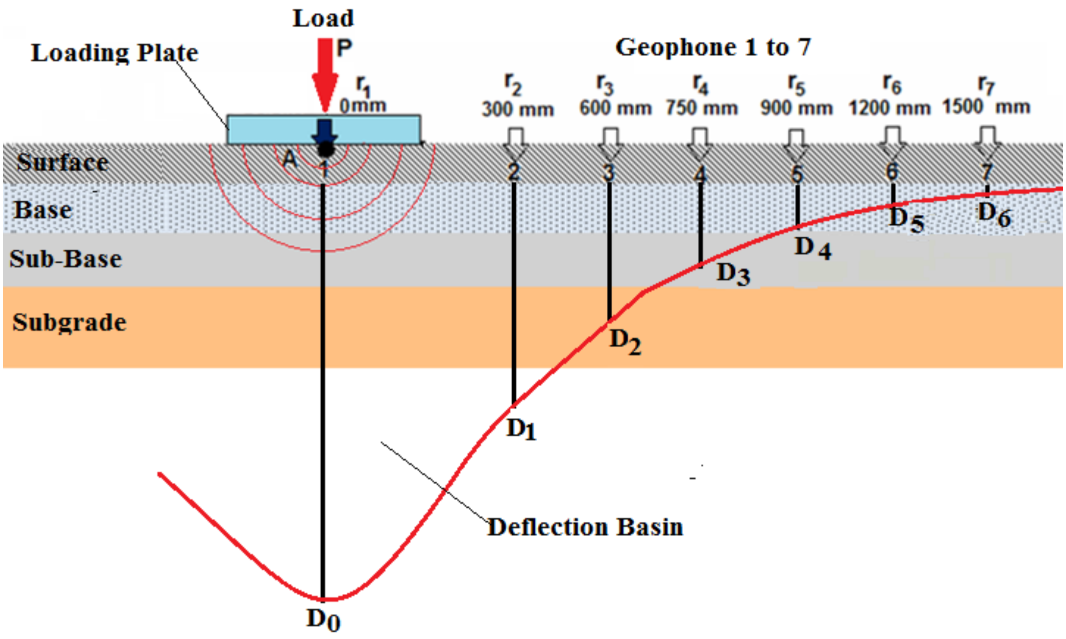


Figure 4. Schematics of FWD load and deflection measurement.

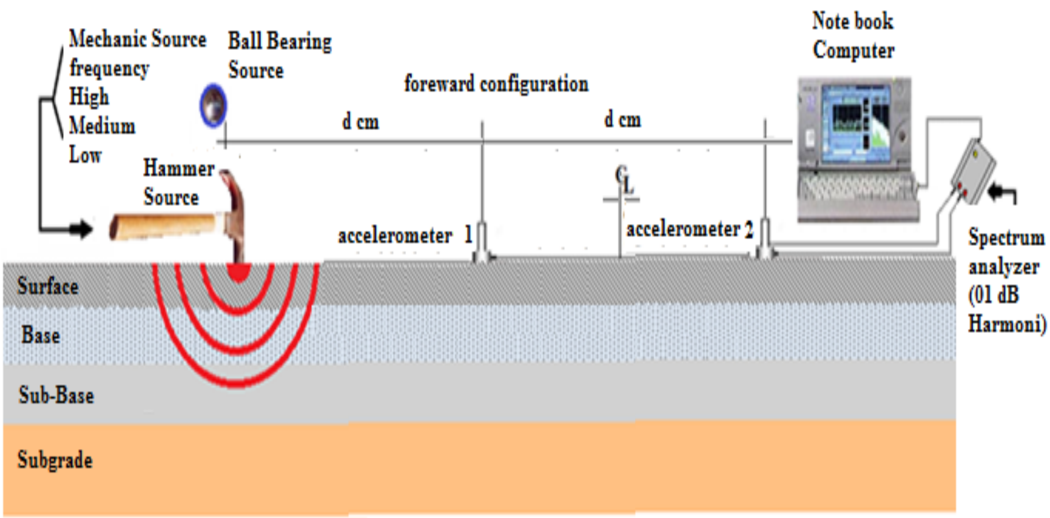


Figure 5. SASW experimental set up

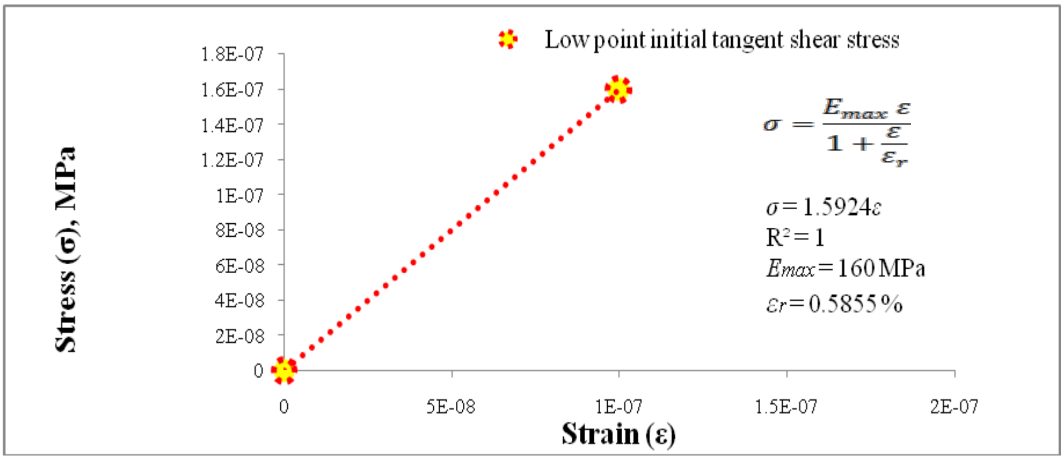


Figure 6. Initial tangent elastic modulus E_{max} (SASW)

Table 2. Elastic modulus and strain characteristic sub grade SASW test on site

SASW test result:	Sukarno -Hatta			Cikampek - Purwakarta			
		Subgrade				Subgrade	
No	Sta	Es (MPa)	ε_r (%)	No	Sta	Es (MPa)	ε_r (%)
1	0+000	260	2,9647	1	0+000	202	0,9618
2	0+020	166	0,5344	2	0+010	185	0,7316
3	0+040	171	0,5805	3	0+020	196	0,8722
4	0+060	169	0,5580	4	0+030	172	0,5885
5	0+080	173	0,6008	5	0+040	167	0,5443
6	0+100	146	0,3969	6	0+050	160	0,4861
7	0+120	146	0,3969	7	0+060	151	0,4251
8	0+140	158	0,4734	8	0+070	168	0,5505
9	0+160	143	0,3823	9	0+080	152	0,4337
10	0+180	151	0,4300	10	0+095	140	0,3630
11	0+200	154	0,4509	11	0+105	127	0,3045
12	0+220	129	0,3129	12	0+115	151	0,4304
13	0+240	127	0,3069	13	0+145	169	0,5661
14	0+260	132	0,3277	14	0+165	172	0,5934
15	0+280	116	0,2647	15	0+175	178	0,6434
16	0+300	111	0,2463	16	0+185	172	0,5912
17	0+320	118	0,2719	17	0+195	169	0,5620
18	0+340	119	0,2755	18	0+205	186	0,7328
19	0+360	107	0,2350	19	0+215	238	1,8772
20	0+380	139	0,3584	20	0+225	211	1,1388
21	0+400	106	0,2318	21	0+235	195	0,8649
22	0+500	132	0,3262	22	0+380	207	1,0517
23	1+000	108					
Avarage		143	0,4750	Avarage		176	0,6961

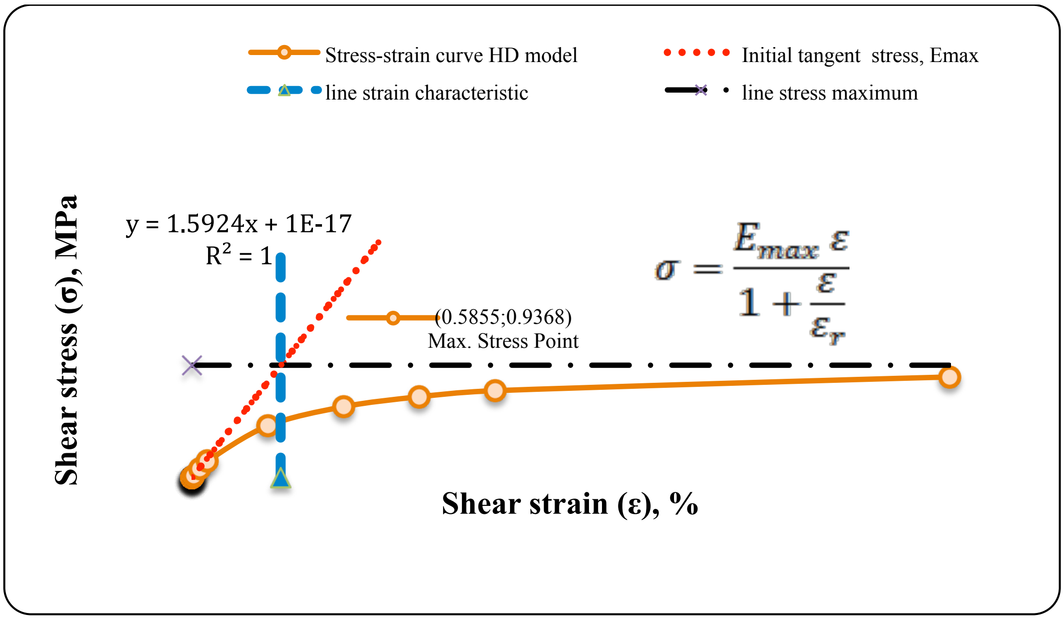


Figure 7. Maximum stress points in elastic modulus E_{max} (SASW) sub grade

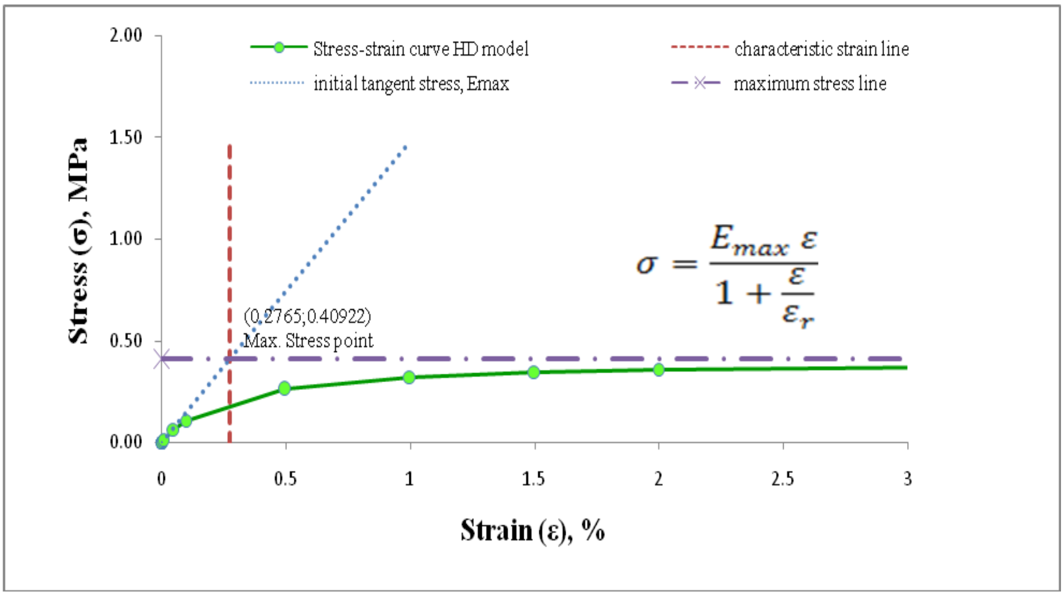


Figure 8. Maximum stress points in elastic modulus E_{max} (FWD) sub grade

The hyperbolic function above (graphic method) is simple method of curve generation that is easily fitted to the initial conditions (Jean and Catherine 1990).

Conclusions

The hyperbolic function model (Hardin and Drnevich 1972) can be used to prediction of the maximum stress subgrade by plotting graphic with combination by damping equation (Abbiss 1983) on FWD and SASW test methods, before and after disaster; at both medium and low strain levels.

Acknowledgments

This research was supported in part by Universitas Muhammadiyah Yogyakarta, Universiti Kebangsaan Malaysia and Puslitbang Bandung Indonesia. These supports are gratefully acknowledged.

References

Abbiss, C.P (1983).'Calculation of elasticities and settlements for long periods of time and high strains from seismic measurements'. *Geotecchnique* **40,** No.4, 641-646.

Abbiss, C.P (1986).'The effects of damping on the interpretation of geophysical measurements'. *Geotechnique* **36**, No.4, 565-580.

American Association of State Highway and Transportation Officials (AASHTO), 1993. *AASHTO Guide for Design of Pavement Structures*. Washington, D.C.: American Association of State Highway and Transportation Officials.

Asphalt Institute (1986) “Soils manual for the design of asphalt pavement structures”, Manual Series No.10.

Athanopoulos, G.A., Pelekis, P.C. and Anagnostopoulos, G.A. (2000). Effect of soil stiffness in the attenuation of rayleigh-wave motions from field measurements. *Soil Dynamics and Earthquake Engineering*. 19. 277-288.

Brown A.F., Tam W.S., Brunton J.M., Structural evaluation and overlay design analysis and implementation, in: Structural Design of Asphalt Pavements I. Cushing-Malloy, Inc., Ann Arbor, MI, 1987.for Asphalt Technology.

Carlos Cornejo C.J., (2002) Elastodynamics with Hysteretic Damping, PhD Thesis, Delft University Technology.

Hardin, B.O. 1965. The nature of damping in sands. *Journal of the Soil Mechanics and Foundations Division* 91 (SM1): 63-97.

Hardin BO, Drnevich VP. Shear modulus and damping in soils:design, equations and curves. Soil Mech Found Div, Proc ASCE 1972;98(SM7):667–92.

Hardin BO and Scott GD. Generalized Kelvin-Voigt Used in Soil Dynamics Study. J. of the Engng. Mech. Div., ASCE, V. 92(No. EM1):pp. 143–156, February 1966.

Heisey JS, Stokoe II KH, Hudson WR, Meyer AH. Determination in situ shear wave velocities from spectral analysis of surface waves. Research Report 256-2, Center for Transport Research, University of Texas at Austin; 1982.

Jean H. Prevost and Catherine M. Keane (1990) “Shear Stress-Strain Curve Generation From Simple Material Parameters” Journal of Geotechnical Engineering, Vol. 116, No. 8.

Joh SH. Advanced in interpretation and analysis techniques for spectral-analysis-of-surface-waves (SASW) measurements. PhD Dissertation,The Unversity of Texas at Austin; 1996.

Nazarian S, Stokoe II KH. In situ determination of elastic moduli of pavement systems by spectral-analysis-of-surface-waves method (practical aspects). FHWA, Report No. FHWA/TX-86/136 þ 368-1F; 1985.

Nazarian S, Stokoe II KH. In situ determination of elastic moduli of pavement systems by spectral-analysis-of-surface-waves method (theoretical aspects). FHWA, Report No. FHWA/TX-87/46 þ 437-2; 1986.

Röesset, J.M. Chang, D.-W., Stokoe II, K.H. and Aouad, M. (1990). Modulus and thickness of the pavement surface layer from SASW test. *Transportation Research Record*. 1260. 53-63.

Rosyidi,S.A., Nayan, K.A.M. and Taha, M.R. (2004). *Measurement of subgrade stiffness using the SASW method*. Proceeding of Malaysian Geotechnical Conference, Petalingjaya, Kuala Lumpur, Malaysia.

Sebaaly, P.E., Tabatanee, N., and Scullion, T., Comparison of backcalculated moduli from falling weight deflectometer and truck loading, *Transportation Research Record*, 1377, 1991, pp.17–25.

Ullidtz, P.(1987). Pavement Analysis, Elsvier, New York.

Woods, R.D. (1997). Dynamic effects of pile installation on adjacent structures. *Vibration Problems in Geotechnical Engineering*. *ASCE Special Publication*. 229-246.

Yang, X.J. (1995). *Evaluation of man-made ground vibration*. Proceeding of 3rd International Conference on Recent Advances in Geotechnical Conference Earthquake Engineering and Soil Dynamics, St.Louis. MO.Vol.3. 1345-1348.

Vulnerability Assessment for Structures Using Microtremor Analysis to Reduce the Impact of Earthquake

Atika Ulfah Jamal

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia, Yogyakarta, Indonesia

Email : atika.ulfah@uii.ac.id , atika_ulfah@yahoo.com

Abstract

It is important to investigate the vulnerability of structures as mitigation effort to reduce the impact of earthquake. It is to know the structures are livable and feasible to be used. Structure will be resonance if the excitation frequency is close to natural frequency of the structures. According to Nakamura (2000), the vulnerability index can be identified from dynamic characteristis of structure one of which is the structure's frequency. One of the easy ways to investigate the structure's dynamic characteristic without damaging the structure is by using a seismometer since it is very sensitive to micro tremors. The research was conducted on KPTU FT UGM Building. The building consists of 3 storey formed asymmetrically plan like letter "Y" and the building configuration has possibility to possess 'soft storey' mechanism on the first storey. Seismometer records the tremors in horizontal direction (N-S and E-W) and in vertical direction (U-D) at the same time. The test was conducted on the ground floor, 1st, and 2nd floor. The test on the ground floor was held on 1 point, while on the 1st floor and 2nd floor was held on 3 different points (south, north, and west side). The analog signal from three sensors (N-S, E-W and U-D) was processed by means of FFT. An averaging technique was applied to eliminate noise. The result shows that the natural frequency of the building on the N-S direction is 1.9043 Hz and on the E-W direction is 1.8555 Hz. The dominant mode shape is the first mode, with higher amplification factor along the height. The vulnerability index of the 1st storey is higher than of the 2nd storey. The highest vulnerability index is on the position 2 (north side), this indicates the first damage occurs on that location.

Keywords: seismometer, structure's frequency, micro tremor, vulnerability index.

Introduction

Livable cities is a term that describes an environment and a comfortable atmosphere of the city as a place to live and a place to activity that viewed from various aspects both of the physical (urban facilities, infrastructure, spatial, etc.) as well as non-physical aspects (social relationships, economic activity, etc.). One criteria of livable cities is livable building and feasible to used. In structure area, a livable building can be seen from the vulnerability of the structure. The diversity of structures may produce different structure vulnerabilities due to the dynamic characteristics differences and seismic performance of the structure, such as natural frequency, amplification factor and vulnerability index of building.

There is not much that can be done to prevent the occurrence of earthquakes. However, the earthquake-induced damage can be reduced with planning and constructing earthquake resistant buildings or evaluating and strengthening existing buildings prevent for earthquake. Nakamura (1997), occurrence of earthquake damage depends upon strength, period and duration of seismic motions. These parameters, of course, depend upon earthquake itself but they are also strongly influenced by the seismic response characteristics of surface ground and structures.

The earthquake load causes the base rock vibrates irregularly in many directions. The base rock acceleration will spread around the foundation and do over the upper structures. The earthquake load is the most significant influence on reinforced concrete structures. The consequences of earthquake were so fatal, especially to most non-engineered buildings. The natural disasters that may changes sructure's stiffness and the strength, site plan that may change during implementation and the human activities also may influence the distribution of mass upon the floor, these things can cause differences in the structural dynamic characteristics of the numerical modeling and implementation.

The Nakamura ideas in predicting the strength / capability of building that resistant to earthquakes, should be actively encouraged and developed, that is investigation of dynamic characteristic of structure by microtremor analysis using seismometer. The seismometer was recording microtremor of structure in the horizontal direction (N-S and W-E) and vertical direction (U-D). Microtremor analysis is easy, not destructive of structure, effective and quick.

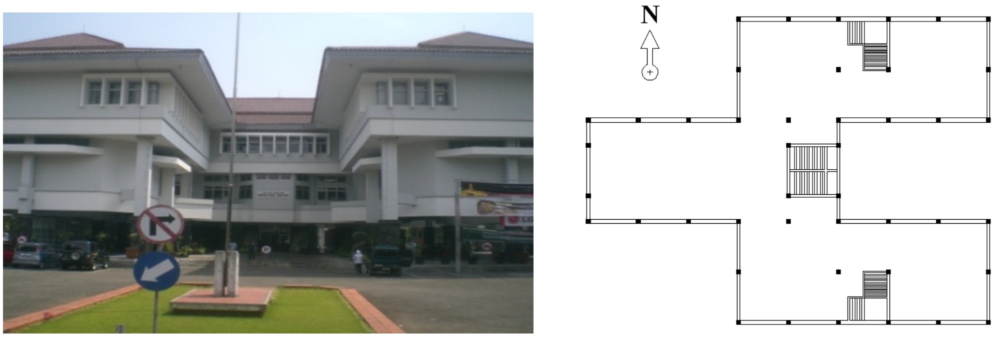
In Indonesia, the research using seismometers is more used to determine the dominant frequency and the amplification or deamplification of vibrations on the ground in earthquake mitigation efforts through microzonation seismic mapping of a region. The natural/ predominant frequencies of a structure are inversely proportional to the periods. The free vibration can take place in Multi Degree of Freedom system (MDOF) at any time and any place, but their magnitudes are normally very small unless being shocked by earthquakes or large artificial impulses.

This paper will evaluate the dynamic characteristic of an educational building (property of Faculty of Engineering of GMU). By knowing the vulnerability index and the position of the structures that are vulnerable to damage due to earthquake, it can be used as a reference in order to strengthen the structure of the building to be more safe and livable.

DESCRIPTION OF THE BUILDING

The research was conducted on KPTU FT GMU Building. The building has asymmetric plan (in y-axis) and an open space on ground floor that may change the stiffness, like seen in Fig. 1. For the sake of analysis purposes, the direction of the vibration at each storey may be assumed to be in horizontal (N-S and E-W) directions and in vertical (U-D) direction only.

The y-building is a center for administrative and social activities where students and faculty members of eight departments meet each other. As the consequences of that, there should be a large open space on the ground. From the distribution of mass along its height of the structure, this building is seemingly prone to fail due to soft storey effect when medium to large earthquake takes place. The stiffness of the first storey is likely much smaller than that the storey above it. Instead of that, the irregular plan in N-S direction (in y-axis) may create torsion under lateral load.



(a) (b)

Figure1. Plan view of Y-building of Faculty of Engineering of GMU

Irregularity in stiffness and site plan may result in non coincidence of center of mass (CM) and center of rigidity (CR). Since earthquake load goes through the center of mass (CM) than there should be an arm in between those centers that produce torque moment.

Literature Review

As it is explained by Nakamura (1989), H/V of microtremor at peak frequency range can be explained with vertical incident SH wave. Seismic experiences between microtremor's waves and characteristics of strong ground motion shows that strong motion at the rock site in horizontal and vertical components does not show much differences (Nakamura, 2000).

Characteristics of surface ground can be approximated by spectral ratio of horizontal to vertical component (QTS: Quasi-Transfer Spectrum) of microtremor (Nakamura, 1989). Seismic response characteristics of structures can be estimated by spectral ratios of microtremors measured simultaneously on structures and their foundation ground surface. QTS of microtremors on the structures are approximated by combined characteristics of ground and structures (Nakamura, 1997).

Lermo and Chávez-García (2000) investigated the function of microtremor in response evaluation. Three different amplitudes (N-S, E-W and U-D) could be provided using Fourier transformation technique. The ratio of horizontal to vertical amplitudes as well as horizontal to horizontal amplitudes between the storey were evaluated. By applying a technique as proposed by Nakamura (2006) the result showed that the measurement of microtremors could be used to predict predominant period of the structure of 0.3 Hz to 5 Hz with very acceptable reliability.

Natural frequency can be obtained from the results of spectral analysis of acceleration recording using seismometers. From the data of frequencies can be used to determine mode shape of structure, determine center of rigidity (CR) and determine displacement direction on the occurred of earthquake (Nakamura, 2000). Vibration mode characteristics are investigated from spectral ratio of higher floors with ground floor. Many modes of vibration of the structure can be shown during experiment but for the purpose of simplicity, only two modes of vibration will be analyzed.

The **s**tructural horizontal displacement relates to the acceleration of the base rock beneath the structure in question, the softer the soil layer upon the base rock, the higher the horizontal acceleration will be on the surface (Nakamura, 2000), while the vertical acceleration may be assumed constant. Thus, the stiffness of the soil layer may be then given as the ratio of horizontal to vertical accelerations. At one particular structure when stiffness of the structure differs from stiffness of soil layer hence there will be an amplification of signals. Amplification of spectrum will have an effect to horizontal displacement at structure.

The identification of damage mechanisms to evaluate the risk of damage can be done by computing the vulnerability index. This value is used as an indicator of resistance building against earthquake vibration. According to Nakamura equation (Nakamura, 2000), the vulnerability index is affected by the amplification factor, the frequency and height of the column structure. If unit of *K* is given in 1/gal, vulnerability index for building can be rewritten as:

$$K_{TJ} = 10^4 . \frac{A_{sj} - A_{sj-1}}{4\pi^2 F^2 h_j} \quad \text{................................ (1)}$$

Where A_{sj} is amplification factor of jth floor of structure. A_{sj} is derived from S_{jh} and S_{gh} which are respectively horizontal spectrum at jth floor and base floor.

$$\alpha_{sj} = A_{sj} \cdot \alpha_g \quad \text{................................. (2)}$$

In Situ Measurement

Seismometers recording sensitivity 0.22 v/ms-2 and in setting the low pass filter and signal averaging as much as 30 times to reduce noise. Three components of vibration were produced by the seismometers, two were in horizontal directions (N-S and E-W) and one was in vertical direction (U-D). These vibrations were recorded simultaneously in a pair (in two seismometers). Time between readings was set to be 10 ms and the length of each record was about 7 minutes. Gain factor was positioned at 100. To avoid noise, the experiment took place at night where the building was no longer occupied or minimum activities.

The measurement of microtremor signal of the-y building of Faculty of Engineering was taken at three positions. One point was located on the first floor and the other three points namely position-1 (South-side), position-2 (North-side) and position-3 (West-side) were on the second floor and third floor, as seen in Fig 2, 3 and 4.

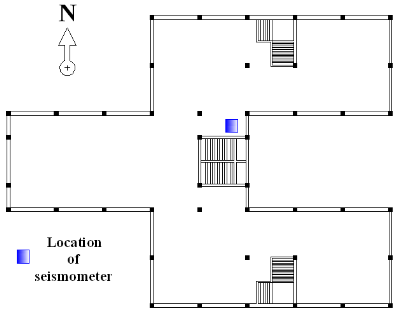


Figure2. Measurement positions on the first floor

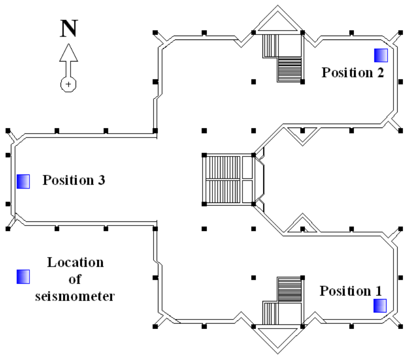


Figure3. Measurement positions on the second floor

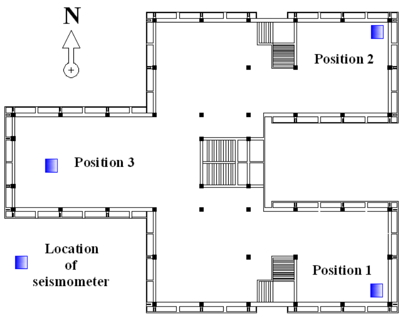


Figure4. Measurement positions on the third floor

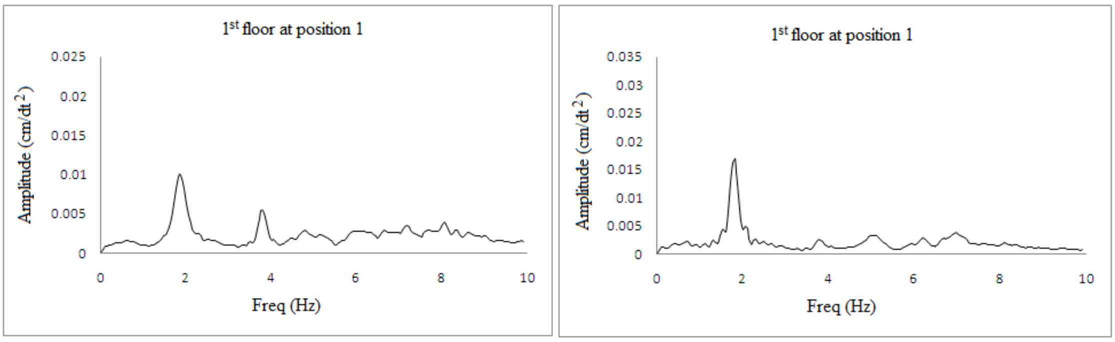
Analysis Method

After measurement being accomplished, amplitudes (in terms of accelerations) of signal were processed by the help of Fast Fourier Transform (FFT) program. By applying averaging technique on thirty spectra, a less noise spectrum was able to be provided. Each spectrum has a 2048 (2^{11}) data consists of 512 data derived from the data recording and the rest is the addition of zero amplitude (zero adding). The results of the addition of zero amplitude will produce a better spectrum or close to the original analog signal. With the addition of zero amplitude is then Δf becomes smaller so that the resulting frequency closer to the actual frequency.

By recognizing the first two natural frequencies, the displacements can be established by integration. The vulnerability indices at every storey can then be analyzed by employing Nakamura equations (2000).

Result and Discussion

Result of the measurement shows that the predominant frequencies of the y-building are of F = 1.9043 Hz in North-South (N-S) direction and F = 1.8555 Hz in East-West (E-W) direction. Figure 5 shows the response spectrum in N-S direction on the 1st floor at position 1. Figure 6 and 7respectively shows amplification factors at each floor at position-1 (South), position-2 (North) and position-3(West).



a. N-S Direction b. E-W Direction (B-T)

Figure5. Response spectrum on the 1st floor at position-1

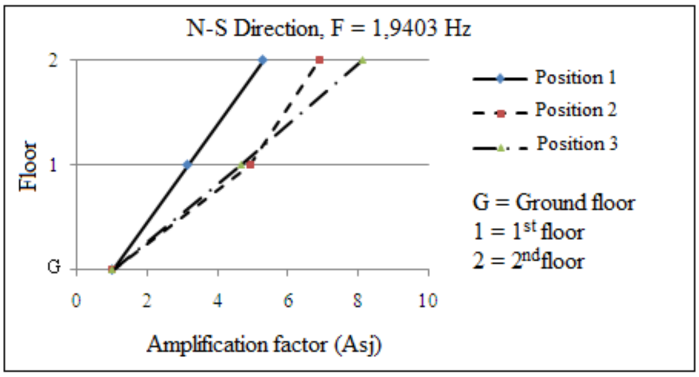


Figure6. Amplification factor in N-S direction

Amplification factor in N-S direction on the 1st floor at position-2 (see Figure 6) is bigger than that at position-1 and 3. The amplification factor ranges from 1 to 8.10. The biggest amplification factor at position-3 takes place at the 2nd floor. In E-W direction at position-2 the amplification factor is bigger than that at position-1 and 3 (see Figure 7). The amplification factor ranges from 1 to 19.32. The biggest amplification factor takes place at the 2nd floor at position-2.

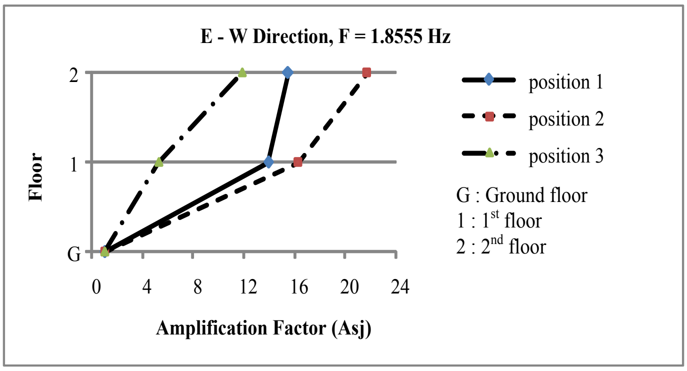


Figure7. Amplification factor in E-W direction

Figure 8 and 9 shows the vulnerability indices in N-S and E-W directions. In N-S direction at position-1, 2 and 3, the vulnerability index decreases from the 1st storey to 2nd storey. At position-2, the vulnerability index decrease significantly from 1st storey to 2nd storey. Vulnerability index ranges from 26.99 to 54.22, and the biggest vulnerability index is at 1st storey at position-2. Therefore, initial damage is predicted to take place at position-2 of the 1st storey.

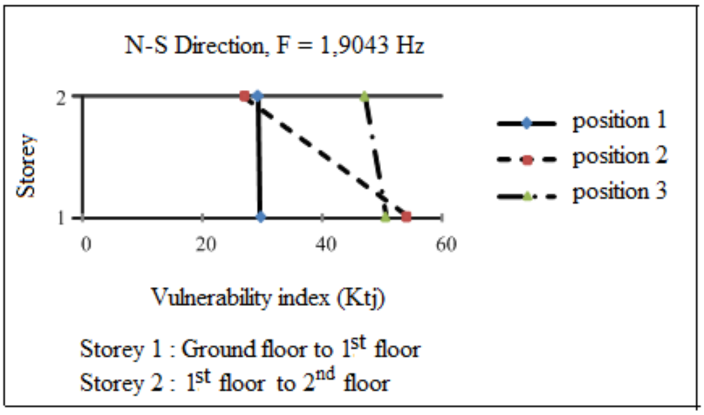


Figure8. Vulnerability index in N–S direction

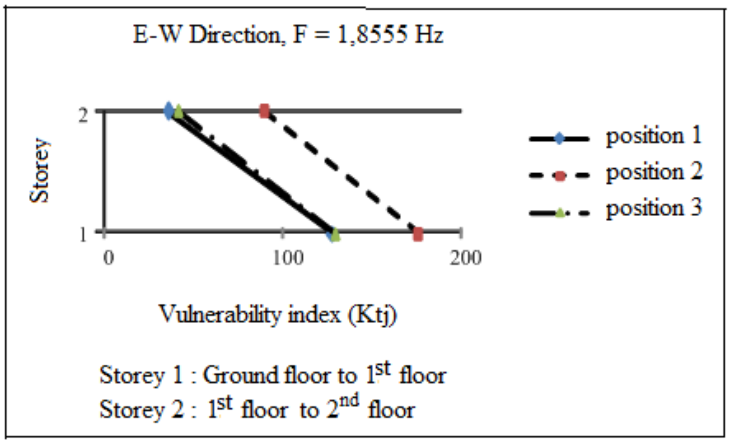


Figure9. Vulnerability index at E-W direction

In E-W direction at position-1, 2 and 3, the vulnerability index decrease significantly from 1st storey to 2nd storey. The vulnerability index ranges from 35.64 to 176.16. Figure9 shows that in position-2 is the biggest vulnerability index take place on the 1st storey, thus initial damage may take place at position-2.

Figure 8 and 9 shows that the biggest vulnerability index is take place on the 1st storey. From the distribution of mass along its height of the structure, the stiffness of the first storey is likely much smaller than that the storey above it.

SNI-03-1726-2002 section 4.2.1 requires the stiffness of the lateral-force-resisting system in any storey shall not be less than 70% of the stiffness in an adjacent storey above or below or less than 80% of the average stiffness of the three stories above. Table 1 shows the stiffness level of this building at E-W and N-S direction. The stiffness at the 1st storey is less from 70% of the stiffness at the 2nd storey. It shows that the 1st storey is soft storey.

Figure 8 and 9 shows that the biggest vulnerability index is take place on the 1st storey. This possible because the damage that ever happened on the structure in 2006 earthqauke, specifically cracked on the beam column joint at the 1st storey and cracked on the column at the 1st storey at position 2. The damage was influential in stiffness structure.

Table1. The stiffness storey at N-S and E-W directions

Position	Storey	N-S direction (F= 1.9043 Hz)			U-S direction (F= 1.8555 Hz)		
		Story drift (γ) (10^{-7})	k = 1/γ (10^{7})	Percentage (%)	Story drift (γ) (10^{-7})	k = 1/γ (10^{7})	Percentage (%)
1	1	0.8958	1.12	98.9	1.8906	0.53	27.8
	2	0.8855	1.13	100	0.5256	1.90	100
2	1	1.6324	0.61	49.8	2.5984	0.38	51.1
	2	0.8125	1.23	100	1.3288	0.75	100
3	1	1.5288	0.65	92.9	1.9105	0.52	32.4
	2	1.4206	0.70	100	0.6188	1.62	100

Conclusion

Measurements microtremor using a seismometer is efficiently and not cause damage to the structure. Seismometers recording sensitivity 0.22 v/ms-2 and in setting the low pass filter and signal averaging as much as 30 times to reduce noise can provide sufficient information on the natural frequency, the amplification factor and the vulnerability index. By defining weak points from larger vulnerability indices, it is possible to obtain possible damage positions before large earthquake take place in the future. The big frequencies have smaller vulnerability index. From the results showed that the vulnerability index of this building at N-S direction smaller than E-W direction.

Ackowledgement

Thank to the Department of Architecture of GMU and the BPPTK Vulcanology Department of Yogyakarta whom have lent their seismometers for this research. The author would also like to thank to the Asset Management and Maintenance Directorate of GMU who have given permission to conduct research on the KPTU FT GMU.

References

BSN, 2002, SNI-03-1726-2002, *"Standar Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung"*, Center for Housing Research and Technology Development, Department of Public Works, Bandung, Indonesia.

Nakamura, Y., 1989," A Method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface", Quarterly Report of RTRI, Railway Technical Research Institute(RTRI), Vol. 30, No.1.

Nakamura, Y., 2000, Clear Identification of Fundamental Idea of Nakamura's Technique and Its Applications, System and Data Research Co. Ltd., 3-25-3 Fujimidai, Kunitachi-shi, Tokyo, Japan yutaka@sdr.co.jp

Nakamura, Y., 2000, Gurler, E., D., Saita, J., Dynamic Characteristic of Leaning Tower of Pisa Using Microtremor –Preliminary Results-, System and Data Research Co., Ltd. SDR Bldg., 3-25-3 Fujimidai, Kunitachi-shi, 186-0003, Tokyo.

Nakamura, Y., Gurler, E., D., Saita, J., Rovelli, A., Donati, S., 2000, Vulnerability Investigation of Roman Colloseum Using Microtremor, 12th World Conference on Earthquake Engineering.

Nakamura, Y, 1997, Seismic Vulnerability Indices for Ground and Structures using Microtremor, World Congress on Railway Research, Florence. Italy, 16-19 Nov.
Nakamura, Y., Characteristic of H/V Spectrum, System and Data Research., 3-25-3 Fujimidai, Kunitachi-shi, 186-0003, Tokyo.

Lermo, J., Chavez-Grazia, 1992, Are Microtremors Useful in Site Response Evaluation? (abstract), EOS 73.352.

Study of Uniform Hazard Spectrum of Suramadu Bridge in Surabaya, Indonesia in conjunction with Seismic Hazard Analysis Program Development

L. L. Makrup

Department of Civil Engineering, Universitas Islam Indonesia, Yogyakarta, Indonesia

Email: lalu_makruf@yahoo.com

Abstract

Suramadu-bridge is one of the connecting-bridge between two islands in Indonesia. The bridge links up the islands of Java and Madura Indonesia with 4 km length and it runs from Surabaya in Java Island to Bangkalan in Madura Island. Seismic hazard study as a basis to account for seismic loading design for the bridge has been achieved with probabilistic seismic hazard analysis methodology. The result of this study is uniform hazard spectrum with hazard level 10% and 2% probability of exceedance in 50 and 100 years is shown respectively. The result compared to other study which evidences that uniform hazard spectrum of this study very similar to the other.

Keywords: Bridge, hazard analysis, uniform hazard spectrum, probability

Introduction

Suramadu-bridge is one of the connecting-bridge between two islands in Indonesia. The bridge links up the islands of Java and Madura. This bridge is 4 km length and it runs from Surabaya in Java to Bangkalan in Madura (Figure 1). Seismic hazard study of the bridge has been carried out by Aldiamar, F (2007), exploited EZ-Frisk software (a computer program of probabilistic seismic hazard analysis) which was developed by Risk Engineering Inc (McGuire, 2005). The similar study acted by Asrurrifak, M. (2010) by operating USGS seismic hazard program, to develop uniform hazard spectrum for some cities in Indonesia.

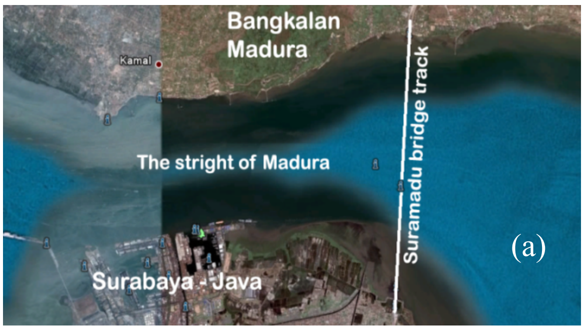


Figure 1: a) the track of Suramadu-bridge (google earth, accessed September, 30th 2010), b) the middle part of Suramadu bridge (http://en.wikipedia.org/wiki/Suramadu_Bridge, accessed September, 30th 2010)

In this study, seismic hazard computation is completed by using software that was developed in the Institute of Technology, Bandung Indonesia (Makruf, L.L., 2009). The result of the study then compared to Aldiamar, F. (2007).

Seismic Sources

Aldiamar, F. (2007) made up uniform hazard spectrum of Surabaya based on some shallow crustal earthquake sources in the vicinity of Java. Almost all of the applied-faults are inferred faults. The faults are Cimandiri, Baribis, Bumiayu, Semarang, Yogya, Sampanahan, and Flores back arc. Threat of Java subduction zone in the south is also included (Figure 2). Earthquakes that may be occurred in all sources can incur disaster to Surabaya and cities around it and can also damage Suramadu-bridge. Those sources are applied in this study.

Some earthquakes have been occurred in those shallow crustal and subduction zones. As an example Yogyakarta earthquake on May, 26th 2006 (Mw6.3), it was a damaging earthquake that gave a big disaster to Bantul area in Yogyakarta. More than 5000 people were dead, 2000 were injured and thousands of buildings were damage in the southern area of Central Java and Yogyakarta. The earthquake was a shallow crustal event that happened in a fault that was suspected as Yogayakarta fault or Opak fault. Another example was the 1994 June 2 earthquake (Mw7.8) took place in Java subduction zone as a mega-thrust event that occurred in interface of subducting Australia plate and Eurasia overriding plate. The earthquake produced a destructive tsunami killing over 200 people and cropped up in south of Java. Both of which produced not so big enough shaking for Surabaya, and no damage was occurred.

For Java subduction zone, the maximum magnitude Mw8.45-8.58 was used by Aldiamar, F. (2007) to analyze seismic hazard in his study. Mw6.98 and Mw7.5 were applied for shallow crustal and Flores back arc respectively. The seismic recurrence parameters of all sources of Aldiamar's study can be seen in table 1.

Table 1: Seismic recurrence parameter

Source zone	a-parameter	b-parameter
Subduction	4.128 - 8.118	0.940 - 1.244
Cimandiri fault	4.995 - 6.545	0.940 - 1. 244
Baribis fault	4.020 - 5.637	0.940 - 1. 244
Bumiayu fault	4.196 - 5.812	0.940 - 1. 244
Semarang fault	4.540 - 6.063	0.940 - 1.244
Yogya fault	4.813 - 6.296	0.940 - 1. 244
Sampanahan fault	5.072 - 6.470	0.940 - 1. 244
Flores back arc	5.494 - 6.040	0.940 -1. 244

Earthquake catalogue

To estimate the future seismic activity based on the rates of past earthquakes, Aldiamar, F. (2007) compiled the catalogs from a few sources. The catalogs are (1) BMG (the Bureau of Meteorology and Geophysics), (2) the EHB (Engdahl, van der Hilst, and Buland), (3) the ISC (Bulletins of the International Seismological Centre), and (4) the PDE (Preliminary Determination of Epicenters catalogs of the US Geological Survey). The combined four catalogs cover an area from 100.0E to 125.0E and 12.0S to 0.0N. Aldiamar, F. (2007) utilized computer program, SHAP (Hendriyawan, 2007) to sort the data. The program employed the Gardner and Knopoff (1974) procedure to eliminate foreshocks, after shocks and duplicate data from the catalogs, remaining main shock only. The table 1 is derived from this main shock.

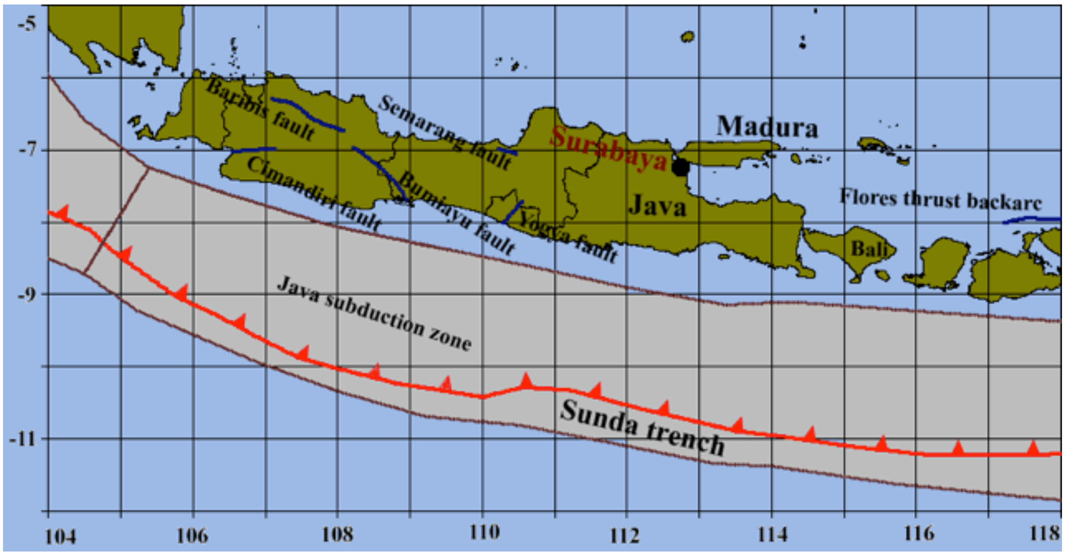


Figure 2: Earthquake sources in vicinity of Java

Ground motion model

Attenuation relations, relate peak ground or spectral acceleration to a given magnitude, distance from the source to the site, fault type, soil condition, and tectonic environment. The prediction equations have been developed for earthquakes associated with four types of tectonic environments i.e. crustal interplate, crustal intraplate, subduction interface, and deep within the subducting slab. To account for ground motion, the 2007 Aldiamar study considered attenuation relationships Campbell and Bozorgnia (NGA, 2006, wt 0.5) equation (1) and Chiou and Youngs (NGA, 2006, wt 0.5) equation (2) and (3) for crustal interplate and crustal intraplate (fault) zones. For interface and deep within the subducting slab (subduction) zone selected Atkinson and Boor (2003, wt 0.5) equation (4) and (5) and Young et al. (1997, wt 0.5) equation (6) and (7).
Campbell-Bozorgnia (*NGA*, 2006)

$$\ln \tilde{Y} = f_{\text{mag}} + f_{\text{dis}} + f_{\text{flt}} + f_{\text{hng}} + f_{\text{site}} + f_{\text{sed}} \quad \text{.................................} \quad (1)$$

where: f_{mag} = the magnitude term, f_{dis} = the distance term, f_{flt} = the style-of-fault (fault mechanism) term, f_{hng} = the hanging-wall term, f_{site} = the shallow site response term, f_{sed} = the basin response term.

Chiou-Youngs (*NGA*, 2006)

$\ln(SA_{1130ij}) = c_1 + c_{1a} F_{RVi} + c_{1b} F_{NMi} + c_7(Z_{TORi} - 4) + c_2(M_i - 6) + [(c_2 + c_3)/c_n]\ln[1 + \exp\{c_n(c_M - M_i)\}] + c_4 \ln[R_{RUPij} + c_5 \cosh\{c_6(M_i - c_{HM}, 0)_{max}\}] (c_{4a} - c_4) \ln\sqrt{R_{rupij}^2 + c_{RB}^2} + [c_{\gamma 1} + c_{\gamma 2}/\cosh\{(M_i - c_{\gamma 3}, 0)_{max})] R_{RUPij} + c_9 \cos^2\delta_i \tanh(R_{RUPij}/2) \tan^{-1}[W_i \cos\delta_I/2\,(Z_{TORi}+1)]1/(\pi/2)\,[1 - R_{JBij}/(R_{JBij} - 0.001)] + \tau z_i$……………….(2)

$\ln(SA_{ij}) = \ln(SA_{1130ij}) + \phi_1 [\ln(V_{S30ij}/1130), 0]_{min} + \phi_2 [\exp\{\phi_2((V_{S30ij}, 1130)_{min} - 360)\} - \exp\{\phi_2(1130 - 360)\}] \ln[(SA_{1130ij}) + \phi_4)/\phi_4] + \sigma z_{ij}$ ……………………(3)

where: M = moment magnitude, R_{RUP} = closest distance to rupture plane (km), R_{JB} = Joyner-Boore distance to rupture plane (km), δ = fault dip angle, Z_{TOR} = depth to top rupture, F_{RV} = reverse faulting flag, F_{NM} = normal faulting flag, V_{S30} = average shear velocity for top 30 m (m/s), $Z_{1.0}$ = depth to shear velocity of 1.0 km/s (m).

Atkinson-Boore (2003)

$\log y = fn(M) + c_3 h + c_4 R - g \log R + c_5\, sl\, S_C + c_6\, sl\, S_D + c_7\, sl\, S_E$…………… (4)

$$R = \sqrt{r_{rup}^2 + \Delta^2} \tag{5}$$

where: M = moment magnitude, h = focal depth, f_n(M) = magnitude term, D_{fault} = closest distance to fault surface (km), PGA_{TX} = is predicted PGA (NEHRP, B) in cm/s, $\Delta = 0.00274\times10^{0.507M}$ (near source saturation term), $S_C = 1$ for NEHRP C soils and $S_C = 0$ otherwise, $S_D = 1$ for NEHRP D soils and $S_D = 0$ otherwise, S_E = 1 for NEHRP E soils and $S_E = 0$ otherwise,

Youngs et al., (1997)

$\ln y = 0.2148 + 1.414 M + C_1 + C_2 (10 + M)^3 - C3 \ln(r_{rup} + 1.7818 e^{0.554M}) + 0.00607 H + 0.3846 Z_T$ (for rock site)…………………………………………...(6)

$\ln y = -0.6687 + 1.438 M + C_1 + C_2 (10 + M)^3 - C_3 \ln(r_{rup} + 1.097 e^{0.617M}) + 0.00648 H + 0.3643 Z_T$ (for soil site)………………………………………… (7)

where: y = spectral acceleration (g), M = moment magnitude, H = depth (km), Z_T = source type (0 for interface and 1 for intra-slab), R or r_{rup} = closest distance to rupture (km).

Development of the uniform hazard spectrum

Uniform hazard spectrum is developed by combining the seismic hazard curve and Poisson process. The seismic hazard curve accounted for based on the total probability theorem and rate of earthquake occurrence (equation 7).

$$\lambda_A(a) = \sum_{i=1}^{n} v_i \int_Z \int_X \int_M P(A > a \mid m, r) f_M(m) f_R(r \mid m, x, z, \delta)\, dm\, dx\, dz \tag{7}$$

where: $\lambda(a)$ is annual rate of exceedance, x and z are the axis of Cartesian coordinates system and y axis is included here, represented by z and fault dip angel (δ), R is distance of rupture-to-site, and M is magnitude.

Probability distribution of a ground motion parameter A exceeded a particular value a (parameter A computed by attenuation relationship) is $P(\mathrm{A}>a|m,r) = P(z^*)$, where z^* is standard normal deviate (equation 8).

$$z^* = \frac{\ln a - \ln A}{\sigma_{\ln A}} \tag{8}$$

where $\sigma_{\ln \mathrm{A}}$ is standard deviation of ln A, a is particular value associated with A.

Equation (8) implies that $P(\mathrm{A}>a|m,r)$ is log-normally distributed. Magnitude distribution, $f_{\mathrm{M}}(m)$, is a truncated exponential distribution (equation 9).

$$f_M(m) = \frac{\beta e^{-\beta(m-m_0)}}{1 - e^{-\beta(m_u - m_0)}} \quad , \; m_0 < m < m_u \tag{9}$$

where m_0 and m_{u} are below and upper limit magnitude respectively and β is seismic recurrence parameter. The distribution is developed based on Gutenberg-Richter's law (1944).

Distance probability distribution, $f_R(r|m,x,z,\delta)$, is a relative distribution that can be calculated based on $f_R(r|m,x,z,\delta)$ = *rupture area/fault area*. To describe the aleatory uncertainty in magnitude maximum, seismic parameters, and ground motion prediction relationship, Aldiamar, F. (2007) using the logic trees (Figure 3 and 4).

Seismic hazard computation

Surabaya's site coordinate of probabilistic seismic hazard analysis calculation is 112.740E, 7.240S. Uniform hazard spectrum is computed based on this coordinate with 5% dumping ratio and 10% probability of exceedance in 50 years and 2% probability of exceedance in 100 years which approximate to 500 years and 5000 years return period respectively. The peak ground acceleration (PGA) and spectral coordinates are obtained from the computation expected represent the hazard of Surabaya, Suramadu-bridge and in vicinity region.

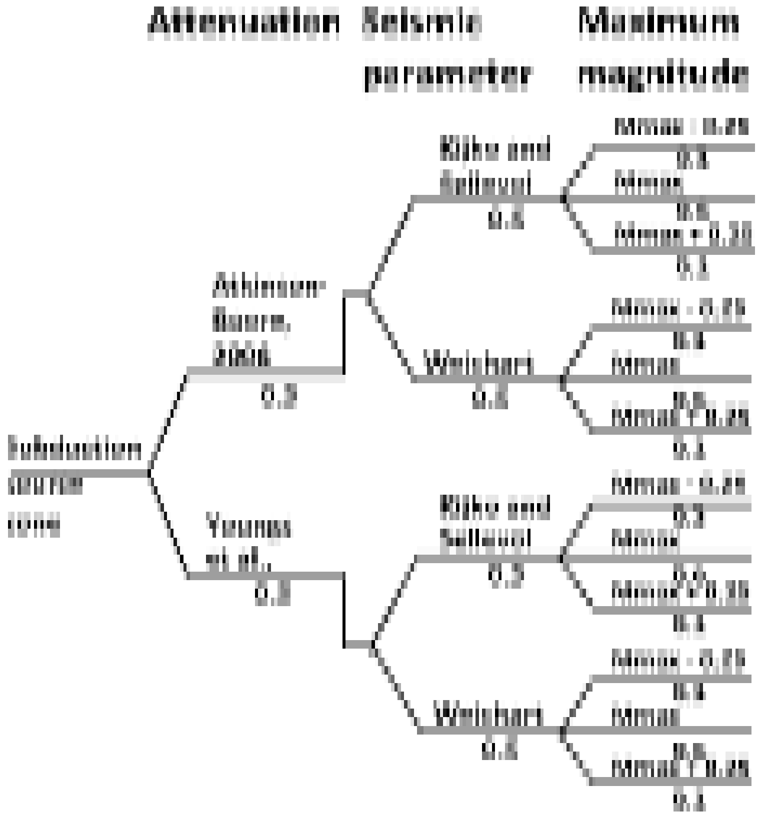


Figure 3: Logic tree for subduction source zone

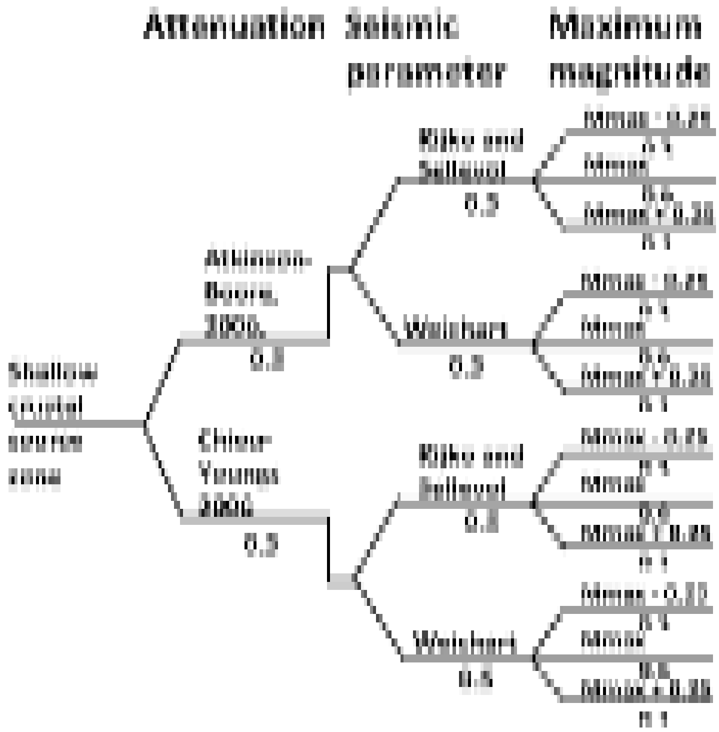


Figure 4: Logic tree for shallow crustal source zone

Result and discussion

Peak ground acceleration (PGA) and spectral ordinates acquired from probabilistic seismic hazard analysis are presented in curves. The curves comprise relationship of PGA and return period, spectral ordinate and return period, uniform-hazard-spectrum with hazard level 10% and 2% probability of exceedance in 50 and 100 years respectively (Figure 5, 6, 7, 8, and 9).

Table 2: Differences of result from EZ Frisk (2007) and the study (2010) of PGA vs return period

Return period (years)	PGA (g)		Differences %
	Aldimar, F 2007	Study 2010	
474.6	0.1092	0.1087	0.458
2474.9	0.1973	0.2020	2.382
3712.4	0.2238	0.2264	1.162
4949.8	0.2444	0.2412	1.309

Figure 5: Difference curve of result from EZ Frisk (2007) and the study (2010) of PGA vs return period

Table 3: Differences of result from EZ Frisk (2007) and the study (2010) of 0.2 second spectral ordinates vs return period

Return period (years)	Spectral ordinate (g)		Differences %
	Aldimar, F 2007	Study 2010	
474.6	0.2146	0.2079	0.670
2474.9	0.3743	0.3675	0.680
3712.4	0.4228	0.4178	0.500
4949.8	0.4591	0.4480	1.110

The PGA or spectral ordinate can be brought into play to generate artificial acceleration time history for the site. The deaggregation analysis can be applied in that time history generation.

The obtained time history could be utilized as a basis to account for the seismic loading design for many types of structure in the same area, on the other hand the PGA gained from this analysis can be employed to derive respond spectra design on ground surface.

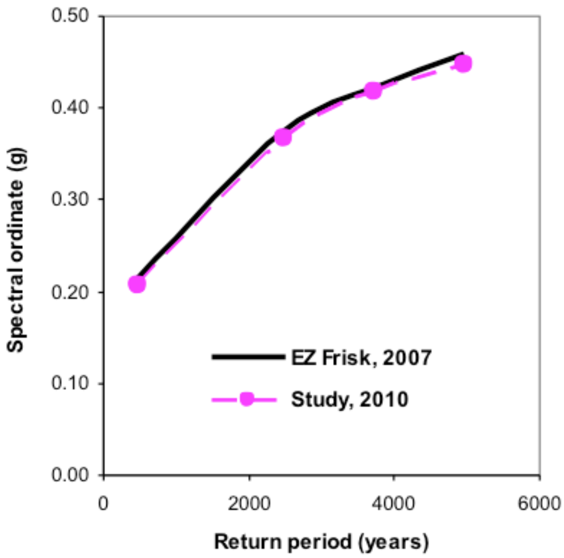


Figure 6: Difference curve of result from EZ Frisk (2007) and the study (2010) of 0.2 second spectral ordinates vs return period

Table 4: Differences of result from EZ Frisk (2007) and the study (2010) of 1.0 second spectral ordinates vs return period

Return period (years)	Spectral ordinate (g)		Differences %
	Aldimar, F 2007	Study 2010	
474.6	0.1036	0.1027	0.869
2474.9	0.1970	0.1957	0.660
3712.4	0.2257	0.2230	1.196
4949.8	0.2484	0.2392	3.704

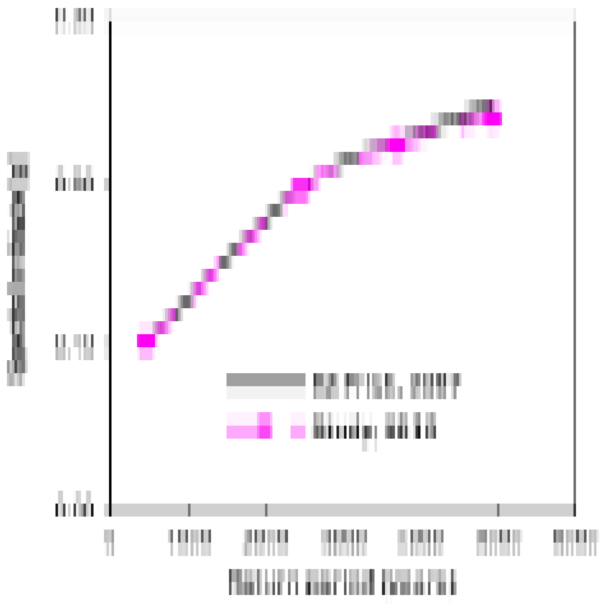
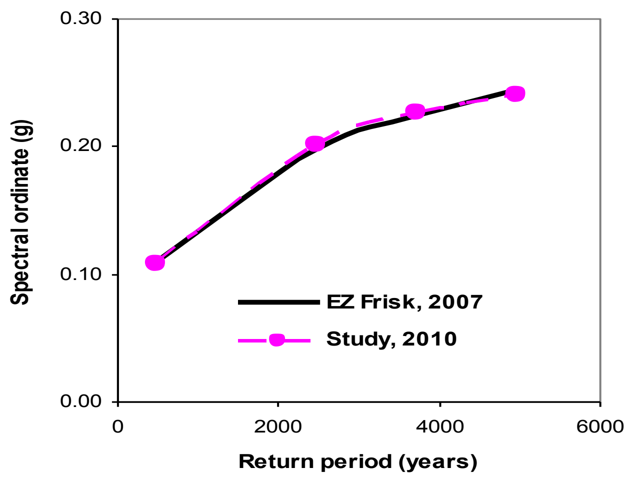


Figure 7: Difference curve of result from EZ Frisk (2007) and the study (2010) of 1.0 second spectral ordinates vs return period

Table 5: Differences of result from EZ Frisk (2007) and the study (2010) of uniform hazard spectrum with hazard level 10% probability of exceedance in 50 years

Period (S)	Spectral ordinate (g)		Differences (%)
	Aldimar, F 2007	Study 2010	
0.00	0.1092	0.1087	0.458
0.05	0.1528	0.1391	8.966
0.10	0.1791	0.1825	1.898
0.20	0.2146	0.2079	3.122
0.30	0.2000	0.2006	0.300
0.40	0.1888	0.1908	1.059
0.50	0.1761	0.1821	3.407
0.75	0.1273	0.1294	1.650
1.00	0.1036	0.1027	0.869
2.00	0.0744	0.0711	4.487
3.00	0.0434	0.0577	32.827



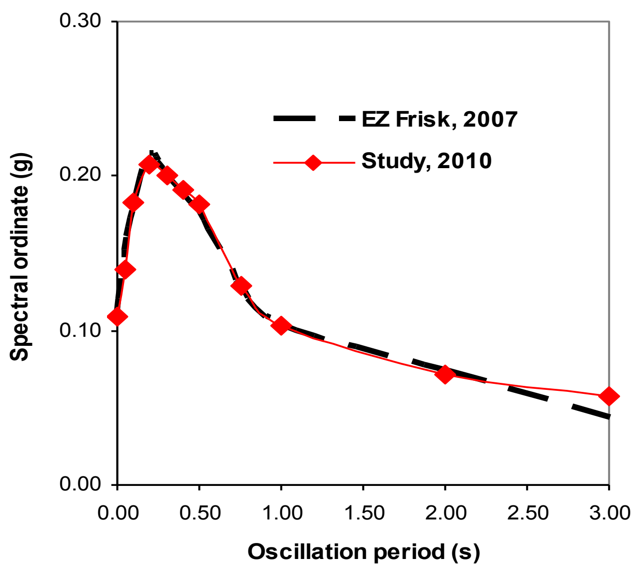


Figure 8: Uniform hazard spectrum difference of EZ Frisk (2007) and the study (2010) for 10% probability of exceedance in 50 years

Table 6: Differences of result from EZ Frisk (2007) and the study (2010) of uniform hazard spectrum with hazard level 2% probability of exceedance in 100 years

Period S	Spectral ordinate (g)		Differences %
	Aldimar, F 2007	Study 2010	
0.00	0.2444	0.2412	1.309
0.05	0.3231	0.3277	1.424
0.10	0.3827	0.3911	2.195
0.20	0.4591	0.4480	2.418
0.30	0.4322	0.4320	0.046
0.40	0.4196	0.4129	1.597
0.50	0.3949	0.3972	0.582
0.75	0.2972	0.3130	5.316
1.00	0.2484	0.2392	3.704
2.00	0.1976	0.2018	2.126
3.00	0.1342	0.1523	13.487

To design earthquake-resistant building it could be utilized the respond spectra combination with national seismic code of building or UBC code or IBC code. As an example, the respond spectra design will be composed for site of Suramadu-bridge. The site soil condition is site class D of UBC code (182.88 m/s < VS30 < 365.76), because average shear wave velocity (V_{S30}) for up to 30 m is 219.17 m/s to 269.73 m/s (Aldiamar, F., 2007). Based on the location condition so the result of calculation of respond spectra design by site class D of UBC code and PGA = 0.109g is in the figure 10.

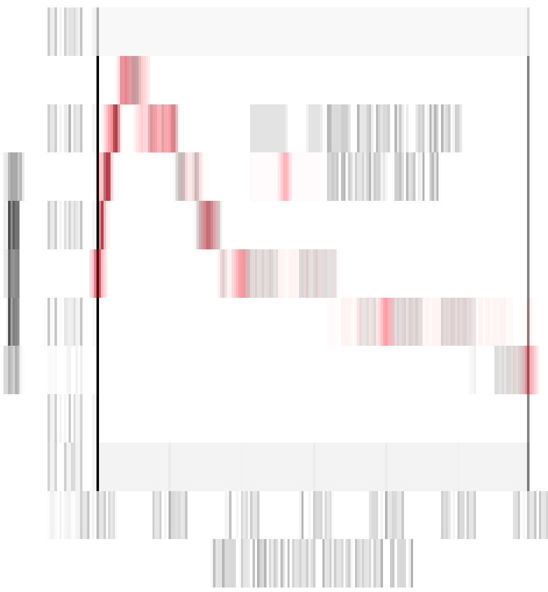


Figure 9: Uniform hazard spectrum difference of EZ Frisk (2007) and the study (2010) for 2% probability of exceedance in 100 years

The above shown-result in figure 5 to 7, identify that by giving an additional return period the result of acceleration calculation granted by EZ Frisk bigger than the study. However, inversely from figure 8 and 9 with additional of oscillation period, acceleration calculation by EZ Frisk is little smaller than by the study. The differentiation arises because there is little dissimilar of parameter to be taken for granted of parameters in distance probability computation. Result of respond spectra design at ground surface in the site shows that the different result between the study and the use of seismic hazard map of Indonesia 2010. The whole the result shows that this study very similar to EZ Frisk's.

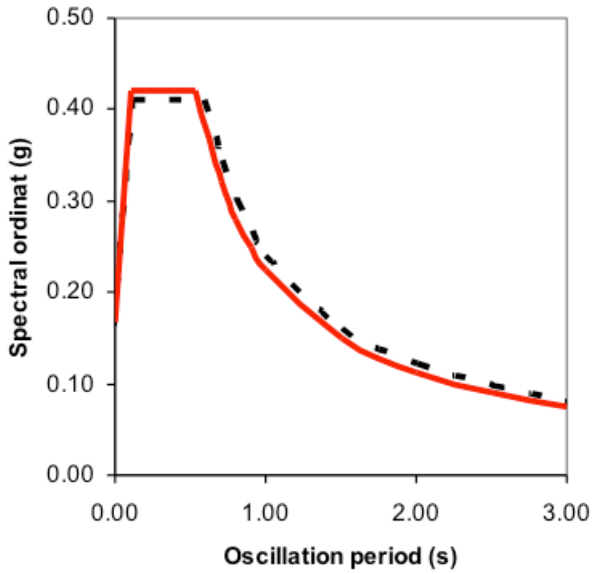


Figure 10: Respond spectra design of Surabaya and Suramadu-bridge for site class D, a) base on this study and seismic hazard map 2002, b) based on seismic hazard map 2010

Conclusion

Probabilistic seismic hazard has been calculated by the computer program that is developed in this study. The program has been used to elaborate uniform hazard spectrum (UHS). The outcome of elaboration has been compared to such UHS of other studies. Both of UHS of two studies are very similar, so the computer program of this study can be exploited for seismic hazard assessment of a region which has earthquake historic data in every where in the world.

References

Aldiamar F. (2007). Analisis Risiko Gempa dan Pembuatan Respon Spektra untuk Jembatan Suramadu dengan Pemodelan Sumber Gempa Tiga Dimensi. Thesis. Institut Teknologi Bandung, 2007.

Atkinson, G.M. and Boore, D.M., 2003. Empirical ground-motion relations for subduction-zone earthquakes and their application to Cascadia and other regions. Bulletin of the Seismological Society of America, v. 93, p. 1703-1729.

Boore D. M. and Atkinson G.M., 2008. Ground Motion Relations for Geometric Mean Horizontal Component of Peak and Spectral Ground Motion Parameters, Next Generation Attenuation (PEER-NGA), Earthquake Spectra, The Professional Journal of Pacific Earthquake Engineering Research Institute (EERI), Vol. 24, No.1. February, 2008.

Campbell K.W. and Bozorgnia Y., 2008. Empirical Ground Motion Model for the Average Horizontal Component of PGA, PGV, PGD and SA at Selected Spectral Periods ranging from 0.01 to 10 seconds, Next Generation Attenuation (PEER-NGA), Earthquake Spectra, The Professional Journal of Pacific Earthquake Engineering Research Institute (EERI), Vol. 24, No.1. February, 2008.

Gardner, J.K., Knopoff, L., 1974. Is the sequence of earthquakes in southern California, with aftershocks removed, Poissonian? Bull. Seismol. Soc. Am. 64, 1363– 1367.

Gutenberg, B. & Richter, C. F., 1944). Frequency of Earthquake in California. Bulletin of the Seismological Society of America, Vol.34, No. 4, pp. pp. 1985-1988.

Hendriyawan, Adnan A., Marto a., dan Irsyam M., 2005. The development of Software for Seismic Hazard Study. Seminar Penyelidikan Kejuruteraan Awam (SEPKA), Universiti Teknologi Malaysia, 5-6 July.

Makrup L.L. 2009. Pengembangan Peta Deagregasi Hazard untuk Indonesia Melalui Pembuatan Software dengan Pemodelan Sumber Gempa Tiga Dimensi, Dissertation, Institute of Technology Bandung, Indonesia.

McGuire R. K., 2005. EZ Frisk Versions 7 manual, Risk Engineering Inc.

Youngs, R.R., Chiou, S. J, dan Silva W.J., 1997. Strong Ground Motion Attenuation Relationships for Subduction Zone Earthquakes. Seismological Research Letters, Volume 68 Januari/Pebruary 1997, Seismological Society of America.

Development of Pushover Analysis on HAZUS Method to Determine Building Damage Probability as an Earthquake Mitigation Effort

Yunalia Muntafi

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Email: yunalia@staff.uii.ac.id

Abstract

Nowadays, the nonlinear static analysis (pushover analysis) using Performance Based Earthquake Engineering (PBEE) concept is one of the well-known choices to evaluate the reinforced concrete frame building's seismic performance. However, the pushover analysis cannot show its damage probability. That is why HAZUS method is very important to solve this problem. This study is conducted to obtain building damage probability by developing pushover analysis on HAZUS to know the damage probability matrix of particular model building type. This study uses pushover analysis capacity spectrum method (procedure B) under ATC-40 and develops it on HAZUS 2001. Analysis is performed by giving static lateral load pattern to the structure model and increasing multiplier factor regularly up to one lateral displacement target of fiducial point is obtained that is figured in response curve, then plot it to capacity curve to get the spectral displacement value on performance point. Then use it into HAZUS to get fragility curve and generate it to damage probability matrix. Results in this study indicate that by SD = 0,22, the probabilities of the buildings having C1M structure properties in slight damage = 0,284%, moderate damage = 0,021%, and 0% for extensive and complete damage. This study shows that the buildings are most vulnerable to slight damage and least vulnerable to complete damage. It also shows that development of pushover analysis on HAZUS is capable to define damage probability of building as an earthquake mitigation efforts.

Keywords: building, earthquake, mitigation, pushover analysis on HAZUS, damage probability

Introduction

Earthquake is one of the world's most commonly discussed natural phenomenons. The impact caused can leave a deep trauma for the victims. Many buildings collapse due to this phenomenon, resulting in many victims suffered. It clearly shows that most of the existing buildings do not meet the requirements of the concept of earthquake resistant building. The existing earthquake resistant building is generally planned using the procedure written in building codes. Based on Wiryanto Dewobroto (2006), building's secure and safety do not only depend on the strength level, but also the deformation level and measured energy at structure performance. The latest trend of building plan and evaluation for the recent earthquake is performance based plan, which is most commonly known as Performance Based Earthquake Engineering (PBEE).

Performance based plan concept is the combination of resilience and service aspect. PBEE concept can be used for designing new building (Performance Based Seismic Design) and evaluating the existing building (Performance Based Seismic Evaluation). As for the development of this concept, nonlinear static analysis which is most commonly known as pushover analysis becomes an interesting choice in planning and evaluating existing building using PBEE concept which can identify seismic performance of the building. However, the existing output can not determine the possibility of damage in the building. Therefore, development of pushover analysis into US-HAZUS is much needed in order to know the damage probability on earthquake mitigation efforts.

Fragility curve in HAZUS method presents the relationship between the intensity of the earthquake phenomenon and the vulnerability of the building structure. Vulnerability curve also suggests the possibility of the optimum strength level of building structure during earthquake phenomenon. This curve classifies the building with the similar characteristics into building level which have been determined.

The objective of this study is to obtain the damage probability using development of pushover analysis in earthquake resistant building vulnerability curve of HAZUS method. The scope of this study uses application model of four levels regular reinforced concrete frame building which is design based on SNI T-15-1991-03 with ductility principal level 3.

Earthquake And Building Damage

Earthquake is one of natural phenomenon which can not be accurately predicted where and when it will happen. Since earthquake force intensity changes with time (time varying), then its effect to the structure also changes with time. Unlike the common static load, Earthquake wave randomly propagate, hence the effect at the structure response can not be easily determined. Structure only carries dead load (D) and live load (L) at the static condition. Earthquake as non-harmonic, non-periodic and non-stationary dynamic load in the form of wave radiation from the source. The wave is then radiated in all directions with the surrounding soil and rocks medium until approaching earth surface and causing vibration.

Ground motion received by foundation is then continued to the upper structure, resulting in oscillation at the building as inertial forces. Structure response as a result of the earthquake is shown in Figure 1.

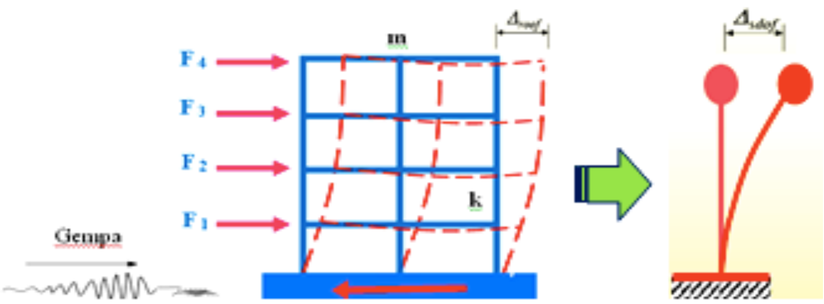


Figure 1. Structure response as a result of an earthquake

Earthquake at certain scale factor, epicentrum and depth where oscillation frequency is either the same or approaching structure frequency will cause a building damage or destruction. Damage and destruction happened can be classified into some level, starting from low level to high level damage.

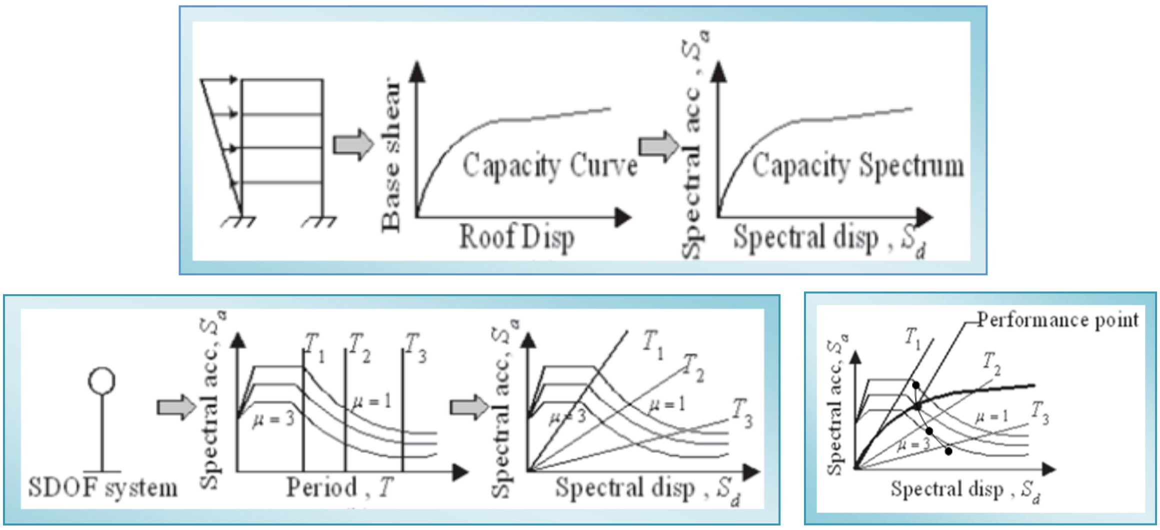
Pushover Analysis

Pushover analysis is a nonlinear static analysis where by the effect of Earthquake Plan at the building structure is considered as static loads at the center of mass of each floor, whose value is gradually increased beyond the loading which cause the first plastic joint in the building structure, then by increasing the load it will undergo heavy post-elastic deformation until approaching plastic condition (Pranata, 2006). Dewobroto (2006) states pushover analysis can be used as earthquake planning tool, as long as it is tailored with any limitations mentioned below:

1. The result of pushover analysis is still an approximation, because the characteristic of actual seismic behavior is back and forth through a certain cycle, while the loading characteristic in pushover analysis is static monotonic.
2. Selection of lateral load pattern used in the analysis is very important.
3. Making non-linear analysis model is more complicated than linear analysis model. Non-linear analysis needs to take into account the inelastic characteristic of load deformation of the important elements and effect P-Δ.

SPECTRUM CAPACITY METHOD

Capacity Spectrum method is the method which is most commonly used to compare the capacity and demand. This method is best used with the aid of built-in ETABS (Anwar, 2007) program. This method is commenced with producing a curve showing the relationship of displacement forces that takes into account the inelastic structure condition. Concept of CSM is the reduction of elastic spectrum intersecting capacity curve at the spectrum coordinate to obtain performance point. From the performance point graph, we can obtain spectral displacement (S_d), acceleration (S_a) and time period (T).



b). Conversion of response spectrum to demand spectrum c). Performance Point

Figure 2. Process of performance point curve plotting

Acceleration-Displacement Response Spectrum

ADRS format is a simple conversion from curve relationship between shear force and control point lateral displacement using dynamic property system and the result is called structural capacity curve. ADRS format is the combination of acceleration displacement response spectrum where x-axis is acceleration (Sa) and y-axis is displacement (Sd) while period T is an oblique line from the origin. Standard format becomes ADRS format is as shown in Figure 2 and Figure 4.

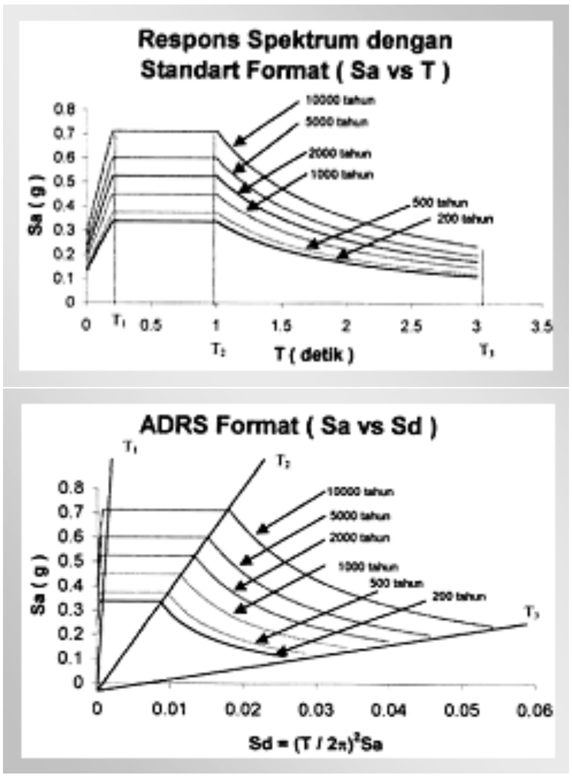


Figure 3.a. Standard format　　　　　　Figure 3.b. ADRS Format

Figure 3. Spectrum Response in standard and ADRS format

Fragility Curve Using Hazus Method

Vulnerability is a possibility of the object of disaster comprises of community, structure, service or geographic area suffered damage or disruption caused by the disaster or the tendency of some object or creation to be broken due to disaster (Sutikno, 1994; UNDP/UNDRO, 1992). Fragility curve is a curve which shows how big is the probability of building vulnerability when it suffered earthquake, either in slight, moderate extensive or complete level (NIBS, 2002). Vulnerability curve elaborates the possibility that the structure will meet or exceed the limitation which is determined during one particular earthquake. In the terminology, probabilistic is cumulative density function which represents sensitivity of the structure to collapse or undergo failure. As stated by Bai and Hueste (2005), structure vulnerability curve is determined by probabilistic relationship between the approximation limit and spectral acceleration (Sa) from the earthquake from some acceleration (PGA) ground motion which has been already determined. HAZUS method is one of the methods which produce vulnerability curve with flexible high level of accuracy and can be applied in analyzing vulnerability level (Gulati, 2006).

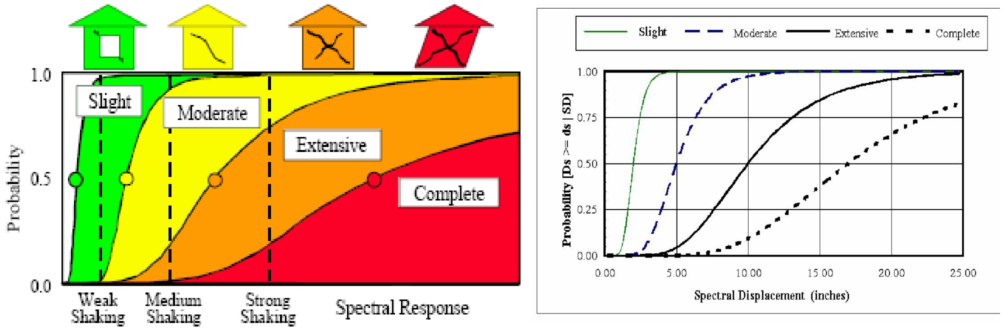


Figure 4. Fragility Curve FEMA, 2003 and NIBS,2002

Vulnerability of buildings are different among each other, this is also caused by the existing building. HAZUS contains 36 building models with various combinations of seismic design level and performance. Each of building represents particular kind of building design in particular construction. Building types suggested by HAZUS is as shown in Table 1.

Damage Probability

In order to determine damage probability caused by the earthquake, we can use the result of pushover analysis which is developed using HAZUS methodology. Hazard-US (HAZUS) method is developed by The National Institute of Building Sciences (NIBS) for risk assessment caused by various disasters. This method is released by Federal Emergency Management Agency (FEMA) in 1997 to estimate the loss caused by the earthquake in US. Several steps are needed in order to obtain cumulative damage probability value at the end of which is obtained using the equation as follows:

$$P[ds / S_d] = \Phi\left[\frac{1}{\beta_{ds}} \ln\left(\frac{S_d}{\bar{S}_{d.ds}}\right)\right]$$

with:

- P [ds / S_d] = damage probability value, ds
- Sd = inelastic spectral displacement (inches)
- $\bar{S}_{d.ds}$ = the median value of spectral displacement at which the building reaches the treshold of damage state, ds
- β_{ds} = the standard deviation of the natural logarithm of spectral displacement for damage state, ds
- Θ = distribution function of comulatve normal standard

Table 1. HAZUS-MH Earthquake model building types (NIBS and FEMA, 2003)

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1 2	W1 W2	**Wood, Light Frame (≤ 5,000 sq. ft.)** **Wood, Commercial and Industrial (>5,000 sq. ft.)**		1 - 2 All	1 2	14 24
3 4 5	S1L S1M S1H	**Steel Moment Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
6 7 8	S2L S2M S2H	**Steel Braced Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
9	S3	**Steel Light Frame**		All	1	15
10 11 12	S4L S4M S4H	**Steel Frame with Cast-in-Place Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
13 14 15	S5L S5M S5H	**Steel Frame with Unreinforced Masonry Infill Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
16 17 18	C1L C1M C1H	**Concrete Moment Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
19 20 21	C2L C2M C2H	**Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
22 23 24	C3L C3M C3H	**Concrete Frame with Unreinforced Masonry Infill Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
25	PC1	**Precast Concrete Tilt-Up Walls**		All	1	15
26 27 28	PC2L PC2M PC2H	**Precast Concrete Frames with Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
29 30	RM1L RM2M	**Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms**	Low-Rise Mid-Rise	1-3 4+	2 5	20 50
31 32 33	RM2L RM2M RM2H	**Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
34 35	URML URMM	**Unreinforced Masonry Bearing Walls**	Low-Rise Mid-Rise	1 – 2 3+	1 3	15 35
36	MH	**Mobile Homes**		All	1	10

In order to obtain the damage probability value, the median value of spectral displacement at which the building reaches the treshold of damage state ($\bar{S}_{d.ds}$) and the standard deviation of the natural logarithm of spectral displacement for damage state (β_{ds}) uses existing data provided in HAZUS. The result of building damage probability could be then presented in damage probability graph below.

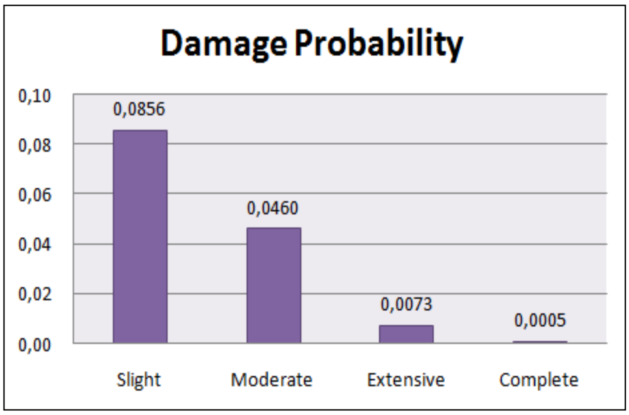
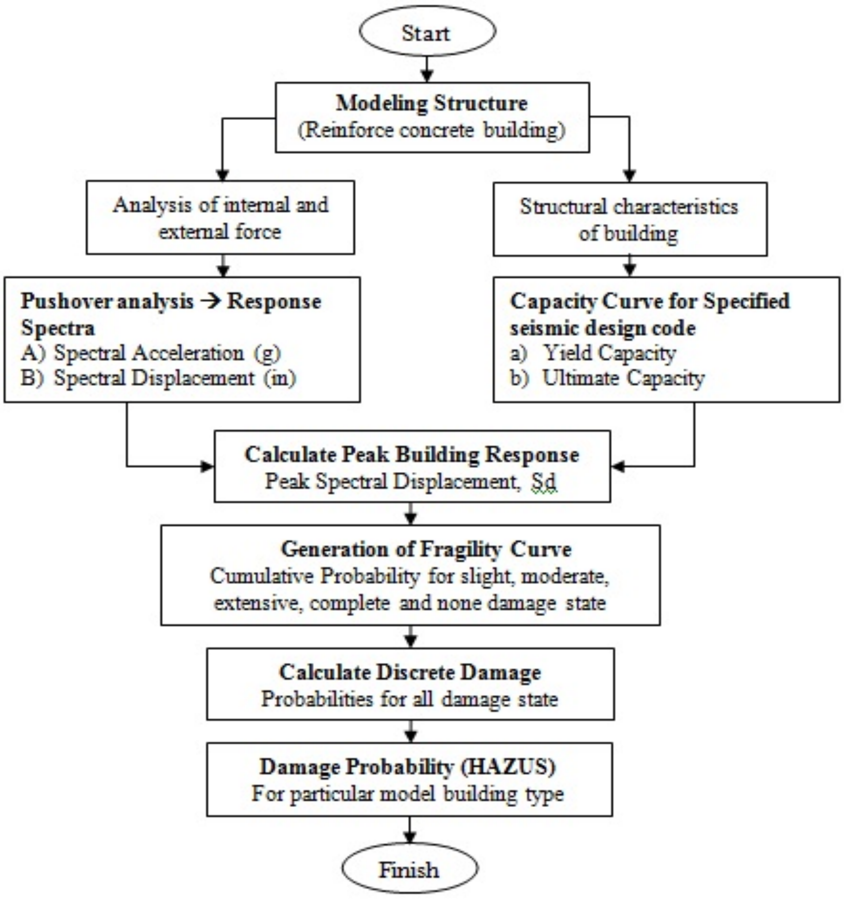


Figure 5. Damage probability diagram

The graph describes percentage of possibility of building damage in each level (slight, moderate, extensive, and complete).

Pushover Analysis On Hazus Method

This research uses pushover analysis method which is developed in HAZUS followed by calculating peak building response (Sd) to fragility curve, continued with building damage probability analysis resulting in modeled building damage probability. The details of research flow and development analysis are best presented in Figure 6 and Figure 7 respectively.



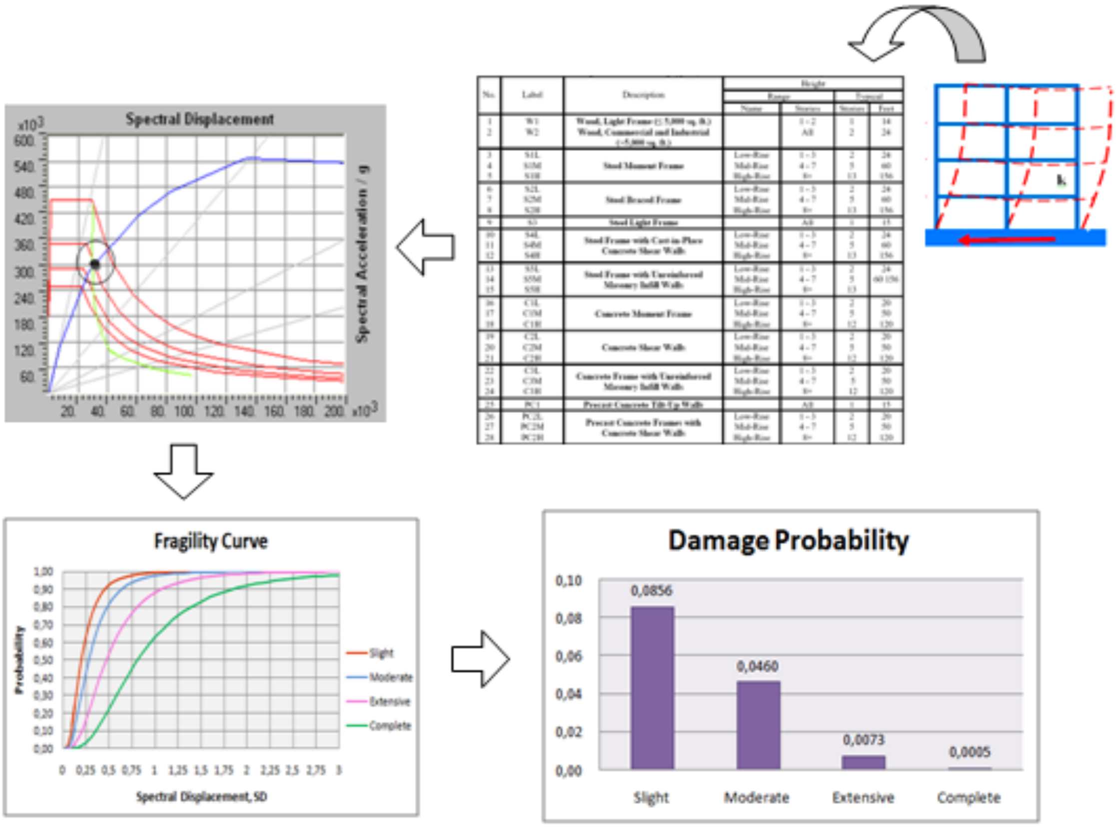


Figure 7. Pushover analysis of the development process on HAZUS

Modeling Structure

Building being analyzed is a 4 level regular concrete moment frame (C1M-HAZUS) building which consist of 5 spans of beam in the x-direction and 3 spans of beam in the y-direction each of length 7m. The height of ground floor is 5.75m and the height of floor is 2.44m. It is located in the earthquake zone 3 and serves as an office. Quality of the concrete f'c and steel are 20Mpa and 350Mpa respectively. The thickness of floor plate and roof plate are 120mm and 90mm respectively.

Cross sectional dimension are as follow:

a) Beam = 500 mm x 700 mm
b) Joist = 300 mm x 500 mm
c) Column = 700 mm x 700 mm

Complete sketch of plate and structure model are depicted in Figure 8, 9 and 10.

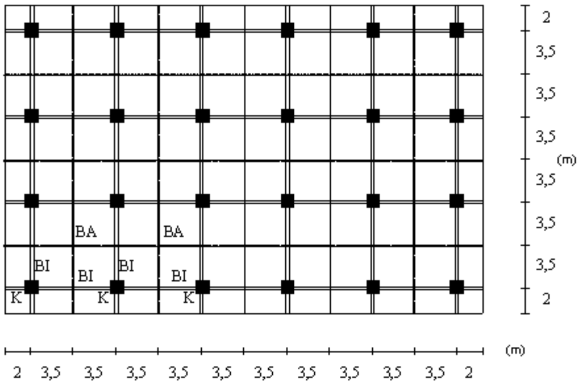


Figure 8. Sketch of plate

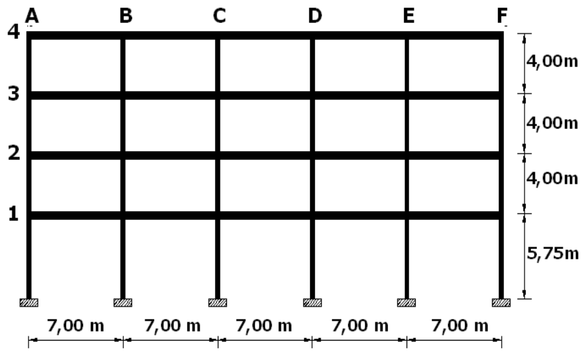


Figure 9. Sideway model of portal structure

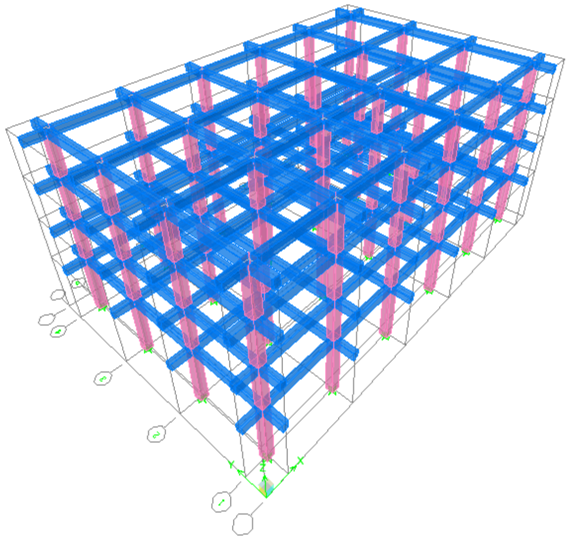


Figure 10. Structure model of four level building

Structural Analysis

Base shear force caused by earthquake based on SNI 03-1726-2002 is as follows:

$$V = \frac{C \times I}{R} \times W_t$$

$$V = \frac{0{,}443 \times 1{,}0}{8{,}5} \times 3547{,}9551\,\text{ton} \quad = 184{,}9111 \ \text{ton}$$

The ratio of building's height to the width of earthquake-suffered building:

$$\frac{\mathrm{H}}{\mathrm{L_x}} = \frac{17{,}75}{39} = 0{,}455$$

The result of above calculation yield a value $H/L_x<3$, hence nominal of base shear force(V) must be distributed along building structure's height forming equivalent static nominal seismic loads F_i which captures at center of mass of i-th level floor.

$$F_i = \frac{W_j.Z_j}{\sum_{i=1}^{n} W_i.Z_i} V$$

Calculation result of shear force is presented in Table 2.

Table 2. Nominal base shear load distribution

Storey	Z_i (m)	W_i (ton)	W_i x Z_i	V	F_{iy}
Roof (4)	17,75	658,0932	11681,1543	184,9111	54,4815
3	13,75	945,6798	13003,0973	184,9111	60,6471
2	9,75	945,6798	9220,3781	184,9111	43,0043
1	5,75	998,5023	5741,3882	184,9111	26,7781
Σ		3547,9551	39646,0178		184,9111

Evaluation is conducted for every point which potentially undergoes plastic joints whose location is determined by analysis model. In capacity spectrum method (ATC 40), pushover curve with certain modification is changed to capacity spectrum. Graph of capacity spectrum is then compared with the response spectrum which has already been changed into acceleration-displacement response spectrum, ADRS (Sa-Sd) format. ADRS is plotted into response curve which then intersects capacity curve to obtain performance point and hence the value S_D at the building considered. Graph of performance point is presented in Figure 11.

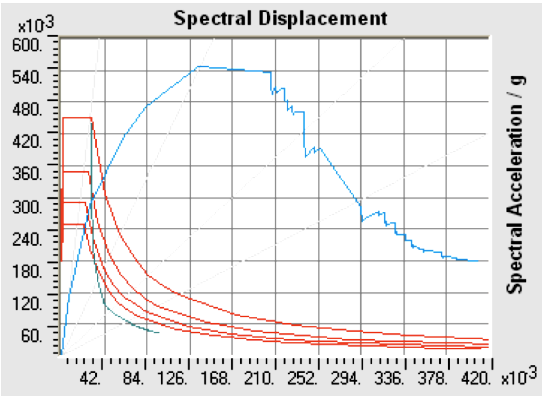


Figure 11. Capacity spectrum

Table 3. Fragility curve parameter for building type C1M HAZUS

Structural Fragility Curve Parameters of C1M Model Class								
Moderate Design Code								
	Slight		Moderate		Extensive		Complete	
Type	$\hat{S}_{d.S/S}$	β_S	$\hat{S}_{d.S/M}$	β_M	$\hat{S}_{d.S/E}$	β_E	$\hat{S}_{d.S/C}$	β_C
C1M	1,5	0,7	2,6	0,7	7	0,7	18	0,89

Results And Discussion

Seismic analysis of post-elastic reinforced concrete building using pushover results in the response curve which contains output in the form of spectral acceleration (S_A) and spectral displacement (S_D). Complete analysis result is shown in Table 4.

Table 4. The Value of Spectral Displcement (obtained from pushover analysis)

Time Period T (detik)	Spectral Acceleration -SA (g)	Spectral Displacement-SD (inches)
0,522	0	0
0,522	0,111	0,295
0,622	0,286	1,081
0,766	0,413	2,371
0,841	0,471	3,257
0,985	0,545	5,177
1,276	0,51	8,114

The results of S_A and S_D are plotted in the form of response curve which then intersects capacity curve of plotting result from HAZUS. Parameter of capacity curve for building type C1M based on HAZUS: (1). Yield Capacity Point (Dy, Ay). (2). Ultimate Capacity Point (Du, Au) which are shown in detail in Table 5.

Table 5. Parameter of capacity curve at building type C1M based on HAZUS

Capacity Curve Parameters for Moderate Code Seismic Design Level				
Type	Yield Capacity Points		Ultimate Capacity Points	
C1M	**Dy (in.)**	**Ay (g)**	**Du (in.)**	**Au (g)**
	0,58	0,104	6,91	0,312

Spectral response describes the relationship between spectral acceleration (SA) and spectral displacement (SD) at certain period. Plot result of both response curve (pushover analysis) and capacity curve (HAZUS) is presented in Figure 12

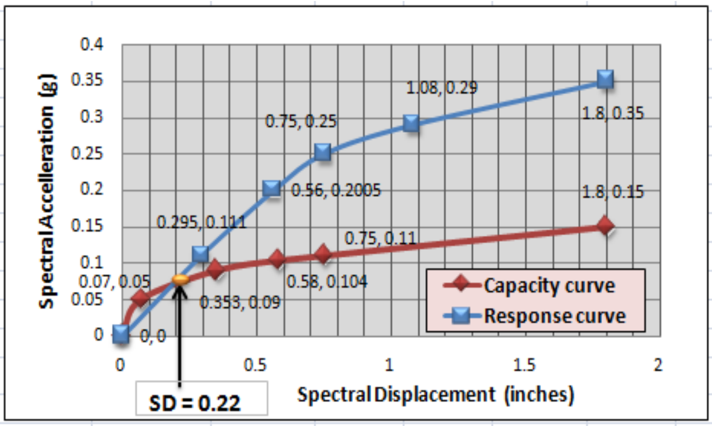


Figure 12. Plot response curve and capacity curve

Based on plot result of response curve and capacity curve, we obtain the value of spectral displacement S_D = 0.22 so that analysis result of peak building response is as follow:

Table 6. Comulative probability of building type C1M

Damage stage	S_d	$\hat{S}_{ds}$	β_{ds}	$X = S_d/\hat{S}_{ds}$	Ln (X)	Y = [Ln(X)]/βds	φ [Y]
Slight	0,22	1,5	0,7	0,1467	-1,9196	-2,7423	0,0031
Moderate	0,22	2,6	0,7	0,0846	-2,4696	-3,5281	0,0002
Extensive	0,22	7	0,7	0,0314	-3,4600	-4,9429	0,0000
Complete	0,22	18	0,89	0,0122	-4,4045	-4,9489	0,0000

Cumulative Probability	$P [S/ S_d]$	$P [M/ S_d]$	$P [E/ S_d]$	$P [C/ S_d]$
	0,0031	0,0002	0,0000	0,0000

Damage Probability Matrix				
Model Type	Slight	Moderate	Extensive	Complete
C1M	0,0028	0,0002	0,0000	0,0000

Based on the value of cumulative probability, we can sketch it into fragility curve, as shown in Figure 13. The result of fragility curve can be used to calculate the value of each damage probability which is shown in Table 7. Results and calculation of building damage type C1M can be presented in the form of bar chart as shown in Figure 14.

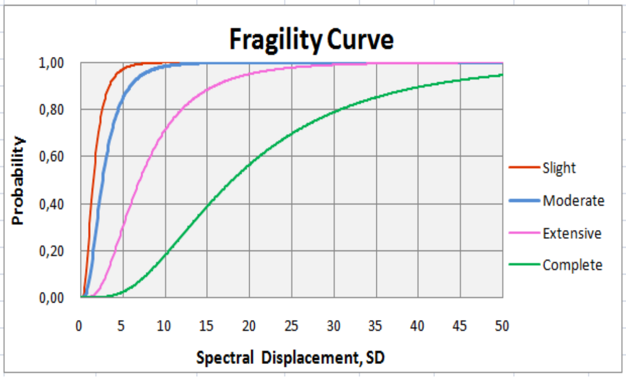


Figure 13. *Fragility curve*

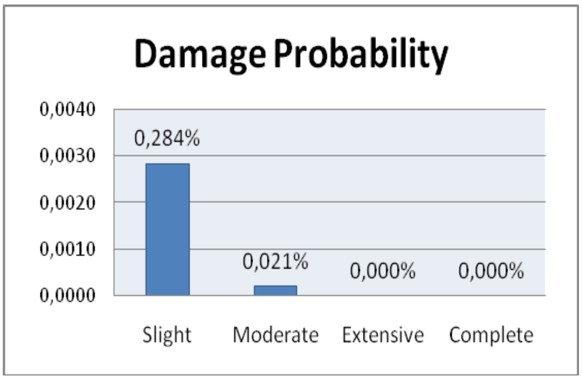


Figure 14. *Damage probability C1M building*

Table 7. Damage probability of building type C1M

No.	Level of damage	Probability
1	Slight	0,284%
2	Moderate	0,021%
3	Extensive	0,000%
4	Complete	0,000%

Conclusion

Based on the results obtained, we can conclude that:

1. The use of pushover analysis developed into HAZUS is able to produce real building damage probability in more detail, starting from slight to complete level.
2. Building type C1M has possibility of possessing *slight* and *moderate* level damage of 0.284% and 0.021% respectively, while *extensive* and *complete* damage level are of approaching 0%.

References

Applied Technology Council (ATC-40). 1996. *Seismic Evaluation and Retrofit of Concrete Buildings.* Volume 1. Redwood City, California.

Applied Technology Council (ATC-40). 1996. *Seismic Evaluation and Retrofit of Concrete Buildings*. Volume II. Redwood City, California.

Badan Standarisasi Nasional. 1989. *Tata Cara Perencanaan Pembebanan untuk Rumah dan Gedung* . SNI 03-1727-1989. Jakarta.

Badan Standarisasi Nasional. 2002. *Tata Cara Ketahanan Gempa untuk Bangunan Gedung.* SNI 03-1726-2002. Jakarta.

Bozorgnia, Yousef, and Vitelmo V. Bertero. 2004. *Earthquake Engineering from Engineering Seismology to Performance-Based Engineering.* United States Amerika: CRC Press LLC.

Dewobroto, Wiryanto. 2006. *Evaluasi Kinerja Bangunan Baja Tahan Gempa dengan SAP2000*. Jurnal Teknik Sipil. Vol.3 No.1.

Federal Emergency Management Agency (Fema 273). 1997. *NERHP Guidelines for The Seismic Rehabilitation of Buildings.* Redwood City, California.

HAZUS 2001. *Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS MH-MR2, User Manual FEMA and NIBS.* Washington, D.C.

National Institute of Building Sciences (NIBS), 2003. *Earthquake Loss Estimation Methodology. HAZUS97 User's Manual*, prepared for the Federal Emergency Management Agency, Washington, D.C.

Pranata, Yosafat Aji. 2006. *Evaluasi Kinerja Gedung Beton Bertulang Tahan Gempa dengan Pushover Analysis (Sesuai ATC-40, FEMA 356, dan FEMA 440)*. Jurnal Teknik Sipil. Vol.3 No.1.

Pranata, Yosafat Aji. 2006. *Studi Perencanaan Berbasis Kinerja pada Rangka Beton Bertulang dengan Metode Direct Displacement-Based Design.* Jurnal Teknik Sipil. Vol.3 No.2.

Factors Affecting Rain Infiltration on Slope Using Green-Ampt Model

Agus Setyo Muntohar

Department of Civil Engineering, Universitas Muhammadiyah Yogyakarta, Indonesia

Email: muntohar@umy.ac.id,

Hung-Jiun Liao

Department of Construction Engineering, College of Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan.

Email: hjliao@mail.ntust.edu.tw

*Corresponding author: Dr. Agus Setyo Muntohar

Universitas Muhammadiyah Yogyakarta. Jl. Lingkar Selatan Taman Tirto, Yogyakarta. Indonesia. 55183

Tel. +62-274 387656. Fax. +62-274 387646

Abstract

Rainwater infiltration in sloping surface is analyzed using Green-Ampt model in this study. Since the Green-Ampt model was originally developed for water infiltration on horizontal surface, the effect of slope steepness on rainwater infiltration during typhoon needs to be taken into account as well as the effect of soil type and soil-water suction. The results show that increase in saturated hydraulic conductivity and moisture-suction will increase the infiltration rate. But increase the slope steepness will decrease the infiltration rate. For slope covered with high permeability material, large variation in moisture-suction will change the infiltration rate considerably comparing with the slope covered with lower permeability material. Finally, this study propose a graphical aid to represent the basic Green-Ampt equation for sloping surface.

Keywords: rain infiltration, Green-Ampt model, sloping surface, typhoons, hydraulic conductivity, moisture-suction.

Introduction

Landslide is a worldwide disaster which has paid attention many researchers to investigate the triggering and causing factors, including the mechanism. Landslides in various types, e.g. shallow and deep, occasionally happen during typhoon season and heavy rainfall periods. Rainfall is widely known as the major triggering factor of landslides. It is related to the landslides by the ways of rain infiltration into the ground and the consequent rising of transient pore water pressure during rainfall. Research indicated that slope failure was initiated by saturation on slope surface. Then, the saturation will advance to wetting front depth during an intense rainfall (Pradel and Raad 1993; Rahardjo et al. 1995). Hence, initiation time for saturation can be determined as a preliminary analysis of slope failure. However, estimating the rain infiltration is by no means a straightforward problem in the natural slopes. Many efforts have been tried to quantify the rain infiltration behavior. Among the models used for rain infiltration analysis, Green-Ampt infiltration model is by far the most commonly used. The Green-Ampt model is relatively a simple model. But it can generate results which are in good agreement with other more rigorous infiltration models such as Richard's equation and Philip's model.

Green-Ampt model is a simplified representation of infiltration process which assumes that the ground surface is horizontal. In other words, the original Green-Ampt model does not applicable to the sloping surface. But up to now, it is still used by many researchers to quantify, properly or improperly, the rain infiltration factors and input them to the slope stability analysis analysis (e.g. Pradel and Raad 1993; Xie et al. 2004; Tofani et al. 2006). To better quantify the rain infiltration on a slope surface, this paper will propose a modified Green-Ampt model which can account for the influence of sloping ground surface. A parametric study has been carried out by using the modified Green-Ampt model to evaluate the effect of sloping surface on rain infiltration. The contents of this paper will focus on the effect of slope steepness and the moisture-suction characteristics of soil on the infiltration process under heavy rainfall condition.

Green-Ampt Infiltration Model

Green-Ampt model has been extensively used to estimate the infiltration process during both steady and unsteady rainfall events (Clausnitzer et al. 1998; Chu 1978). The basic Green-Ampt infiltration equations for horizontal surface are written in Equation 1 and 2.

$$f(t) = k_{sat}\left[1 + \frac{(\psi_f \cdot \Delta\theta)}{F(t)}\right] \tag{1}$$

$$F(t) - (\psi_f \cdot \Delta\theta)\ln\left[1 + \frac{F(t)}{(\psi_f \cdot \Delta\theta)}\right] = k_{sat} \cdot t \tag{2}$$

The equations 1 and 2 do not account for the influence of slope steepness. To take into account the effect of sloping ground surface, Chen and Young (2006) modified the Green-Ampt equations as in Equation 3 and 4.

$$f(t) = k_{sat}\left[\cos\beta + \frac{(\psi_f \cdot \Delta\theta)}{F(t)}\right] \tag{3}$$

$$F(t) - \frac{(\psi_f \cdot \Delta\theta)}{\cos\beta}\ln\left[1 + \frac{F(t)\cos\beta}{(\psi_f \cdot \Delta\theta)}\right] = k_y \cdot t \tag{4}$$

where $f(t)$ = infiltration rate at time t, $F(t)$ = cumulative infiltration at time t, ψ_f = suction head at wetting front, $\Delta\theta$ = volumetric water content deficit (= $\theta_s - \theta_i$), β = slope angle, and $k_y = k_{sat}\cos\beta$, and k_{sat} = saturated hydraulic conductivity. For horizontal surface where β = 0 and $\cos\beta$ = 1, equations (3) and (4) become the same as equations (1) and (2). Equation (3) shows that the increasing slope angle reduces the infiltration rate. This equation is in agreement with the field infiltration test done by Lu et al (1996) and Fox et al (1997). Use equation (1) and (3), the reduction of infiltration rate can be expressed as

$$f(t)_{\beta=0} - f(t)_{0<\beta<90} = k_{sat}\left[1+\frac{(\psi_f \cdot \Delta\theta)}{F(t)}\right] - k_{sat}\left[\cos\beta + \frac{(\psi_f \cdot \Delta\theta)}{F(t)}\right] \\ = k_{sat}(1-\cos\beta) \tag{5}$$

During a rainfall event, three types of rain infiltration can occur as shown in Figure 1: (1) Rainfall intensity is larger than infiltration rate. During this time interval, ground surface is in saturated condition (case 1); (2) Rainfall intensity is smaller than the infiltration rate at the beginning of the time interval but becomes larger than the infiltration rate later. So the ground surface changes from unsaturated to saturated state in this time interval (case 2); (3) Rainfall intensity is smaller than infiltration rate. There is no surface saturation in this time interval (case 3). For case 3, all the rainfall infiltrates into soil. But the surface is not saturated.

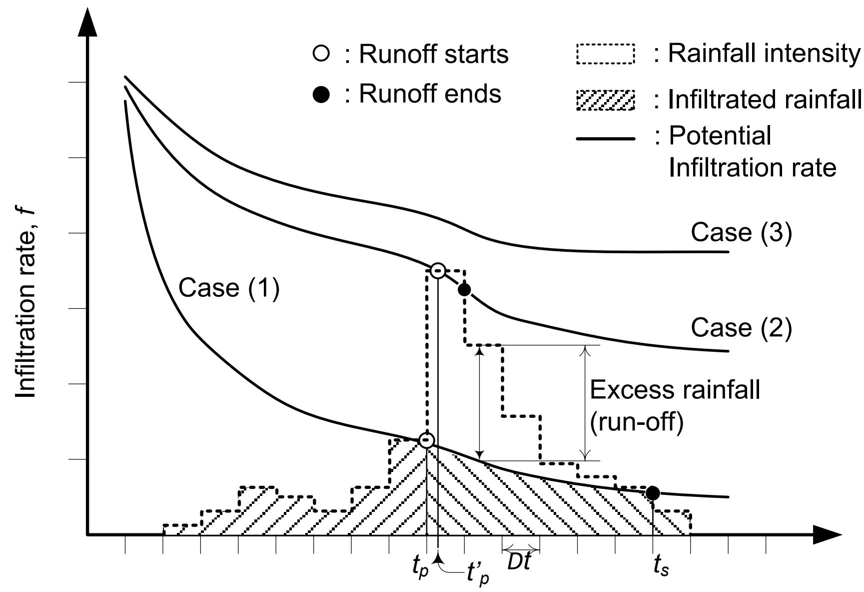


Figure 1 Typical of infiltration and excess rainfall under unsteady rainfall

The surface saturation occurs only if the potential infiltration rate becomes less than the rainfall intensity. Hence, the infiltrated rainfall can be calculated using the following equation:

$$F(t+\Delta t) - F(t) - \frac{(\psi_f \cdot \Delta\theta)}{\cos\beta} \cdot \ln\left[\frac{(F(t+\Delta t)\cos\beta + \psi_f \cdot \Delta\theta)}{(F(t)\cos\beta + \psi_f \cdot \Delta\theta)}\right] = k_y \cdot \Delta t \tag{6}$$

After surface saturation, any additional rainfall will become the surface run-off.
If case 2 occurs, the time needed to reach saturation is defined as follows:

$$t'_p = \frac{F\left|t'_p\right|. - F(t)}{I(t)} \tag{7}$$

Thus, the infiltrated rainfall can be calculated using the following equation:

$$F\left(t'_p\right) = \frac{k_{sat}.\left(\psi_f \cdot \Delta\theta\right)}{I(t) - k_{sat}\cos\beta} \tag{8}$$

The flow chart for calculating the rainwater infiltration is shown in Figure 2. Equations (3) and (4) need iteration techniques to carry out the calculation for unsteady rainfall. So, they are re-written with different implicit forms as presented in Equation 9 and 10.

$$\frac{f(t)}{k_{sat}} = \left(\cos\beta + \frac{1}{F_t^*}\right) = f_t^* \tag{9}$$

From equation (4):

$$\frac{F(t)}{\left(\psi_f \cdot \Delta\theta\right)} = \cos^{-1}\beta \cdot \ln\left[1 + \frac{F(t)}{\left(\psi_f \cdot \Delta\theta\right)}\cos\beta\right] + \frac{k_y \cdot t}{\left(\psi_f \cdot \Delta\theta\right)} = F_t^* \tag{10}$$

f_t* and F_t* are the normalized infiltration rate and cumulative infiltration for the unsteady rainfall respectively. Both of f_t* and F_t* are dimensionless. For simplicity, a graphical presentation for equations (9) and (10) will be developed and discussed later in Figure 5.

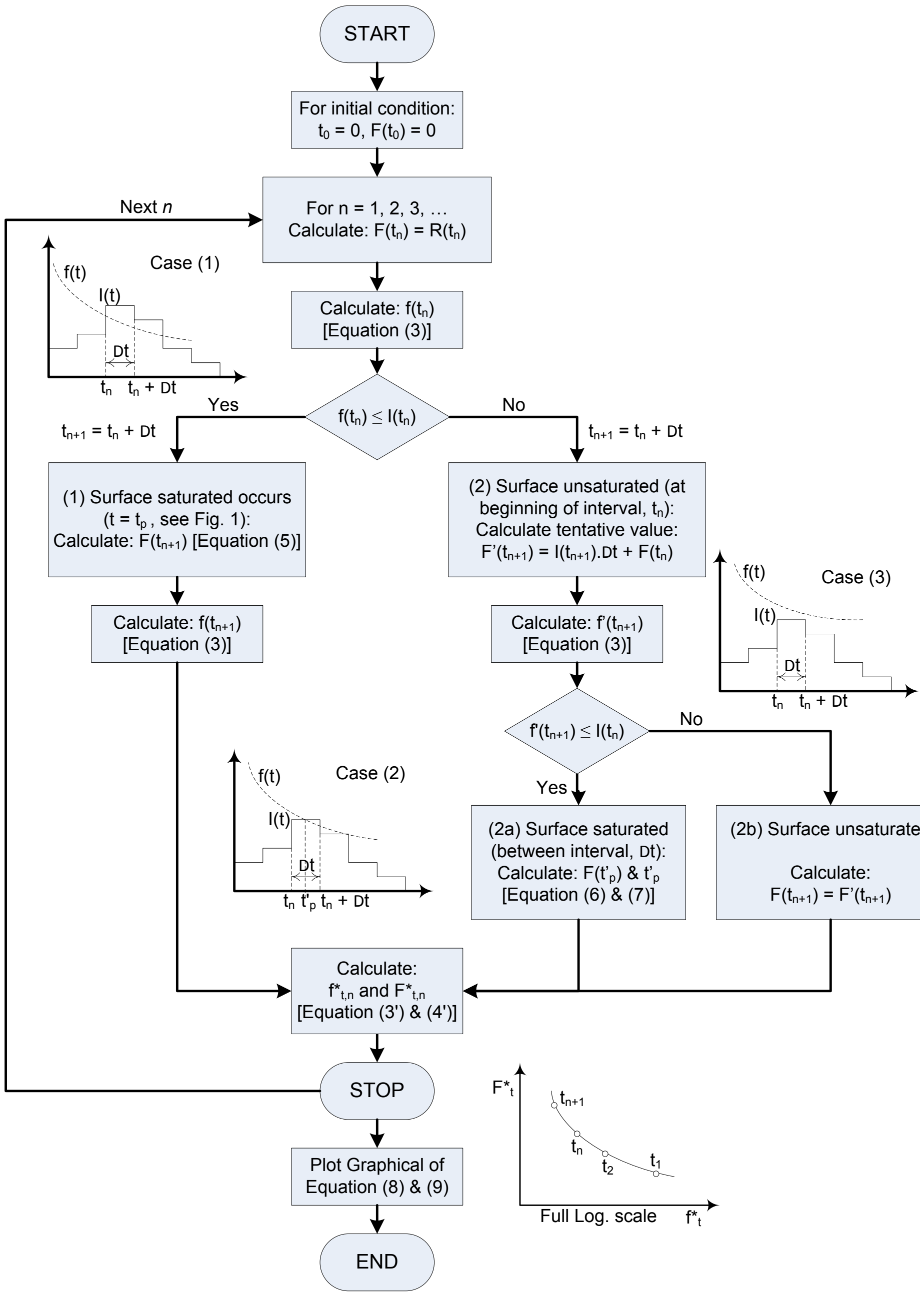


Figure 2 Calculation flow chart for rain infiltration

Data and Analysis

Rainfall Record

In this study, the precipitations were recorded from three rain gauges installed along the T-18 mountain road in central Taiwan at mileages of 27K+200, 56K+200, and 64K+800. Three typhoons, Ewiniar (July 7 to 9, 2006), Bilis (July 13 to 16, 2006), and Kaemi (July 23 to 26, 2006) that attacked Taiwan in July 2006 were chosen as the rainfall events for infiltration analysis. The hourly rainfall and accumulated rainfall for each typhoon recorded at mileage 27K+200 are shown in Figure 3. Among these three typhoons, typhoon Bilis brought in an intense rainfall with the accumulated rainfall approaching 800 mm and the maximum rainfall intensity reached 51.5 mm/h. In comparison, the recorded accumulated rainfalls for the other two typhoons were around 400 mm and 200 mm for typhoons Ewiniar and Kaemi respectively.

Figure 3 Location of a rain gage at T18 road

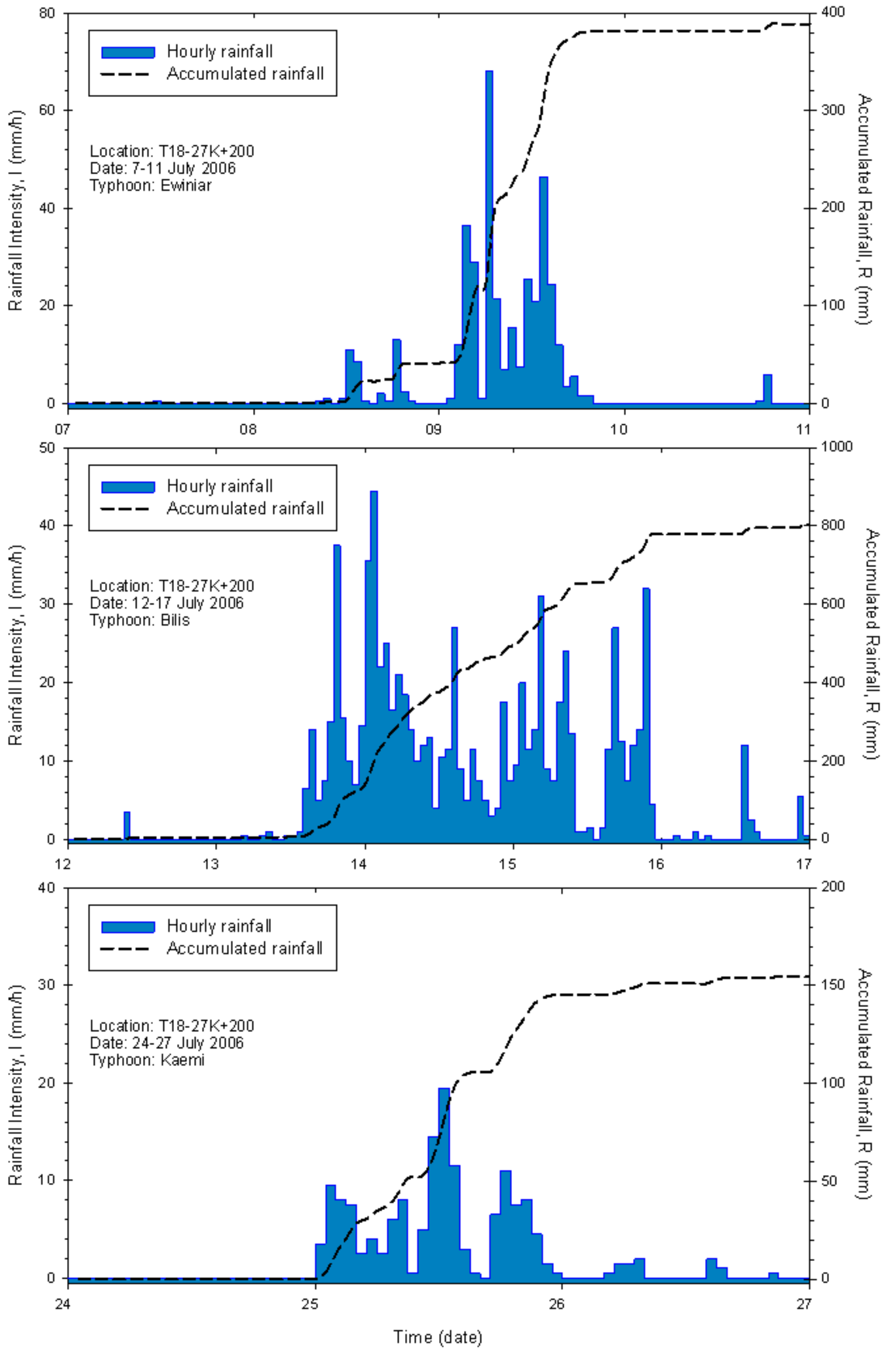


Figure 4 Rainfall hyetograph in July 2006: three typhoons attacked Taiwan i.e. Ewiniar, Bilis and Kaemi at mileage 27K+200 along T18 road

Green-Ampt Parameters

The parameters used in the Green-Ampt model include the moisture content conditions (Dq), suction head (y_f), and saturated hydraulic conductivity (k_{sat}). The saturated hydraulic conductivity and suction are known as the inherent parameters for soil. Those parameters can be obtained from the laboratory or field tests. Table 1 summarizes the range of Green-Ampt parameters for various soil textures (USDA classification) (Chow et al, 1988). It can be found that disparities in the suction head parameter (y_f) as tabulated in column 4 are large for the soils chosen in this study. When input to the Green-Ampt model, the moisture deficit and suction head are combined as one parameter (y_f Dq) as shown in Table 2.

Table 1 Green Ampt infiltration parameters for typical soils (Rawls et al., 1983)

Soil Type	Range of η	Range of θ_e	Range of ψ_f (mm)	k (mm/h)	ψ_f (mm)	k_{sat} (= 2k) (mm/h)
Sand	0.374~0.5	0.354~0.48	9.7~253.6	117.8	49.5	235.6
Loamy Sand	0.363~0.506	0.329~0.473	13.5~279.4	29.9	61.3	59.8
Sandy Loam	0.351~0.555	0.283~0.541	26.7~454.7	10.9	110.1	21.8
Loam	0.375~0.551	0.334~0.534	13.3~593.8	3.4	88.9	6.8
Silt Loam	0.42~0.582	0.394~0.578	29.2~953.9	6.5	466.8	13
Sandy Clay Loam	0.332~0.464	0.235~0.425	44.2~1080	1.5	218.5	3
Clay Loam	0.409~0.519	0.279~0.501	47.9~911	1	208.8	2
Silty Clay Loam	0.418~0.524	0.347~0.517	56.7~1315	1	273	2
Sandy Clay	0.37~0.49	0.207~0.435	40.8~1402	0.6	239	1.2
Silty Clay	0.425~0.533	0.334~0.512	61.3~1394	0.5	292.2	1
Clay	0.427~0.523	0.269~0.501	63.9~1565	0.3	316.3	0.6

Table 2 The Green-Ampt parameters and soil shear strength properties used in this study

Soil type	k_{sat} (mm/h)	$\psi\Delta\theta$ * (mm)	Degree of permeability
1	360 (1 x 10^{-4})	30, 120, 240, 360	Higher to lower
2	36 (1 x 10^{-5})	30, 120, 240, 360	
3	3.6 (1 x 10^{-6})	30, 120, 240, 360	
4	0.36 (1 x 10^{-7})	30, 120, 240, 360	

Values in the brackets are in m/s. * $\Delta\theta$ = 0.3

Analysis

To study the effect of slope steepness on the infiltration process, slope angle is varied from 0 to 70^o in this study. The rain infiltration is calculated using equations (3) to (10). The calculation sequences are shown in Figure 2. This computation algorithm follows the procedures proposed by Chow et al (1988). The flow chart shown in Figure 2 is used to evaluate whether or not the surface run-off will occur in a rainfall event based on the relative values between infiltration rate f(t) and rainfall intensity I(t) at time t. For the case 1 shown in Figure 2, f(t) is equal to or smaller than I(t). It indicates that ground surface is saturated with water. Rainfall with this intensity will not only infiltrate into the ground but also generate surface run-off. For case 2, f(t) is larger than I(t). It indicates that the ground surface will remain unsaturated under this raining condition (Case 3). But for case 2, the ground surface will become saturated sometime between t_n and $t_{n+\Delta t}$ interval, although it is not yet saturated at time tn.

Results and Discussion

Infiltration response process

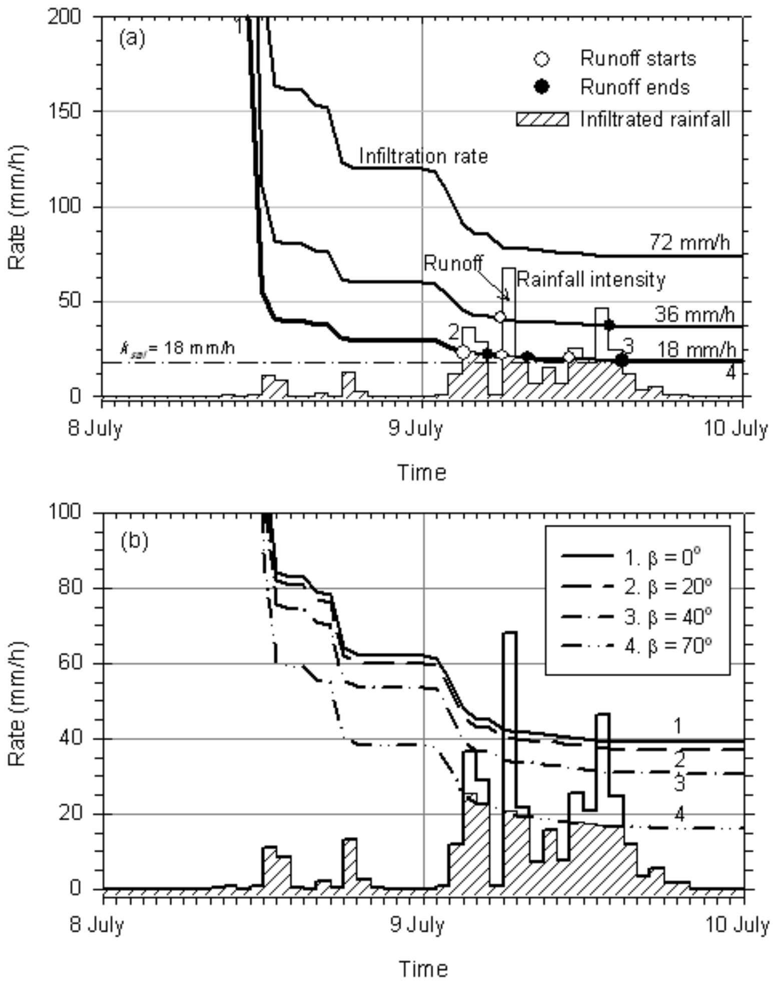


Figure 5 (a) Typical infiltration rate for unsteady rainfall for $\beta = 20^{o}$ with various k_{sat}; (b) Effect of slope angle for k_{sat} = 36 mm/h

Figure 4 shows the typical infiltration rate for soils with k_{sat} = 36 mm/h, $\psi_f \Delta\theta$ = 30 mm, and for slopes with angle $\beta = 0^{o}$ to 70^{o}. The infiltration rates for soils with k_{sat} = 18, 36, and 72 mm/h are compared in Figure 4a. The first feature of the typical infiltration figure (like Figure 4) shows that the infiltration rate declines with elapsed time. Once the surface gets saturated, surface runoff starts and infiltration capacity decreases over time until the minimum infiltration capacity is reached. In the Green-Ampt model, the infiltration capacity is assumed to be equal to soil hydraulic conductivity at saturated condition. For example, the soil with hydraulic conductivity at saturated condition (k_{sat}) equal to 18 mm/h, then the infiltration rate of the soil will drop to 18 mm/h at the end (Figure 5a). If the rainfall intensity is less than the infiltration capacity ($I(t) < k_{sat}$), then all the rainfall infiltrates into soil and no run-off occurs. During typhoon Ewiniar period (July 8 to 10, 2006), rainfall infiltrated completely into the subsurface soil if k_{sat} is equal to 72 mm/h.

The second feature of the infiltration figure is to identify the moment when the rainfall intensity is greater than the saturated hydraulic conductivity ($I(t) > k_{sat}$). The rainfall intensity fell above the curve of infiltration rate will result in surface run-off. As shown in Figure 4a, the white points on the infiltration curve stand for the time when the run-off starts; the black points stand for the time when the run-off stops. So the shaded area from point 2 to 3 below the curve of infiltration rate represents the amount of rainwater will infiltrate into the ground.

The third feature of the infiltration figure is to determine the time when the surface begins to become saturated or the time to start run-off (t_p). Time to saturation can be continued till the end of rainfall if the rainfall intensity remains smaller than the hydraulic conductivity at saturation (k_{sat}). Soil with k_{sat} = 18 mm/h reaches saturation earlier than the soil with k_{sat} = 36 mm/h. This feature explicates that a soil with lower permeability will get saturated earlier than a soil with higher permeability at the same initial moisture-suction condition.

Infiltration rate decreases with increase in slope as shown in Figure 4b. This behavior is in agreement with the field-infiltration experiments carried out by Lu et al. (1996). Lower infiltration rate on steeper slope is caused by higher flow velocities and shorter detention time of rainwater on steeper surface (Fox et al. 1997). Theoretically, a longer detention time increases the surface water storage and results in higher infiltration rate.

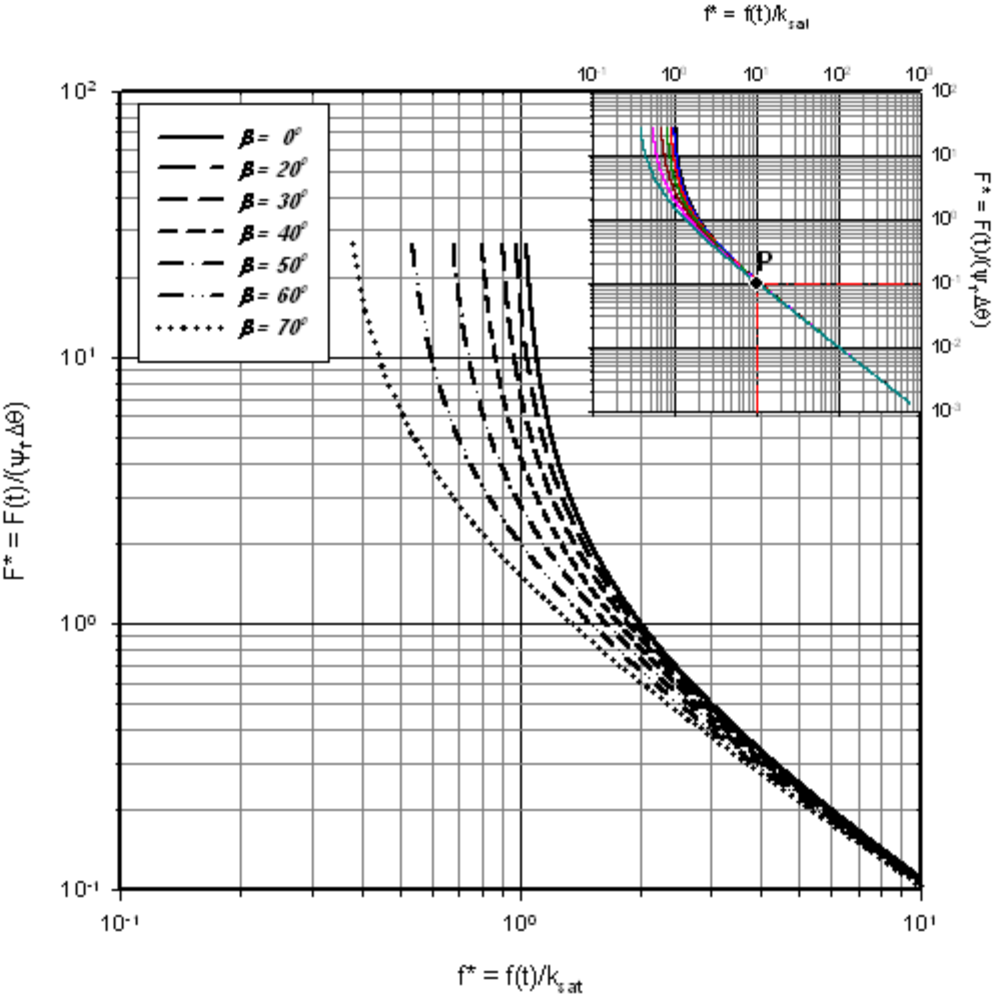


Figure 6 Representation chart of Green-Ampt equation on sloping surface

Figure 5 presents a graphical aid to represent the infiltration rate and cumulative infiltration as depicted by equation (9) and (10). Correlation between these equations shows a unique relationship. The infiltration decreases with increasing slope angle of surface. But, beyond point P (inset graph in Figure 5), the rain infiltration does not change greatly with the slope angle. Because all the rainwater infiltrates into subsurface layer if the rain infiltration rate goes beyond point P. Compare the infiltration rate of horizontal surface ($\beta = 0^o$) and sloping surface ($\beta > 0^o$), hence, using equation (5) for slope with $\beta = 70^o$, the infiltration rate reduced 66 percents compared to that of the horizontal surface ($\beta = 0^o$).

Effect of saturated hydraulic conductivity

The saturated hydraulic conductivity k_{sat} of soil changes with soil types. For sandy soil, the k_{sat} is usually larger than 360 mm/h (10^{-4} m/s); for clayey or silty soil, the k_{sat} is lower than 0.36 mm/h (10^{-7} mm/s) (Pradel and Raad, 1993). Equation (3) shows that infiltration rate is linearly correlated with the hydraulic conductivity. However, under the unsaturated condition, the hydraulic conductivity can vary considerably as a result of change in the volume-water content of soil. As described in earlier section, moisture content at ground surface increases gradually during rainwater infiltration until surface saturation is reached. At this moment, saturated hydraulic conductivity k_{sat} is reached. The Green-Ampt infiltration model is used to describe this phenomenon. To illustrate the effect of change in saturated hydraulic conductivity on rainfall infiltration, figure 6 shows the relationship between saturated hydraulic conductivity k_{sat} and infiltration rate corresponding to the maximum rainfall intensity for each typhoon.

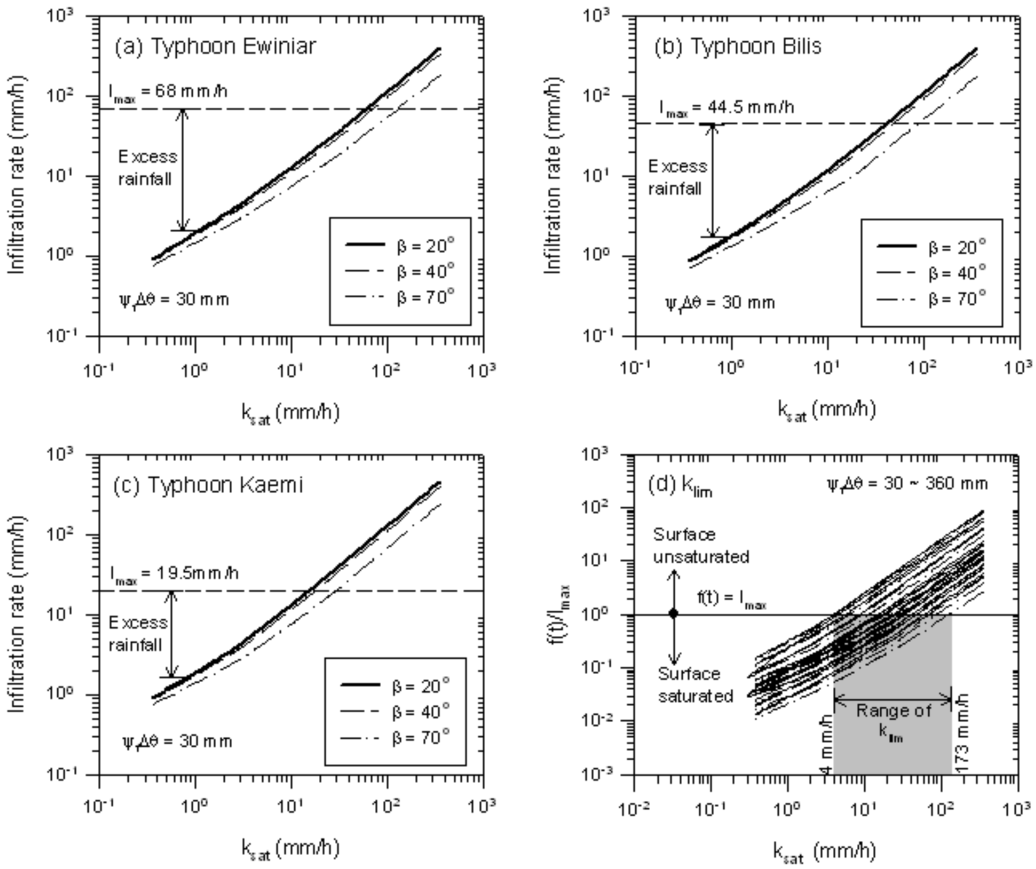


Figure 7 Change of infiltration rate with soil type for (a) Ewiniar, I_{max} = 68 mm/h, (b) Bilis, I_{max} = 44.5 mm/h, (c) Kaemi, I_{max} = 19.5 mm/h, (d) Determination of k_{lim}

Figure 6a to 6c shows that the infiltration rate increases with increasing saturated hydraulic conductivity of the slope. The infiltration rate of slope with higher permeability (k_{sat} = 360 mm/h) is always higher than the maximum rainfall intensity of each typhoon. It is because of the rainfall intensity is lesser than the infiltration capacity which is equal to the saturated hydraulic conductivity. So, if the rainfall lesser than the infiltration capacity will infiltrate into subsurface with very higher rate. The infiltration rate will be slower if the infiltration capacity is reached. In contrast, the infiltration of soil with lower permeability, i.e. k_{sat} = 0.36 – 3.6 mm/h, is always lower than the maximum rainfall intensity of each typhoon. As described in previous section and Figure 2, surface saturation occurs if the infiltration rate is smaller than the rainfall intensity. So, the surface starts to become saturation if the rainfall rate is equal to the rainfall intensity. At this moment, there exists a threshold saturated hydraulic conductivity (k_{lim}) which corresponds to the beginning of surface saturation. Normalized the infiltration rate with the maximum rainfall intensity, Figure 7d plots the relationship between the normalized rainfall intensity ($f(t)/I_{max}$) and saturated hydraulic conductivity for varying $\psi_f \Delta\theta$ (see Table 2) and slope angle β = 20°, 40°, 70°. Based on this relationship, the k_{lim} is determined at intersection with $f(t)/I_{max} = 1$. Thus, it results in range of k_{lim} = 4 mm/h – 173 mm/h.

In practice, k_{lim} will be a valuable parameter as indicator for slope stability. Because of in many slope failures case, slope is likely instable if the whole the slope depth is saturated. As shown in figure 6a to 6c and illustration given in figure 1, excess rainfall occurs when the slope surface is in saturation state. This excess rainfall is potentially become runoff which will result in surficial erosion and may cause shallow slip and/or limited debris flow. Pradel and Raad (1993) noted that if k_{lim} reached 3.6 mm/h (1 x 10^{-6} m/s), rainfall induced slope instability might be resulted. In addition, Lee et al. (2007) also considered that k_{lim} between 0.28 – 2.82 mm/h (7.8 x 10^{-8} - 7.8 x 10^{-7} m/s) was likely to cause shallow slip. For the slope studied here, the k_{lim} lay on larger range that is between 4 – 173 mm/h.

Effect of moisture-suction head

The saturated hydraulic conductivity (k_{sat}), suction head at wetting front (ψ_f) and deficit of volumetric water content ($\Delta\theta$) are three influencing parameters in Green-Ampt equation to study the rainwater infiltration. The last two parameters can be aggregated in one parameter as moisture-suction parameter ($\psi_f\Delta\theta$) since both parameters are closely related. Figure 7 shows the effect of moisture-suction on the infiltration rate for higher and lower permeability slope under three typhoons studied here.

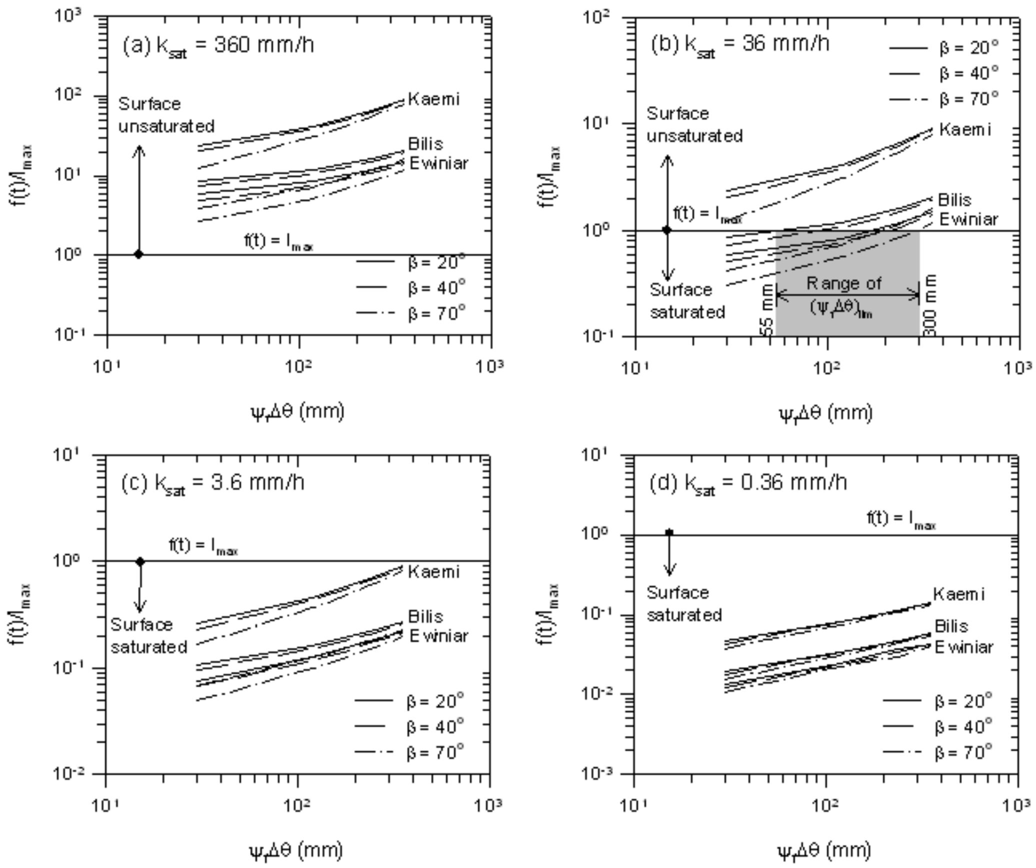


Figure 8 Change of infiltration rate with moisture-suction (a) k_{sat} = 360 mm/h, (b) k_{sat} = 36 mm/h, (c) k_{sat} = 3.6 mm/h, (d) k_{sat} = 0.36 mm/h

In general, increasing moisture-suction increases linearly the infiltration rate as shown in Figure 7. This phenomenon can be explained with the unsaturated soil theory. In unsaturated soil, the matrix suction ($u_a - u_w$) is the pressure difference which is acting on the contractile skin of air–water interface in the pores. During transient infiltration process, pore air is draining out but pore water is flowing in simultaneously. Wang et al. (1998) noted that the rate of pore water inflow is corresponding to the rate of pore air outflow during infiltration. In other words, higher suction will result in higher infiltration rate. The infiltration rate of the slope with lower hydraulic conductivity (k_{sat} = 0.36 mm/h and 3.6 mm/h) increases approximately 1.2 - 2 times by changing the moisture-suction from 30 mm to 360 mm (10 times increasing moisture-suction). For slope with high hydraulic conductivity (i.e., k_{sat} = 36 mm/h and 360 mm/h), the infiltration rate increases about 5 – 6 times when the moisture-suction of soil is increased from 30 mm to 360 mm. As presented in Table 1, the range of suction head (ψ_f) for the typical soil is very wide, for instances, the range of suction head of clay soils is 63.9 mm – 1565 mm (±25 times increasing suction head) and for sand soils is 9.7 mm – 253.6 mm (±26 times increasing suction head). In this study the suction head is varied in the range of 100 mm – 1200 mm (12 times increasing). According to the result in this study, the infiltration rate of the sand soils will vary significantly compared with clay soils. Parameter sensitivity analysis of Green-Ampt model done by Hsu et al (2002) also found that change in suction head has increased considerably for loam and sand soils. But, it is contrary for clay soils. Therefore, determination of suction head in the Green-Ampt model should be well defined. Lu & Likos (2004) and Wang & Benson (1995) proposed that the suction head at wetting front can be approached by air entry value (AEV) method. However, the suction head at wetting front is close to zero at the moment of saturated condition. For the some soils, Mein and Larson (1973) said that the suction value near saturation cannot be well defined. For this reason, the average suction head is proposed to represent suction at wetting front.

As mentioned in previous section, the slope surface starts to saturate if the slope infiltration rate is the same with rainfall intensity. In Figure 7b, for k_{sat} = 36 mm/h under typhoon Ewiniar and Bilis, the slope is in unsaturated states at beginning and tend to become saturation by decreasing the moisture-suction from 360 mm to 30 mm. At this case, the slope surface starts to saturate when the moisture-suction in the range between 55 mm – 300 mm. This phenomenon explains that changing moisture-suction not only changes the infiltration rate but also affects the degree of slope surface saturation. Therefore, the moisture-suction value should be well defined by relevant data or tests. However, it should be noted that determination of suction is a rather complex process, even if the data needed is available.

Conclusions

This paper has presented the result of rainfall infiltration analysis on sloping surface using Green-Ampt infiltration model. Based on the study carried out on the effect of slope angle, soil type and soil-water suction on the Green-Ampt infiltration model, the following conclusions can be drawn:

1. Increasing slope steepness reduces the rainwater infiltration rate. Comparing the infiltration for sloping surface and horizontal surface, the reduction of infiltration rate is given by $k_{sat}(1 - \cos\beta)$ [equation (5)].

2. The infiltration rate increased linearly with increasing the saturated hydraulic conductivity. In this study, the slope surface starts to saturate when the saturated hydraulic conductivity is below the k_{lim} is defined as threshold saturated hydraulic conductivity which is corresponding to the infiltration rate equal with rainfall intensity. The k_{lim} range from 4 mm/h to 173 mm/h.
3. Increase in the moisture-suction head at wetting front will increase the infiltrability during rainfall. Change in moisture-suction increased considerably the infiltration rate of slope with high permeability such as sand soils comparing with slope with lower permeability such clay. Therefore, the difference in moisture-suction should be paid attention for a slope with higher hydraulic conductivity such as sand soils.
4. By using equations (9) and (10), a graphical aid (Figure 5) has been developed to represent the basic Green-Ampt equation for sloping surface.

Acknowledgement

This paper is part of research entitled "Numerical and Experimental Study on the Rainfall-Infiltration Model in corporation with Slope Stability" which is granted by Ministry of Education and Culture of Republic of Indonesia through Fundamental Research scheme in 2011-2012. The first author thanks to Taiwan Tech for the rainfall record and supplementary data provided to complete the research.

References

Chen, L., & Young, M.H., 2006, Green-Ampt infiltration model for sloping surface, Water Resour Res 42: 1-9. doi 10.1029/2005WR104468

Chow, V.T., Maidment, D.R., & Mays, L.W., 1988, *Applied hydrology*, Mc. Graw-Hill New York, Ch. 4, 110-116.

Chu, T.C., 1978, Infiltration during an unsteady rain, Water Resour Res 14(3): 461-466.

Clausnitzer, V., Hopmans, J.W., Starr, J.L., 1998, Parameter Uncertainty Analysis of Common Infiltration Models, Soil Sci Soc Am J 62: 1477–1487.

Fox, D.M., Bryan, R.B., & Price, A.G., 1997, The influence of slope angle on final infiltration rate for interrill conditions, Geoderma, Vol. 80, 181-194.

Lee KH, Jeong SS, Kim TH (2007) Effect of fines on the stability of unsaturated soil slopes, J Korean Geotech Soc 23(3): 101-109.

Lu HS, Hu SC, Lin JP (1996) Infiltration model for soils on a sloping betel palm farm in the Lienhuachi are of Central Taiwan, J For Sci 11(4): 409-420.

Lu N, Likos WJ (2004) Rate of capillary rise in soil. J Geotech Geoenviron Eng 130(6): 646-650.
Mein RG, Larson CL (1973) Modeling infiltration during a steady rain. Water Resour Res 9(2): 384-394.

Pradel D, Raad G (1993) Effect of permeability on surficial stability of homogeneous slopes, J Geotech Eng 119(2): 315-332.

Rawls WJ, Ahuja LR, Brakensiek DL, Shirmohammadi A (1993) Infiltration and soil water movement, In: Maidment DR (ed.) *Handbook of Hydrology*, Mc. Graw-Hill, New York, Ch. 5.

Santos CAG, Suzuki K, Watanabe M, Srinivasan VS (1999) Determining the soil moisture-tension parameter in the Green-Ampt infiltration equation for runoff-erosion modeling. Proceeding of the 28th IAHR Congress, 22-27 August 1999, Graz, Austria.

Wang Z, Feyen J, van Genuchten M.Th, Nielsen DR (1998) Air entrapment effect on infiltration rate and flow instability. Water Resour Res 34(2): 213-222.

Tofani V, Dapporto S, Vannocci P, Casagli N (2006) Infiltration, seepage and slope instability mechanisms during the 20–21 November 2000 rainstorm in Tuscany, central Italy. Nat Hazards Earth Syst Sci 6: 1025–1033.

Xie M-W, Esaki T, Cai M-F (2004) A time-space based approach for mapping rainfall-induced shallow landslide hazard. Environ Geol46:840–850. doi 10.1007/s00254-004-1069-1.

Rahardjo H, Lim TT, Chag MF, Fredlund DG (1995) Shear strength characteristics of a residual soil. Can Geotech J 32: 60-77.

Notation in Used:

F(t)	: cumulative infiltration at time *t* (mm)
F'(t)	: tentative cumulative infiltration at time *t* (mm)
F*	: normalized cumulative infiltration
f(t)	: infiltration rate at time *t* (mm/h)
f'(t)	: tentative infiltration rate at time *t* (mm/h)
f*	: normalized infiltration rate
I(t)	: rainfall intensity at time *t* (mm/h)
I_{max}	: maximum rainfall intensity (mm/h)
k	: coefficient of unsaturated hydraulic conductivity (mm/h)
k_{lim}	: limit of k_{sat} correspond to 10% infiltration rate
k_{sat}	: coefficient of saturated hydraulic conductivity (mm/h)
k_y	: coefficient of saturated hydraulic conductivity at sloping ground (mm/h)
R(t)	: accumulative rainfall at time *t* (mm)
t	: elapsed time (h)
t_p	: ponding time (time to start surface saturation) (h)
t'_p	: time needed to reach saturation between the time intervals (h)
t_s	: time of the end of saturation (h)
Δt	: time interval (h)
$\Delta\theta$	: deficit of the volumetric moisture content
β	: degree of slope angle
η	: the soil porosity
θ	: volumetric moisture content (mm^3/mm^{-3})
θ_i	: initial moisture content
θ_s	: moisture content at saturated condition
ψ_f	: soil-water suction head (mm)
$\psi_f\,\Delta\theta$	: moisture-suction (mm)

An Approach to Classified Earthquake-resistant Building for Pre-disater Mitigation

Fitri Nugraheni

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Email: fitri.nugraheni@uii.ac.id

Abstract

Indonesia is a disaster-prone 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. Previous research has been done to assess existing building condition using photographs. The result showed that photographs could be used as a source of information to evaluate that existed non-engineered buildings are either in earthquake-resistant condition or earthquake-irresistant condition. It is obvious that the irresistant condition needs to be retrofitted. For resistant condition, it is not totally resist from earthquake. It is still a risk associated with the condition. Therefore, the resistant building needs to be classified. The classification could be used as a base of retrofitting priority. Further, there is a need to have an approach for the resistant building classification using photographs. Based on different score of resistancy being used and because in the real world things are not a crisp, so the approach proposed for this is initially based on Fuzzy Theory. From ten earthquake-resistant condition building photographs as an example, the result revealed that five buildings classify as a most likely resistant, two buildings classify as a fairly resistant, and three buildings classify as a most likely non-resistant. In conclusion, proposed approach demonstrates how it is possible, using existing building photographs, to classify earthquake-resistant building into three categories.

Keywords: existing building photographs; earthquake-resistant building; Fuzzy Theory

Introduction

Indonesia is a country that geographically lies between 92^o EL to 141^o El and 14^o SL to 7^{o}20 NL and fortunately 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 turns into some of the Indonesia's regions vulnerable to earthquakes and tsunamis. These regions include Aceh, North Sumatra, West Sumatra, Bengkulu, Lampung, West Java, Central Java, East Java, Bali, Nusa Tenggara, Sulawesi, Maluku, and Papua.

Major earthquake recently hits Yogyakarta in May 27, 2006. Yogyakarta is a part of Central Java, so it lies in earthquake vurnerable area. 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 (Yogyakarta and Central Java Preliminary Damage and Loss Assessment 2006). From that overwelmed 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.

Efforts to improve earthquake preparedness can take many forms. While earthquake mitigation measures have traditionally been implemented during post-disaster phase, many believe that additional actions can and should be taken before disaster hit, and soon after the disaster. Unfortunately, a pre-disaster condition data are rarely obtainable. Therefore, there is a need to provide pre-disaster condition database, in this paper inclusive of domestic buildings or houses, and keep the information in database for further use.

Problem statement and research objective

Building/house condition in the form of photographs, are 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 existing building condition photographs 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, during 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 classify 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 Yogyakarta. The distance between the photographer and the object of photograph was varied so as to produce two main types of photographs, the 'whole building' 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 (Table 1). 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.

The checklist has been used to make an assessment of building condition of collected data. The assessment method initially adapted the concept of Bayes' Theorem (Nugraheni, 2010). The assessment was done completed for every photograph in Figure 1 and the result of that process was shown in Table 2 (Nugraheni, 2010).

Table 1. The attributes and sub attributes for non-engineered building earthquake resistant

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

The result in Table 2 shows from 16 photographs for non-engineered building, ten building defined as earthquake-resistant building (P(H│E comb score = 1) and six building as earthquake non-resistant building (P(H│E comb score < 1). Each photographs that consists of the earthquake-resistant condition has the score of degree of confidence of earthquake-resistant building condition given earthquake-resistant attributes, P(H│E comb), of 1. Vice versa, the photographs that consist of earthquake non-resistant condition have the score of < 1. Interestingly, for earthquake-resistant condition photographs, the score of degree of confidence of the condition is resistant that can cause earthquake-resistant attributes were varied. The scores are some value between 0 and 1. For example, one photograph has a score of 0.835 (building no.3); its means the degree of confidence that the building is resistant is 83.5%. Another image has a score of 0.018 (building no.15); its means the degree of confidence that the building is resistant is 1.8%. Those two buildings were defined as earthquake-resistant building, and so what does a score such as 83.5% or 1.8% mean? Is 83.5% means resistant or partly resistant or little-bit resistant? How about 1.8%, is that score has a meaning of almost resistant or most likely non-resistant? Or both of those score have a same meaning?

To deal with this problem, this research proposed an approach to classify an earthquake-resistant condition based on fuzzy logic theory. This theory is known as theory to deal with uncertainty reasoning which is primarily concerned with quantifying and reasoning using natural language in which many words have ambiguous meaning such as *a little, very much*, and so on (Giarratano and Riley, 1998)

Figure 1. A set of building condition photographs

Table 2. Probability of earthquake-resistant

Building 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	0.449	0.250	0.109	0.750	0.578778
5	0.221	0.333	0.221	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	0.018	0.111	0	0.889	1
13	0	0.111	0.280	0.889	0
14	0.018	0.111	0	0.889	1
15	0.018	0.111	0	0.889	1
16	0	0.111	0.186	0.889	0

Fuzzy logic - a basic concept

The traditional way of representing which objects are elements of a set is in term of a ***characteristic function***. If an object is an element of a set, then its characteristic function is 1. If an object is not an element of a set, then its characteristic function is 0. Set to which this applies are called ***crisp sets***. This type of thinking is called two-valued or ***bivalent logic***, in which true or false are the only possibilities. The problem with this bivalent logic is that the real world live in an analog. In the real world things are generally not in one state or another, but partially belong to a set. This is a basic concept of ***fuzzy sets***. The degree of membership in fuzzy set is measured by a generalization of the characteristic function called the ***membership function***. This membership function defined as: μ_A (x): X $\rightarrow$ [0,1]. Which states that the membership function maps all elements of X into the codomain of real numbers defined in the interval from 0 to 1 inclusive and symbolized by [0,1]. That is, the membership function is a real number $0 \leq \mu_A \leq 1$, where 0 means no membership and 1 means full membership in the set. While it is difficult to think of an object as being only partially in a set, another way is to consider the membership functions as representing the degree to which an object has some attribute. This concept of degree of attribute means how well one object conforms to some attribute (Giarratano and Riley, 1998:259), and this degree represented by a particular value of the membership function, such as 0.5, which is called a ***grade of membership***.

Depending on the application, a membership function may be constructed from one person's opinions or from a group of people. Intuitively, the membership function for a group of people also may be thought of in terms of an opinion poll. It is important to realize that a membership function is really not a frequency distribution. The opinions are likelihoods or degree of confidence because it's expressed a personal belief.

The S-curve of membership function is a mathematical function that is often used in fuzzy sets as a membership function. In this definition α, β, and γ are parameters that may be adjusted to fit the desired membership data. Depending on the given membership data, it may be possible to give an exact fit for some values of α, β, and γ, or the fit may only be approximate. The S-curve is flat at a value of 0 for $x \leq \alpha$ and at 1 for $x \geq \gamma$. In between α and γ the S-curve is a quadratic function of x

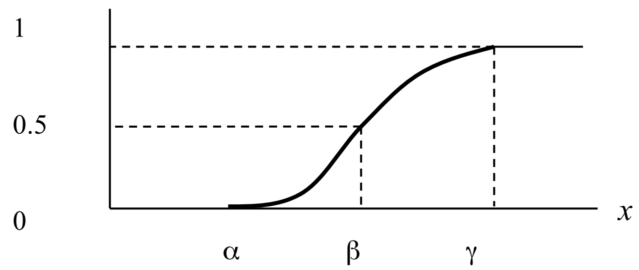


Figure 2. The S-curve of the membership function in fuzzy logic

As shown by Figure 2, the β parameter corresponds to the crossover point of 0.5 and is (α + γ)/2. The mathematical function for S-curve is defined as follows (Giarratano and Riley, 1998):

$$S(x; \alpha; \beta; \gamma) = \begin{cases} 0 & \text{for } x \le \alpha \\ 2\left(\dfrac{x-\alpha}{\gamma-\alpha}\right)^2 & \text{for } \alpha \le x \le \beta \\ 1 - 2\left(\dfrac{x-\gamma}{\gamma-\alpha}\right)^2 & \text{for } \beta \le x \le \gamma \\ 1 & \text{for } x \ge \gamma \end{cases}$$

Where:

α is a minimum value of the parameter,

β is a value of the crossover point of membership function, and

γ is a maximum value of the parameter.

For example:
Suppose a group of people was asked to specify a minimum value for the word *SPEEDING*. Probably no one would say that a vehicle with speed less than 50kph is speeding. Likewise probably everyone would say that a vehicle with speed 70kph and over is speeding if the limit speed on a particular road is 60kph. Referring to this example, the α correspond to 50kph and γ correspond to 70kph, and β correspond to the crossover point where μ = 0.5.

A membership function parameters determination

Referring to the value of the likelihood, the value of α, β, and γ will be some value between 0% and 100% or between 0 and 1. To determine a value for α of likelihood of resistant building could be done by approximation. If 0 refers to non-resistant building, then the value of 0.25 was chosen for the minimum value of resistant building. For a value of γ of course the maximum value is 1, as the highest value for likelihood is 100% or 1. Vice versa, for non-resistant building, the lowest value for likelihood is 0% or 0. A value for γ of likelihood of non-resistant building was determined by approximation and the value of 0.75 was chosen. The mathematical calculation to develop membership function for resistant building and membership function for non-resistant building was demonstrated below.

Example:
The membership function of resistant building has a value of α = 0.25, β = 0.625, and γ = 1. By using mathematical formula for S-curve from Giarratano and Riley (1998), so the value of the axis *y* that refers to the grade of membership is calculate as follow:

S (*x*; 0.25; 0.625; 1)

- The membership is 0 for x ≤ α, which is 0 for x ≤ 0.25
- α = 0.25, β = 0.625, γ = 1, then:

  $$2\left(\frac{x-a}{\gamma-a}\right)^2 = 2\left(\frac{x-0.25}{1-0.25}\right)^2 = 3.556(x\text{-}0.25)^2 \text{ for } 0.25 \le x \le 0.625$$

  Example: for x = 0.5 then y = 0.222

  $$1 - 2\left(\frac{x-\gamma}{\gamma-a}\right)^2 = 1-2\left(\frac{x-1}{1-0.25}\right)^2 = 1-3.556(x-1)^2 \text{ for } 0.625 \le x \le 1$$

  Example: for x = 0.75 then y = 0.778
- The membership is 1 for x ≥ γ, which is 1 for x ≥ 1

Likewise, for the membership function of non-resistant building has a value of α = 0, β = 0.375, and γ = 0.75. To calculate the membership function for non-resistant building, the mathematical formula was changed. For α ≤ x ≤ β, the formula was $1 - 2\left(\frac{x-\gamma}{\gamma-a}\right)^2$ and for β ≤ x ≤ γ, the formula was $2\left(\frac{x-a}{\gamma-a}\right)^2$. The whole calculation was shown on Table 3, and the S-curve of the membership function was shown on Figure 3.

Table 3. Membership function for resistant and non-resistant likelihood

value x	0	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1
Resistant function.	0	0.000	0.000	0.009	0.080	0.222	0.436	0.680	0.858	0.964	0
Non-resistant function	1	0.964	0.858	0.680	0.436	0.222	0.080	0.009	0.000	0.000	0

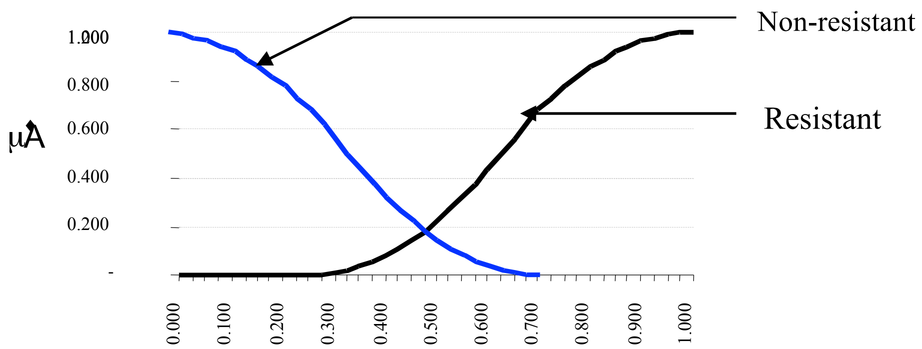


Figure 3. Membership function curves for resistant and non-resistant likelihood

Previously stated the membership function means how well one object conforms to some attribute and representing by a value that correspond to the grade of membership. Referring to Figure 3, it can be seen that for the value x ≤ 0.25, the grade of membership for resistant is 0% and the grade of membership for non-resistant is between 82% and 100%. This area is a plot for the linguistic term "most likely non-resistant". For the value $0.25 \leq x \leq 0.75$, the membership grade for resistant is between 0% and 77.8% and the membership grade for non-resistant is between 0% and 77.8% respectively. This area is a plot for the linguistic term "fairly resistant". For the value $x \geq 0.75$, the membership grade for resistant is between 82% and 100 % and the membership grade for non-resistant is 0%. This area is a plot for the linguistic term "most likely resistant". The classification of resistant building using a proposed approach will be described in the following section, and the meaning of the value of the grade of membership will be described respectively.

Classification of earthquake resistant building using Fuzzy Logic Theory

The grade of membership was developed and shown in Table 3 (as resistant function row and non-resistant function row) and Figure 3 (represent by μA or axis-*y*). The occurrence of resistance or likelihood of resistance was occurs, P(E|H), was shown in Table 2. Referring to these two tables, the classification of resistant building will be demonstrated. This calculation was used for all resistant building shown on Figure 2.
Example:

- See Figure 2 building number 3, which is referring to Table 2 building number 3.
- This image has a value of P(E|H) = 0.835.
- This particular value then referred to Table 3. This value was used for x. By looking to the table, it can be seen that the grade of membership of x = 0.835 is nearly the value of x = 0.900. The value of x = 0.900 has a grade of membership of 0.964 or 96.4% for resistant membership function and 0.000 or 0% for non-resistant membership function. This means that by observed the photograph, it can be stated that the existed building condition shown at that photograph, 96.4% represent a resistant and 0% represent non-resistant building based on building condition attributes. Further, if the value then plotted into Figure 3, this value of 96.4% will be on "most likely resistant" area.

Thus, the building condition shown in building photograph number 3 can be classified as a most likely resistant building.

Results of the research

Using proposed approach described above, the result of the research are shown in Table 4.

Table 4. Classification for earthquake resistant building

Building number	P(E│H)	P(H│E comb)	Classification
	A	E=(AB)/(AB+CD)	
1	0	0	Non-resistant
2	0.165	0.089918	Non-resistant
3	0.835	1	**Most likely resistant**
4	0.449	0.578778	Non-resistant
5	0.221	0.333333	Non-resistant
6	0.67	1	**Fairly resistant**
7	0.67	1	**Fairly resistant**
8	1	1	**Most likely resistant**
9	1	1	**Most likely resistant**
10	1	1	**Most likely resistant**
11	1	1	**Most likely resistant**
12	0.018	1	**Most likely non-resistant**
13	0	0	Non-resistant
14	0.018	1	**Most likely non-resistant**
15	0.018	1	**Most likely non-resistant**
16	0	0	Non-resistant

From Table 4 it can be revealed that:

- Five buildings can be classified as "most likely resistant" buildings [Figure 2, building numbers 3, 8, 9, 10, 11].
- Two buildings can be classified as "fairly resistant" buildings [Figure 2, building numbers 6, 7].
- Three buildings can be classified as "most likely non-resistant" buildings [Figure 2, building numbers 12, 14, 15].

Analysis of the results

The result of this research was developed using information observed from building photographs shown in Figure 2. The likelihood for each building based on photograph was calculated by uncertain information revealed from the photograph, thus the building's conditions were classified using uncertain information respectively. The distance between the observer and the observation object caused this uncertain information. For example, building 3 and 15 (see Figure 2) both were defined as earthquake resistant building (see Table 2). However, those building have different classification (see Table 3).

To avoid being uncertain, the observer can go through to the object of observation, and gain exact information from that. By doing that, this approach is not longer suitable as this approach were based on uncertain information. So the results of these calculations can be compared with 'direct' observation and a conflict or difference between them can prompt a check of the direct observation.

Conclusion

Earthquakes quite often hit Indonesia. Recent earthquake in Yogyakarta happen in May 27, 2006. The lost figure was devastate, 154,000 houses completely destroyed and 260,000 houses suffered some damage (Yogyakarta and Central Java Preliminary Damage and Loss Assessment 2006). From that overwhelmed 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.

The preliminary research has investigated existed building condition using building photographs. The Bayes' Theorem was used initially to define the building condition. The result from previous research has shown some of the buildings were defined as earthquake resistant buildings and some were defined as non-resistant building. Interestingly, the resistant building has different score of probability and it shows even resistant building it has membership for non-resistance. Therefore, the resistant buildings need to be classified further, and this classification can be used for retrofitting priority. The approach for classification based on Fuzzy Logic Theory.

An example demonstrates how it is possible, using this proposed approach, to classify resistant building into three resistance classifications. The result showed from ten buildings, five were classified as "most likely resistant"; two were classified as "fairly resistant", and three were classified as "most likely non-resistant". Future work will focus on developing a photograph database to identify, define, and classify existed building condition using these and related methods.

References

Damage and Loss Assessment Report. (2006). *Preliminary Damage and Loss Assessment. Yogyakarta and Central Java Natural Disaster.* Joint cooepereation of BAPPENAS, the Provincial and Local Government of D. I. Yogyakarta, the Provincial and Local Government of Central Java, and international partners.

ECLAC. (2003). *Handbook for Estimating the Socio-economic and Environmental Effect of Disasters.* Economic Commision for Latin America and the Carribean. United Nations.Giarratano, J and Riley, G (1998) *Expert Systems: Principles and Programming*. 3ed. Boston: International Thomson Publishing Inc.

FEMA 74. (2005). *Earthquake Hazard Mitigation for Nonstructural Elements. Field Manual.* The Federal Emergency Management Agency. Available at: http://www.fema.gov

FEMA 154. (2002). *Rapid Visual Screening of Buildings for Potential Seismic Hazards.* The Federal Emergency Management Agency. Available at: http://www.fema.gov

Giarratano, J and Riley, G (1998) *Expert Systems: Principles and Programming*. 3ed. Boston: International Thomson Publishing Inc.

Haslam, et al (2005) Contributing factors in construction accidents. Applied Ergonomics, 36, 401-415.

Hecker, et al (2005) Designing for worker safety. *Professional Safety*, 50 (9), 32-44.

International Research Committee on Disasters. Stallings, R. A. (Ed.). (2002). *Methods of Disaster Research.* Xlibris Corporation. The United States of America.

Jochum, C (1990) Integrated safety. *Journal of Occupational Accidents*, 13, 139-144.

Kartam, N (1997) Integrating safety and health performance into construction CPM. *Journal of Construction Engineering and Management*, 123 (2), 121-126.

Lee, S and Halpin, DW (2003) Predictive tool for estimating accident risk. *Journal of Construction Engineering and Management*, 129 (4), 431-436.

National Research Council of The National Academies. (2003). *Preventing Earthquake Disaster*. The National Academies Press. Washington, D. C.

Naryanto, H. S. et al. (2007). *Science and Technology as A Principle of Disaster Management in Indonesia.* The Ministry of Research and Technology. The Republic of Indonesia.

Occupational Safety and Health Administration, http://www.osha.gov

State of the Work Environment (2005), available from http://www.worksafe.wa.gov.au

Toole, T.M (2002) Construction site safety roles. *Journal of Construction Engineering and Management*, 128 (3), 203-210.

Whitaker, et al (2003) Safety with access scaffolds: Development of a prototype decision aid based on accident analysis. *Journal of Safety Research*, 34, 249-261.

Promoting Volcano Tourism in Hazard Zone Area for Rebuilding Local Economy: Case study of Tourism in Cangkringan Sub-District, Mt. Merapi, Yogyakarta

Saut Sagala*[1], Arief Rosyidie[1], Alpian Pratama[1], Ramanditya Wimbardana[1] and Anastasia Wijayanti[2]

[1]*Research Group of Regional and Rural Planning*
School of Architecture, Planning and Policy Development,
Institute of Technology Bandung, Indonesia, Jl. Ganesha 10, Bandung 40132

[2]*Study Programme of Regional and City Planning*
School of Architecture, Planning and Policy Development,
Institute of Technology Bandung, Indonesia, Jl. Ganesha 10, Bandung 40132

*Corresponding author: saut.sagala@sappk.itb.ac.id

Abstract

As a country that is prone to natural disaster impacts, Indonesia has been highly affected by many disaster events. While a disaster normally brings negative impacts, there are positive impacts from disasters that can be used for economic development, such as tourism. This paper explores the potentials provided by the location of hazard zones and history of disaster records as a tourism attraction. More specifically, it identifies the role of tourism in promoting the local economic development in hazard zone. Taking the case study of Cangkringan Sub-District, Sleman District, Yogyakarta, this paper examines the development of tourism sectors in the area that was heavily damaged by the pyroclastic flows during the eruption. This research applies quantitative and qualitative analysis to identify what factors and reasons that interest tourists to visit the area. Interviews were carried out to the tourists and tourism service workers. Further question is whether the current tourism attraction can sustain and bring sustainable impact to the local communities. We explore the characteristics of tourists and tourism service workers. The research found that the local economy has developed and the tourism sector has become a potential for the local community to participate. This paper recommends that local government can increase the quality of the tourism service in the area and sees the potentials of up-scaling the benefit of the tourism in the hazard zone area.

Keywords: disaster, Merapi, tourism, Yogyakarta

Introduction

As a country that is prone to natural disaster impacts, Indonesia has been highly affected by many disaster events. While a disaster normally brings negative impacts, there are positive impacts from disasters that can be used for economic development, such as agriculture, livestock, settlements, termal energy and tourism. Located at the pacific ring of fire, Indonesia has more than 100 active volcanoes (SI-USGS, 2009). Most of the volcanoes are inhabited since they offer many sources of economy to the inhabitants (fertile land, cold climate, tourism).

Despite the benefits, a volcano also poses risk to the inhabitants living nearby. Therefore, it is important to integrate the benefits and costs of living near an active volcano through the concept of “living with risk” (Kelman and Mather, 2008).

The last eruption of Mt. Merapi, Yogyakarta Indonesia in 2010 has been recorded as the biggest eruption in the history for the last one decade (PVMBG, 2010). 196 people lossed their lives due to the pyroclastic flows, 258 injured and 410,338 people had to evacuate. The impact also causes as many as 3,245 destroyed houses. This big eruption has caused not only physical damage, but also social and economic that causes a lot of impacts to the people and their livelihood. People had to lose their previous jobs as cattle owners since many cattle are dead and they had to live far from their previous place which was damaged by the volcanic eruption. The number of cattles in Sleman Sub-District, the district which was mostly affected by Merapi Eruption, was reduced significantly.

Benefits in hazard prone area are not only obtained from the potential of resources that a disaster prone area can offer. It may also includes the impact that is caused after a disaster. The heavily damaged areas by Mt. Merapi became a tourist attraction soon after the situation was declared safe. Since December 2010, slowly some visitors enter the area which was later famous as a Volcano Tour tourism area. Inskeep (1991) and Mill & Morrison (1985) suggest that many tourism areas can open several sources of livelihood. directly or indirectly to the people living nearby the areas.

Living in hazard prone area should be integrated with community resilience concept (Tobin, 1999). Sagala (2009) observed that the application of hazard zone in Mt. Merapi seems difficult since there is a conflict between people safety and socio-economic interests. As explained earlier, people living in Mt. Merapi are faced with socio-economic problems when they are forced to relocate. Previous example was when some of the residents in Turgo Hamlet, Pakem Sub-District that had to relocate down to another hamlet located down 10 km away from the volcano top. The relocation didnot work well since most of them returned back to Turgo.

Apart from economic reason, Dove (2009) also suggests that there is a strong attachment between the community and the existence of Mt. Merapi. Therefore, the potential of increasing the economic benefit of Mt. Merapi will be important for the people, at least for two reasons. *First*, it provides an alternative source of livelihoods which subsequently increase community resilience. *Second*, the use of the area as a volcano tourism will decrease the density and the built up area of the hazard zone which ultimately will make people exposure to the volcano decreases as well.

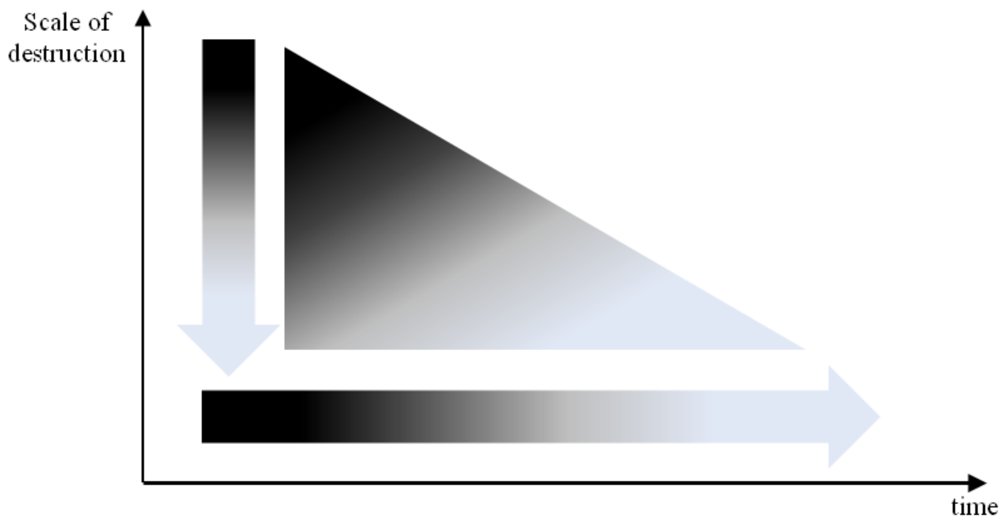
This paper explores the potentials provided by the location of hazard zones and history of disaster records as a tourism attraction. More specifically, it identifies the role of tourism in promoting the local economic development in hazard zone. Taking the case study of Cangkringan Sub-District, Sleman District, Yogyakarta, this paper examines the development of tourism sectors in the area that was heavily damaged by the pyroclastic flows during the eruption. The paper aims to examine how the potential sources from volcano tourism may bring economic benefit for rebuilding the local economy.

The rest of the papers will discuss the methods that are used in this research as well as the respondents that are met in the fieldwork processes. It subsequently follows by the explanation of the characteristics of study area location. Some findings and recommendation are finally presented in the papers.

Volcano Tourism

Volcano tourism can be categorized as dark tourism. Normally, the strength of the dark tourism depends on two main things: the scale and the time when the event occurs (Petford et al 2010). Figure 1 explains the relationship between time, scale and the darkness of tourism object. Normally, the closer the time with the event, the more interesting the object is and attracts more people to visit. The type of event also affects the color of the tourism object. The larger the impact, i.e. more victims, more destruction, the larger the interest for the tourism object. Some dark tourism activities are often found in post volcano eruption areas. In Mt. Etna, tourists came to look for the remnant of the volcanoes as well as the level of destruction (MtEtna.net, 2012). In Sakurajima volcano (Japan), some remnants of past eruptions, i.e. remnants of lava as well as a shrine gate covered by lava constantly attract some tourists to visit. The tourist package was integrated with other attraction that was found in this volcano island, including hot spring, natural parks and hotels (JapanGuide.com, 2012). Some additional foreign languages, such as English and Korean were introduced to attract more tourists. In Hawaii, many volcanoes became attraction for tourists to visit as well. They see the flowing lava coming out from the volcano (DiscoverHawaiiTour.com, 2012).

Cohen (1972, 1974) in Petford et al (2010) categorized tourists into four types, namely: (1). mass and organized tourists, (2). individual tourists, (3). explorer tourist, and (4). drifter tourist. People who do the volcano tourism can be categorized into explorer tourists. Explorer tourists are type of tourists that do not select normal routes which are used by general tourists. This type of tourists likes to explore new route to find a destination or new destination, therefore it could be less luxurious and comfortable. Their aim is to express self actualization and learn about new culture and find new ideas.



Figureure 1. Illustration of Dark Tourism Theory. Source: Modified from Petford et al (2010)

Volcano tourism is a type of tourism that explores the potential of volcano (Petford et al., 2010). Development of volcano tourism needs support from several stakeholders in order to develop a comprehensive and sustainable tourism planning. This will include strategy, effective allocation and management of resources in the tourism area (Newsome, 2010). Some factors that have to be identified include: identification of the exploitation of natural resource which will be enjoyed by the visitors, deliniation of areas that can be used for the tourism, the finding of natural asset, the identification of impact that happened and might happen in the future, the decision of standar and indicator to monitor the visitor activities as well as the effectiveness of management (Newsome, 2010). As a tourism near volcano is potentially affected by risk, it is important that related agencies to provide information that is needed to remind the tourists on potential impacts of volcano hazards (Erfurt-Cooper & Cooper, 2010). This strategy is important for recommendation to increase community awareness of volcano hazards.

Method and Research Location

Research Method

As an initial research that integrates tourism, economic development and disaster management, this research started by identifying what factors on tourism and disaster management that contribute to the local economic development. To do so, qualitative survey and analysis were applied to find the basic reasons why and how things are going in the study area, in relation to volcano tourism.

This research applies quantitative and qualitative analysis to identify what factors and reasons that interest tourists to visit the area and the activities of the tourism service workers. Qualitative survey was conducted through interviews to some selected key-informants. Interviews were carried out to the tourists and tourism service workers. Early observation was carried out in July 2011 and March 2012. Finally, this was followed by a week survey in April 2012. Each interviews normally took around 1-2 hours. All the interviews were recorded and subsequently transcripted and made into coding sheets. The coding sheets were grouped and analyzed with qualitative content analysis in order to support the key findings. To obtained objective information, triangulation was made through several key informants that represent different job types. The information obtained was also confirmed through interviews to government officers and through secondary data that was obtained through surveys to district agency offices, namely: Planning and Development Agency and Tourism Agency.

We conducted interviews to the workers in the volcano tourisms. They are selected as respondents through purposive sampling and snow-balling techniques through previous contact information that led us to another key-informants. The total number of key-informants are 28 people (see Table 1). They consisted of restaurant owner, souvenir seller, motor trail driver, jeep drivers, ojek driver, parking service and entrance ticket officer. Apart from this informants, we managed to interview the volcano tourism management that was managed by local village association.

In fact, Mt. Merapi has been a long-term research in various themes related to disaster risk management and sustainable development by the first author between 2006-2011. Therefore, a large number of data base and information provided from the previous field work activities were used to support the current paper.

Table 1 Key-informants and information obtained for Qualitative Data

Informant		Number	Information
Workers in *Volcano Tour* in Umbulharjo	Restaurant owner	5	Disaster impact, livelihood before and after the disaster, reasons of livelihood change.
	Souvenir Seller	5	
	Motor trail driver	5	
	Jeep drivers	3	
	Ojek driver	3	
	Parking Service	3	
	Ticket Officer	4	

We surveyed 95 tourists through structured questionnaire. The survey of tourists was carried out in weekday and weekend time between 16-20 April 2012. Questionnaire survey includes demographic data of the respondents, purpose of visit, how they understand about the volcano and their impression about the facilities in the volcano tourism. The tourists were selected from those who are convenient and willing to be interviewed. From each group of tourists, the respondent was selected only one in order to have a deep variety of information. In addition to that, the data on tourist visit was obtained through the ticketing office to estimate the number of visitors each day.

Research Location and Mt. Merapi

The research is conducted in the tourism area of Volcano Tour, Mt. Merapi, Umbulharjo Village, Cangkringan Sub-District, Sleman District, Yogyakarta Province. It is located in north of Yogyakarta City, the capital of Yogyakarta Province. The areas were affected heavily by the recent 2010 volcanic eruptions.

The common economic bases in Cangkringan Sub-District before the 2010 Merapi eruption was dominated by agriculture, raising cattle, sand and rock mining activities and some small tourism activity (Sagala, 2009a). Normally, the sand and rock mining activities are available along the river valleys which channelled the lahars from Mt. Merapi eruptions in the past time. The agriculture and farm activities get benefit from the mild climate on the slopes of the mountain. The tourism activities include renting the rooms in the weekend, providing sightseeing of the mountain. Thus, the economic bases of these sub-districts are mainly influenced by the existence of Mt. Merapi (Sagala, 2009a).

Mt. Merapi or Mount of Fire is a conical volcano located on the border between Central Java and Yogyakarta, Indonesia. It is the most active volcano in Indonesia and has erupted regularly since 1548. The height of Mt. Merapi changes over time due to the active materials produced and the current height is 2,968 metres (9,738 ft). It is very close to the city of Yogyakarta, and thousands of people live on the flanks of the volcano, with villages as high as 1700 m above sea level. Merapi has been very active within the last two decades. The records noted that the volcano previously erupted in 1994, 1997, 2001, 2006 and 2010.

Tourist attraction in Cangkringan Volcano Tourism

There are at least three attractive objects for tourists found in the Cangkringan Volcano Tourism. These objects are as follows: *first*, the grave of Marijan, the late gate keeper of Mt. Merapi who died in the eruption of 2010, *second*, objects or built environment that destroyed by the eruption and *third*, volcano tour drive to the large scale devastated area by the volcano eruption. Apart from these tourist attractive objects, the mounstain scenery and the temporer facilities provided by the local people added to the comfort of visiting the volcano tourism.

Grave of Marijan

Marijan was refused to evacuate when the eruption was getting more intensity which finally costed his lives and some local residents living nearby his house. Marijan has been famous nationally since the 2006 eruption that he insisted to stay in his house and showed that no impact of volcanic eruption affected his house. Since then, became a star for an energy-drink commercial advertisement and have been invited to several public occassion. In fact, in the Yogyakarta Sultanate, Marijan has a duty as a gate keeper or servant of Yogyakarta Sultanate that maintain annual offering to Mt. Merapi through labuhan ceremony and to communicate spritually to Mt. Merapi (Schlehe, 1996 and Schlehe 2007). After the 2006 eruption subsided, Marijan house' has been visited by many visitors from many parts of Indonesia to meet him and learn from his wisdom.

His death in the eruption 2010 has become an interesting story and therefore, his grave since then has become a place where many people pay a visit (Figure 2). His daughter opened a souvenir shop adjacent to his grave.

Figure 2. Grave of Mr. Marijan. Source: Authors' observation (2012)

Destroyed built environment

The area that is presently famous for the volcano tourism used to be two hamlets: Pelemsari and Pangukrejo. The strong volcanic eruption demolished many built environment objects (houses, motorcycles, cars). Some remaining objects have become interesting objects for tourists (Figure 3) to take photographs and to learn from how large the destruction was. Some of these objects were moved to a public area where tourists can easily access while some others still remained in the place where they were hit. A wooden made tower was also provided by the local people for some people who would like to see a wide range of the devastation with some little contribution of money.

Figure. 3 A car that was destroyed by the volcano eruption in 2010. Source: Authors' observation (2012)

Volcano tour

The volcano tour area covers the area that was demolished between Pelemsari Hamlet and Kaliadem Hamlet. The volcano tour has short, medium and long routes and has different rates for each route. The local people provided motor trails and jeeps for single and group passengers subsequently (Figure 4).

Figure 4. Motor trails and jeeps for volcano tour. Source: Authors' observation (2012)

Findings

Further question is whether the current tourism attraction can bring sustainable and significant impact to the local communities. To understand this, we explore the characteristics of tourists and tourism service workers and the role of volcano tourism to the local people.

The establishment of volcano tourism

After the eruption in 2010, the communities from Pelemsari and Pangurekjo Hamlets have to live in relocation place in Ploso Kerep Hamlet. Ploso Kerep is located down south from the their previous hamlet. Some temporer woden structured houses were constructed with limited space and no space for keeping their livestock. Temporarily, the communities were provided food by the government to support their living. However, they have to lose their livelihood since they have no place to raise their livestock and the grass for their livestock are located up near the mountain slope.

The interest of people from outside of Cangkringan to visit the areas after eruption have opened new opportunities for Pelemsari and Pangukrejo residents to start other types of livelihoods. To make an agreement among the residents on how to manage the volcano tourism they formed an association that consists of people living in these two hamlets (Figure 5). The association subsequently managed the money obtained from the ticket and to decide how the money is distributed among the people and public purpose. More and more services, such as motor trails, jeeps, small restaurants, souvenirs, etc were established by local people which normally formed through new associations related to the job types.

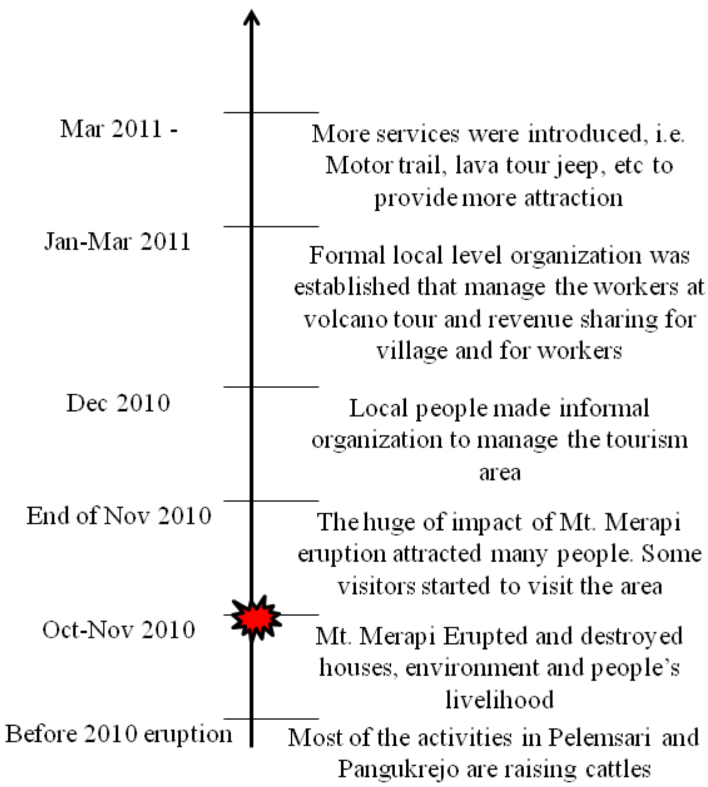


Figure. 5 Volcano Tour Establishment in Umbulharjo Village

Tourist Characteristics

From the survey we carried out to 95 tourists, most of the respondents came to the area for holiday (68,4%) while some of them on study/research purpose (20%) (Figure 6). The large number of tourist purpose as a holiday show that the volcano tour still serves as a tourist attraction. Some respondents who said they came for study explains that the volcano tour attracts people to learn from what happened in the last eruption.

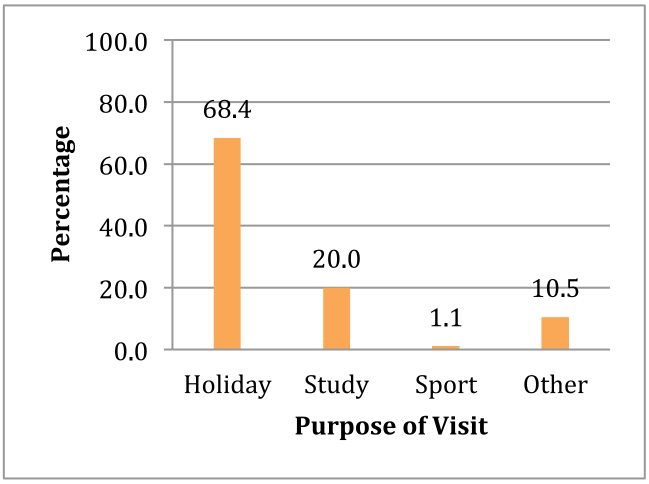


Figure 6. Purpose of Visit (n=95)

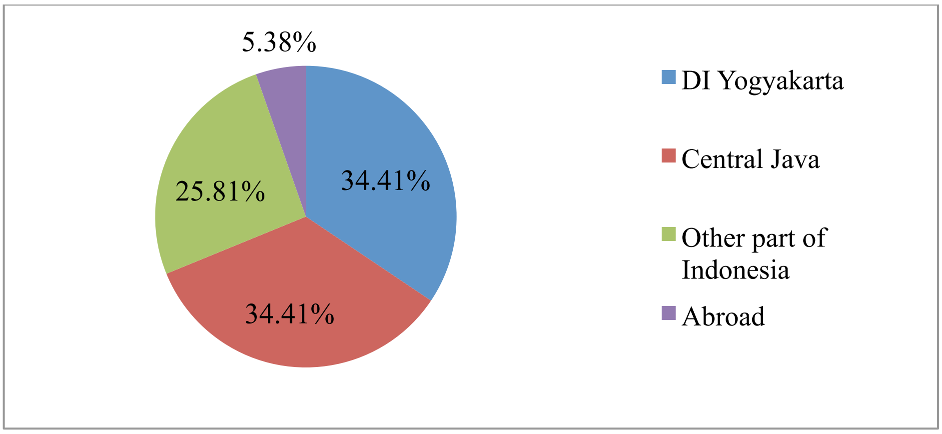


Figure 7. Tourists' Origin

The origin of the tourists are mostly from Yogyakarta and Central Java Province (68%). This is indicating that the volcano tourism still attracts people coming from nearby areas. A quarter number of respondents coming from other parts of Indonesia explains that there is a potential that the volcano tourism as an interesting object to see.

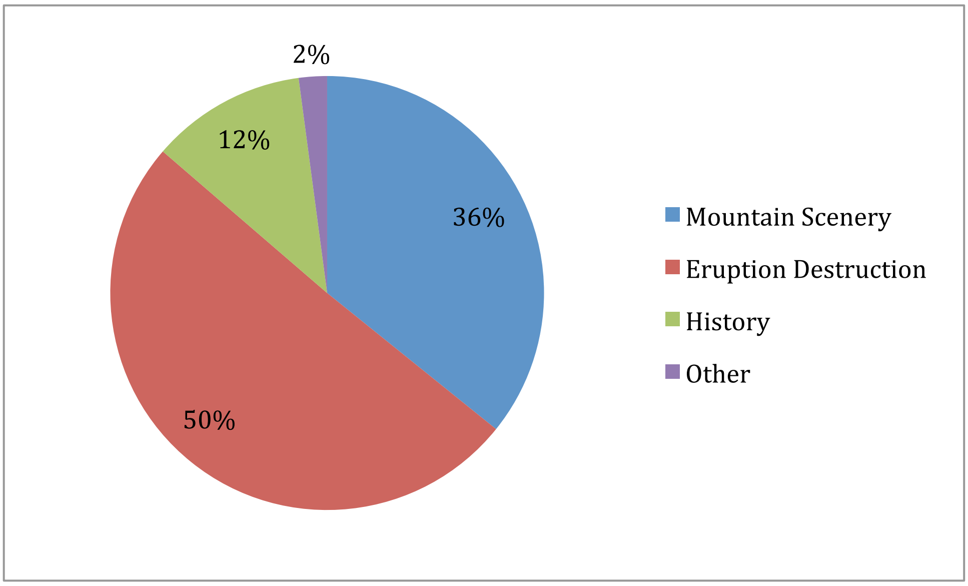


Figure 8. Tourist Motivation

When they were asked on what was their motivation to visit Merapi, half of the respondents said due to the eruption destruction. Indeed, this is in line with the theory of dark tourism (Petford et al 2010). People motivation to visit Mt. Merapi is still affected by the previous eruption.

Tourism Service Association

The tourism service in Volcano Tourism are categorized into *ojek*, food stall and souvenir shops, motor trail tour and jeep tour. Each of this is managed by an association. Each association has schedule and contribution from each member to the association. It has it's own rule. Apart from association, there are some groups, such as parking and ticketing staf that receive monthly salary.

Ojek Association

Ojek driver normally takes passenger to the location of Marijan Grave. For one time service, a passenger has to pay IDR 20,000. Some IDR 5,000 will be contributed to the association. As the number of Ojek driver is larger than the daily demand, the ojek drivers are distributed that each driver can only work one time in each three days. While driving, an ojek driver also guides the passenger about the story of eruption and the areas they pass by. However, they didnot receive proper training how to guide tourists.

Food Stall and Souvenir Shop Association

The food stall and souvenir shops open everyday in a fix place. Some retribution is provided to the association and some land rent for people coming from outside of Pelemsari and Pangukrejo Hamlets. There has been a good link between the shop owners and the goods distributors and producers. This is accomodated by village government, NGO and some private donations. In the relocation place, people were trained to produce some food and goods to be sold in the volcano tourism place.

Trail and jeep tour association

The trail tour association was established in December 2011. The number of trail tour is small and therefore there is no scheduling for who will be able to work weekly. The route for motor trail costs 50.000 for short route, 100.000 for medium route and 150.000 for long route. Some 10,000 has to be contributed to the association for each route. Jeep tour association was established also in December 2011. The route for jeep costs 250.000 for short route, 350.000 for medium route and 450.000 for long route. Since the jeep needs higher investment, normally the driver rents the jeep from other people.

Parking and Ticketing Group

There are 300 residents of Pelemsari and Pangukrejo Hamlets work as parking and ticketing staffs. They receive the salary was shared from the ticketing and parking charge. Since the number of workers are many, they receive only small amount of money monthly.

Contribution of Volcano Tourism to Local Economy

In general, the volcano tourism has generated income to the local community and to the village. The contribution from the entrance ticket can be seen from Figure 9. About 19% of the revenue goes to village budget which is expected to increase the quality of the village service to it's community.

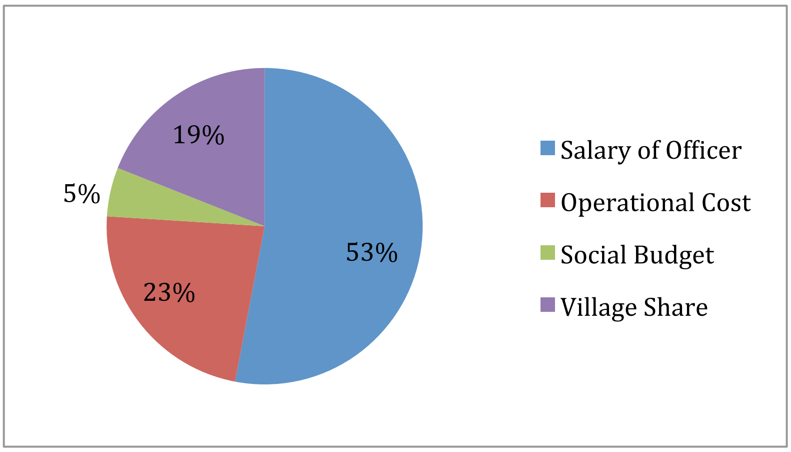


Figure. 9 Ticket Selling Revenue Share (Source: Tim Pengelola Volcano Tour Desa Umbulharjo, 2012)

Unfortunately, the number of the visitors tends to decrease from the time it was opened. The volcano tourism was opened in January 2011 and since then the number of tourists tend to decrease. The high number of tourist in September 2011 is due to the month was on public holidays where many people visit Mt. Merapi.

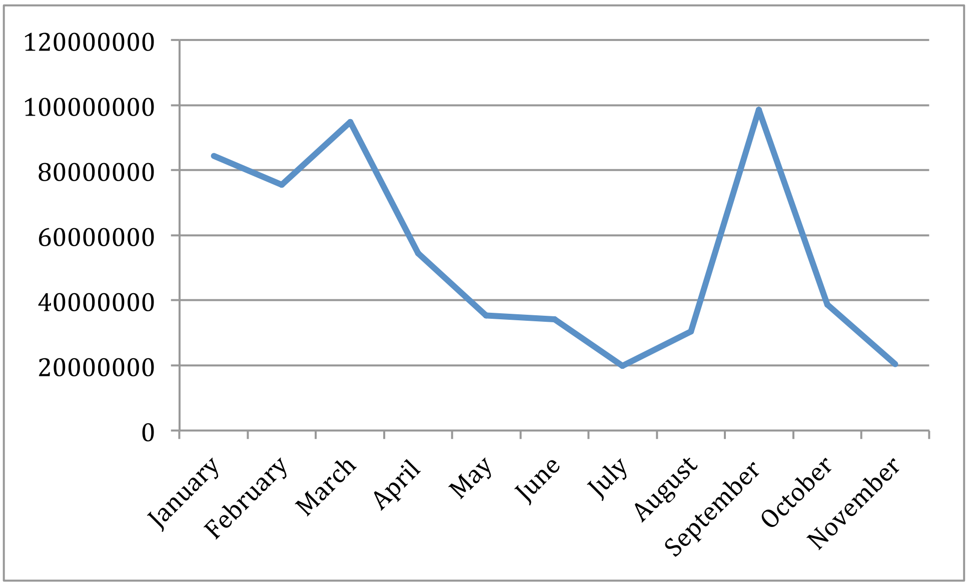


Figure 10. Revenue from Volcano Tour January-November 2011

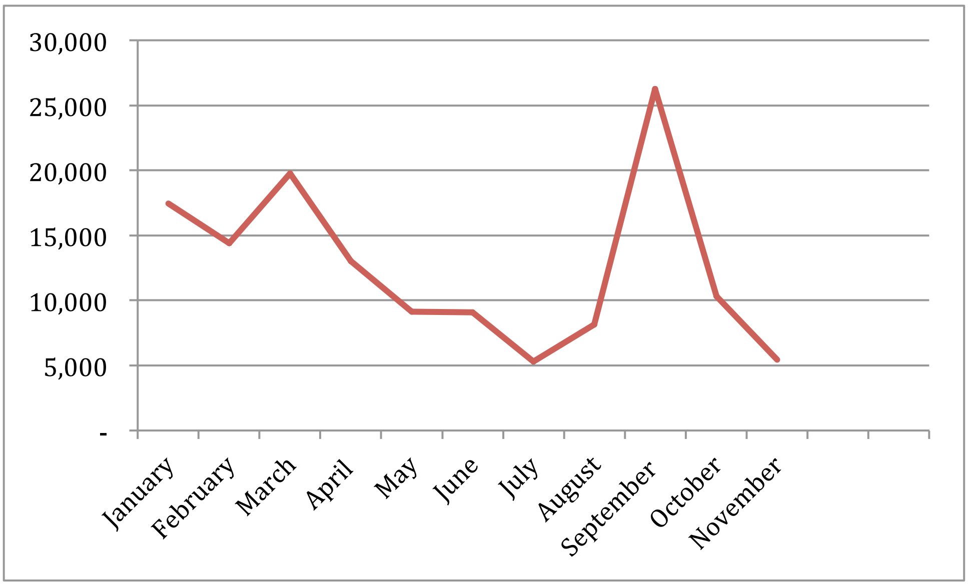


Figure 11. Number of Visitors of Volcano Tourism (Source: Tim Pengelola Volcano Tour Desa Umbulharjo, 2012)

Conclusion

This paper has examined the potential how a volcano hazard prone offers benefit through volcano tourism to the communities living on the slope of the volcano. This potential is in line with the concept of living with risk that is recently promoted by many stakeholders natiaonally and internationally. This paper shows that the huge impact of the volcano eruption has become a strong attraction for people and become a source of income for local community that works in the tourist area. As a volcano tourism place, this area is limited with the built environment characteristics and thus it is inline with the function of hazard zone 3 or forbidden zone for permanent activity that is strongly urged by government. While there is a decrease in the attractiveness of the area, local government can take role to support it's function as a volcano tourism and to integrate this with other potential of tourism activities in order to increase it's economic value and attract more people to visit. While the income obtained from the tourism activities is still less than the income they receive from working as

Indeed, there is a question of the sustainability of the volcano tourism as also observed in the decrease number of tourists in the area. However, this can be promoted more, if the district tourism agency and community are hand in hand to promote and increase the quality of the volcano tourism. This achievement will be important in increasing the community resilience by contributing not only to hazard related factors but also to socio-economic factors that contribute to decreasing the vulnerability of the society.

In the contect of tourism planning, this research offers other potential tourism activities that can be explored in Indonesia. As many disasters have taken place in Indonesia in the past, many interesting history and objects can be promoted and become interests of people to visit. This potential will increase the economic development of the disaster prone area.

Acknowledgement

This paper is part of publication produced from a research project entitled "The role of tourism for local economic development in hazard prone area" under research project number 118/I1.C10/PL/2012 funded by Research and Community Service Center (LPPM) - Institut Teknologi Bandung. In addition, we thank other research team who also helped in data collection as follows: Roby Dwiputra, Febriyanti, Adrian Mangunsong and Dodon.

References

Dove, M. R. (2008). Perception of Volcanic Eruption as Agent of Change. Geoforum 39 , 736-746.

Kelman, I., & Mather, T. A. (2008). Living with volcanoes: The sustainable livelihoods approach for Volcano Related Opportunities. Journal of Volcanology and Geothermal Research 172 , 189–198.

Newsome, D. (2010). The Need for a Planning Framework to Preserve the Wilderness Values of Sibayak Volcano, North Sumatra, Indonesia. Dalam E. Cooper, Volcano and Geothermal Tourism: Sustainable Geo-resources for Leisure and Recreation (hal. 131-141).

Sagala, S., Okada, N., & Paton, G. (2009). Modeling the Social Resilience of Mountain Communities under Volcanic Risk. Proceeding of the 2009 IEEE International Conference on System, Man, and Cybernetics , 1935-1940.

Sagala, S. (2009). Implementable Land Use Plan in Volcano Prone Area in Indonesia: Challenges and Opportunities. nternational Conference on Urban and Regional Planning: "Positioning Planning in Global Crises" .

Sagala, S. (2009). System Analysis of Social Resilience against Volcanic Risks. Case Studies of Mt. Merapi, Indonesia and Mt. Sakurajima, Japan. Department of Urban Management Graduate School of Engineering, Kyoto University. Disertation

Sagala, S., Okada, N., & Paton, D. (2009). Predictors of Intention to Prepare for Volcanic Risks in Mt. Merapi. Indonesia. Journal of Pacific Rim Psychology , 47-57.

Schlehe, J., (1996). Reinterpretation of Mystical Traditions: Explanation of a Volcanic Eruption in Java. Anthropos, 91: 391-409.

Schlehe, J., (2007). Cultural politics of natural disasters: Discourses on volcanic eruptions in Indonesia. In: M. Casimir (Editor), Culture and The Changing Environment: Uncertainty, cognition and risk management in cross-cultural perspective, Berghahn, Oxford/ New York.
SI-USGS, 2009. Global Volcanism Program, accessed from: http://www.volcano.si.edu/reports/usgs/ on July 4, 2009.

Tobin, G. A., & Whiteford, L. M. (2004). Chronic Hazards: Health Impact Associated with On-Going Ash Falls around Mt. Turungahua, Ecuador. Papers of the Applied Geography Conferences Vol. 27 , 84-93.

Tobin, G. A., & Whiteford, L. M. (2001). Economic Ramifications of Disaster: Experience of Displaced Person. Papers of the Applied Geography Conferences, Volume 25 , 316-324.

Tobin, G. (1999). Sustainability and Community Resilience The Holy Grail of Hazards Planning. Environmental Hazards , 13-25.

Online Sources:
MtEtna.Net, 2012
JapanGuide.Com, 2012
DiscoverHawaiiTour.Com, 2012

Damage Detection in Reinforced Concrete Beams Using Frequency Response Functions

Fadillawaty Saleh[1,2]

Department of Civil Engineering, Faculty of Engineering, Muhammadiyah University of Yogyakarta[1)]

School of Engineering and Science, Faculty of Health, Engineering and Science, Victoria University, Australia[2)]

Email: fadillawaty.saleh@live.vu.edu.au

Abstract

This paper investigates a technique where cracks propagated in concrete beams are detected based on the frequency response curve of the beam obtained from vibration testing. This is done using the impact test and ICATS software to capture the Frequency Response Functions (FRFs) data. An experimental using reinforced concrete beams simply supported on rollers with a layer of rubber between the concrete beam and supports. A numerical algorithm using frequency response functions was performed to compare crack locations identified by the algorithm with those found in experiments.

Keywords: Reinforced concrete, damage detection, frequency response functions, vibration testing

Introduction

Reinforced concrete (RC) structures are subject to micro-crack initiation and propagation at load levels far below the actual failure load. While visual inspection fails to assess the damage at this early stage, vibration measurements are sufficiently sensitive to detect and monitor the damage evolution, even when the micro-cracks are situated in hidden or internal zones. However, most currently used vibration techniques are linear techniques, based on the loss of stiffness (or equivalently wave speed), or the increase of attenuation with damage. Generally, the sensitivity of such methods to micro-scale damage is not extraordinary.

Dynamic system identification of RC beams i.e. natural frequencies, damping ratios and mode shapes are of high importance due to their special roles in most civil engineering structures. Dynamic characteristics of reinforced concrete (RC) structural beams can be recognized as dynamic system identification. In general damage in the RC structural system is detected by comparing the identified dynamical indices of the damaged and undamaged (intact) structures. Most of the civil engineering structures, dynamic system identification of beams during service time is essentially important to be investigated. In case of the bridge structure failure, for instance, the beams are important structural elements that may cause overall instability of the bridge structure. With this regard, various studies have been conducted (Salawu, 1997; Doubling et al., 1998; Saleh, 2010). Monitoring of bridges and building based on vibration measurements are widely addressed in literatures such as an extensive overview is briefly described. Turner and Pretlove (1988) performed a numerical vibration analysis on a simple beam representation of a bridge subjected to random traffic loading. The authors stated that the measured response of a bridge to traffic appears to provide a method of determining resonant frequency. The motivation for the work was the development of a structural condition monitoring system that did not require a measured excitation force. Spyrakos *et al.* (1990) performed a series of experiments on a set of beams. Each beam was given different damage scenarios (type, location and degree), and low-level free vibration tests were performed. They found a definite correlation between the level of damage and the dynamic characteristics of the structure. Ren (2002) and Roeck (2002) experimentally developed a methodology of structural damage identification through changes in the dynamic characteristics. They used concrete beams stiffness for damage assessment and the proposed methodology relied on the fact that damage leads to changes in the dynamic properties of the structure such as natural frequencies and mode shapes.

Identification algorithms to minimize the experimental measurement errors, structure model errors, and the damage identification analysis errors have been important issue in most structural damage identification researches. Some researchers have investigated the damage-induced changes in natural frequencies, mode shapes, and curvature mode shapes with varying the location and severity of a damage. However, very few attentions have been given to the effects of the change of mode shapes, damage-induced coupling of vibration modes and the higher vibration modes omitted in the analysis on the accuracy of predicted vibration characteristics of the damaged beam, from a damage identification viewpoint.

The modal-data-based structural damage identification method (SDIM) has some shortcomings. First, the modal data can be contaminated by measurement errors as well as modal extraction errors because they are indirectly measured test data. Second, the completeness of modal data cannot be met in most practical cases because they often require a large number of sensors. On the other hand, using measured FRFs may have certain advantages over using modal data. First, the FRFs are less noise contaminated because they are directly measured from structures. Second, the FRFs can provide much more information about damage in a desired frequency range than modal data are extracted from a very limited number of FRF data around resonance (Ren, 2002). Thus, the use of FRFs seems to be very promising for structural damage identification. The purposes of the research are: to develop an FRF-based SDIM, to investigate effects of the mode shape changes on the accuracy of the predicted vibration characteristics of damaged plates, and finally to verify the feasibility of the present SDIM through some numerically simulated damage identification tests.

The damage of concrete structures reinforced both with prestressed wires or tendons and normal steel bars is a topic of interest for researchers and practitioners. Damage of prestressed reinforced concrete (PRC) and reinforced concrete (RC) beams can be affected by the result of insufficient reinforcement, large deflections, poor concrete quality, steel corrosion linked to environmental condition (Capozucca, 1995). Although a number of interesting experimental studies have been developed in recent years, the structural behavior of damaged reinforced concrete elements still needs to be fully investigated. Fruitful algorithms based on dynamic testing have been proposed to address the problem of locating and quantifying structural damage in both beams with homogeneous material and reinforced concrete beams using changes in the structure’s vibration characteristics (Cerri, 1997; Capozucca and Cerri, 2000; Capozucco, 2008, 2009). Frequency response data is directly measured through test data and can provide much more damage information in a desired frequency range, even if the experimental data obtained could be contaminated by measurement errors (Cawley, 1979; Pandey et al. 1991; Thyagarajan et al., 1998).

This paper reports on damaged RC beams experimentally investigated through dynamic testing in order to assess damage degree due to reinforcement corrosion or cracking correlated to loading. In terms of RC beams, the experimental program foresaw the analysis of the dynamic response of beams subjected to artificial crack at mid span subjected to static loading. As for RC beams, the comparison of response between two beams was developed considering the effects of increasing loading.

Dynamic investigation was carried out on both damaged and undamaged RC beams measuring natural frequencies and evaluating vibration mode shapes. The dynamic tests allowed recording frequency response variations at different modes of vibration as well as verifying that frequency values of natural vibration were reduced by damage due to cracking.

Description of Damage Detection Techniques

Natural Frequencies and FRFs

Rytter (1993) introduced a damage state classification system, which has been widely accepted by the community dealing with damage detection and Structural Health Monitoring (SHM). Generally, identification of the damage type and extent require prior knowledge of the structural behavior in the presence of each of the possible expected failure modes for future correlation with experimental data, which is normally achieved by resorting to analytical models. For example, in operational monitoring, the modal parameters of the damaged structure must be compared to the parameters of the structure in its undamaged state, in what is called global diagnostics.

Once damage existence is detected, the use of a model of the structure in a damaged state may be used to determine the damage location, in what is called local diagnosis (Uhl and Mendrok, 2004). Some difficulties may be encountered in the practical application of modal models, such as the knowledge of excitations and loads during machine operation, with several sources and with unknown distribution along the system. However, several output-only modal identification techniques can be found in the literature. Prognosis, which is traditionally related to fracture mechanics and fatigue, is starting to be brought up by the modal analysis community as a field of interest, as seen in Farrar et al. (2003).

The development of modal analysis techniques for damage detection and SHM resulted from the observation that changes in the structural properties has consequences on the natural frequencies. Nevertheless, the relatively low sensitivity of natural frequency to damage requires high levels of damage and measurements made with high accuracy in order to achieve reliable results. Moreover, the capacity to locate damage is slightly limited, as natural frequencies are global parameters and modes can only be associated with local responses at high frequencies.

Methods based on natural frequency shifts often fall into one of two categories: the forward and the inverse problem. The forward problem consists in determining what the natural frequency changes due to a known damage case (which may include its location, extension and type) will be. Typically, damage is modeled numerically and the natural frequencies are measured experimentally and compared to those related to each of the damage cases initially predicted. The inverse problem consists of determining damage parameters, such as crack length or location, from changes in the natural frequencies.

Mode Shape and FRFs Curvatures

Mode shape and FRFs curvatures are widely used as an alternative to damage identification from mode shape changes. Williams and Salawu (1994) evaluated the performance of some procedures for locating damage using mode shape curvature (MSC) and mode shape changes. The first method estimates the mode shape curvatures using a central difference approximation as proposed by Pandey et al. (1991):

$$v''_{jr} = \frac{\phi_{(j+1)r} - 2\phi_{jr} + \phi_{(j-1)r}}{h^2} \tag{1}$$

where h is the distance between the measurement co-ordinates and ϕ_{jr} are the modal displacements for mode shape r at the measurement co-ordinate j. Since a local reduction in stiffness results in a local increase in the curvature v, it is reasonable to suppose that these can be used to detect, locate and quantify damage. The second method studied by Salawu and Williams (1994) is based on the mode shape relative differences proposed by Fox (1992), in which a graphical comparison of displacement mode shapes is used to indicate damage position.

Ho and Ewins (2000) attempted to evaluate whether the presumption that damage is located at the point where the mode shape change is the greatest is valid using both simulated and experimental data, since the differentiation process enhances the experimental variations inherent to mode shapes. They addressed five methods based on mode shapes and their derivatives: flexibility index (FI), mode shape curvature (MSC), mode shape curvature square (MSCS), mode shape slope (MSS) and mode shape amplitude comparison (MSAC). If more than one mode is defined, it follows that:

$$FI_i = \sum_j |{}^d\phi_{ij}^2 - \phi_{ij}^2| \tag{2}$$

$$MSC_i = \sum_j |{}^d\phi''_{ij} - \phi''_{ij}| \tag{3}$$

$$MSCS_i = \sum_j |{}^d\phi''^2_{ij} - \phi''^2_{ij}| \tag{4}$$

$$MSS_i = \sum_j |{}^d\phi'^2_{ij} - \phi'^2_{ij}| \tag{5}$$

$$MS_i = \sum_j |{}^d\phi_{ij} - \phi_{ij}| \tag{6}$$

The last two methods correspond to equations (5) and (6) are presented by Ho and Ewins (2000). The first (5) corresponds to an attempt to introduce the mode shape deflection as a feature sensitive to damage but relatively insensitive to experimental variation. The second equation (6) has the advantage of not requiring the mode shape differentiation. In calculating the derivatives of mode shapes, instead of using finite difference approximation, polynomial functions are used: a local polynomial is fitted through every set of four consecutive measurement points and the resulting polynomial is differentiated. These authors conclude that the experimental results show that higher derivatives are more promising for damage identification, but that false damage indications may be observed at mode shape nodal points or where the quality of the measurements is relatively poor. It was also observed that this might also occur at the boundaries.

Battipede et al. (2001) extend the gapped-smoothing technique to bi-dimensional models or plate-like structures, showing that the method is able to locate single and multiple damage sites of medium and great extent. This technique, which had already been applied to one-dimensional models by Ratcliffe and Bagaria (1998) and Ratcliffe (2000), takes advantage of the presence of an irregularity in the curvature shape in order to detect damage. The displacement shape is converted into curvatures by applying a second order finite differentiation procedure:

$$C_{xx}(x_i, y_j) = \frac{Y(x_{i+1}, y_j) - 2Y(x_i, y_j) + Y(x_{i-1}, y_j)}{h_x^2} \tag{7}$$

in which $Y(x_i, y_j)$ is the measured displacement (perpendicular to the plate plane) and h_x is the uniform spatial separation of the measurement sensor grid along the x direction. The curvature along the y direction, C_{yy}, is evaluated similarly. In the absence of damage and other irregularities, the curvature has a smooth shape and can thus be represented as a polynomial function.

Experimental research on RC beams

Response comparisons of the results of the dynamic tests on damaged and undamaged RC beams were carried out in laboratory. Damage was due to cracks propagation obtained in the beam by incremental static loads. During the experimental research, four groups of beam with different confinement ratios were tested. The first group (1B, 1C, 1D, 1E) was consisted of four specimens and the rest three groups (2A, 2B, 3A, 3B, 4A, and 4B) were comprised two specimens only. The different types of beam specimens were chosen to represent the typical beams experienced in design, covering a range of design situations.

A mixed design of concrete was carefully computed based on the method of Australian Concrete Technology. Based on the calculation, the required materials for each cubic meter of concrete were consisted of 16.4 % cement, 36.5 % sand, 36.5 % broken stone with roughly diameter of 14 mm, and 10.6 % water, respectively. After testing, the compressive strengths of concrete (f_c') was averaged ranging from 33.30 to 45.6 MPa and were used for entire beam specimens. In this research, all typical beam specimens were strengthened with reinforcing bars consisting of longitudinal reinforcements and stirrups. Tensile yield stresses of reinforcing bar (f_y) were 500 and 260 MPa for diameter 10 mm (R10) and 6 mm (R6), respectively. Two pairs of longitudinal reinforcements with the diameter of 10 mm were placed at the top and bottom beam for the flexural resistance. Whilst, the shear reinforcements with diameter of 6 mm were used in all three typical beam specimens having a variety of stirrup pitches ranging from 60 to 150 mm.

Dynamic tests developed with the same procedure were carried out on the ten RC beams measuring 1.20 m in length (1.00 m in span) and with a rectangular section measuring 100x150mm^2. 1B, 1C, 1D, and 1E beams were reinforced with four longitudinal steel bars with a diameter of 10mm without stirrups. The flexural reinforcements used in the first specimen model was extended to other three groups by disposing 6mm diameter of stirrup with varying pitches of 133, 100, and 67 mm, respectively (Figure 1). The stirrups were positioned along L_1 = 400 mm length from the support. The RC beams were subjected to monotonic load, P, at two points (11 and 15) at midspan (Figure 2). The bending test foresaw that the mid zone section of beam was to be subjected only to bending moment. Damage degrees were then correlated to bending values.

The test beam was applied to static two-point bending tests to introduce crack-damage in a controlled way (Figure 3). The loading steps were incrementally performed on a universal testing machine by controlling the displacement. The static load was applied to the beam specimen until the ultimate load was reached. Since the beam length was larger than the width of the testing bench, the beam had to be mounted orthogonal to the plane of the machine. The middle section of the test beam was instrumented with a dial gauge at midspan to measure the vertical deflection. Each beam was applied to a static load step, which was gradually increased to reach the ultimate load. The loading scheme on each beam (Figure 3) was ranged between 5 to 10 steps depending on the confinement ratio used. The load step was recorded from the beginning up to failure occurred in order to measure the deflection value and crack propagation.

A modal test utilizing a dual channel signal analyzer and other devices was setup to collect frequency response functions (FRFs) at each specified node. During the dynamic test, the Imperial College Analysis & Testing Software (ICATS) was carried out. A feature of the software so called Modacq program was used in the data acquisition from IEEE (Institute of Electrical and Electronics Engineers) interface analyzers, sine sweep with frequency response analyzers. Another program so called Modent was carried out to extract the modal parameters from measured data while the corresponding predictions could be obtained using the finite element package. The dynamic test was firstly undertaken on each undamaged beam and continued to record the FRFs data after completing each step of static loading.

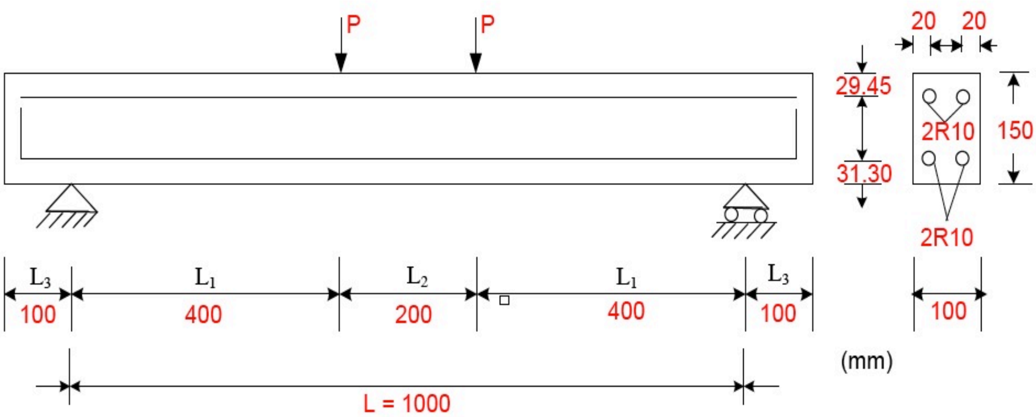


Figure 1. Typical RC Beam Specimens

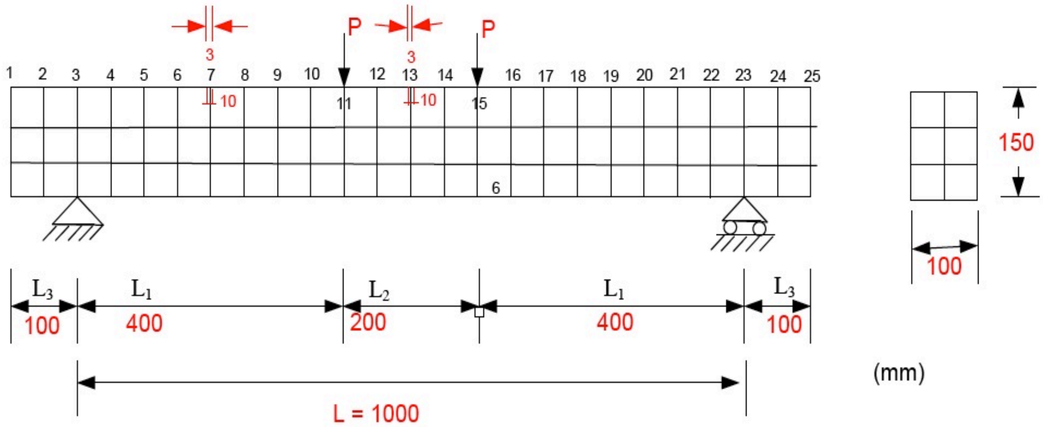


Figure 2. Discretization of RC Beam Specimen

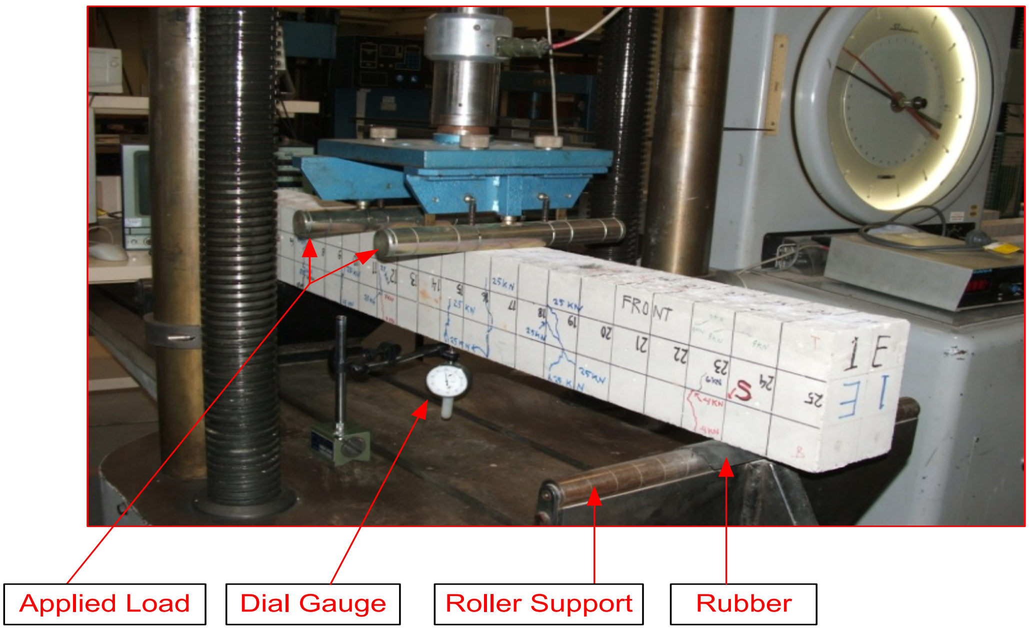


Figure 3. Static loading scheme for the beam specimens

Results and Discussion

Load-displacement Response

It has been clearly described that four beams type 1 were reinforced with four longitudinal reinforcing bars without confining with stirrups mounted along the beam length. Whilst other beams were similarly used four flexural reinforcements and confined with varying stirrup pitches disposed along specified length, L_1. Whilst at midspan L_2 was simply applied to minimum confinement ratio. During the test, applied load, vertical deflection, and crack propagation were consistently recorded.

Load-displacement responses of two different beam specimens (type 1C and 2A) as depicted in Figure 4 extremely show how the experimental model works. It is observed that beam type 1C with no stirrups provides inadequate strength compared to the beam type 2A with stirrup pitch of 150mm. This beam likely presents a brittle structural element showing that small vertical deflection and less ultimate load were achieved. In contrast, the beam type 2A presents higher load-displacement response resulting better strength and greater displacement ductility to withstand the applied static loads. It can be concluded that the displacement, applied load, and strength of beam type 1C are approximately 40% lesser than the beam type 2A due to the effect of confinement ratio and different compressive strength of concrete.

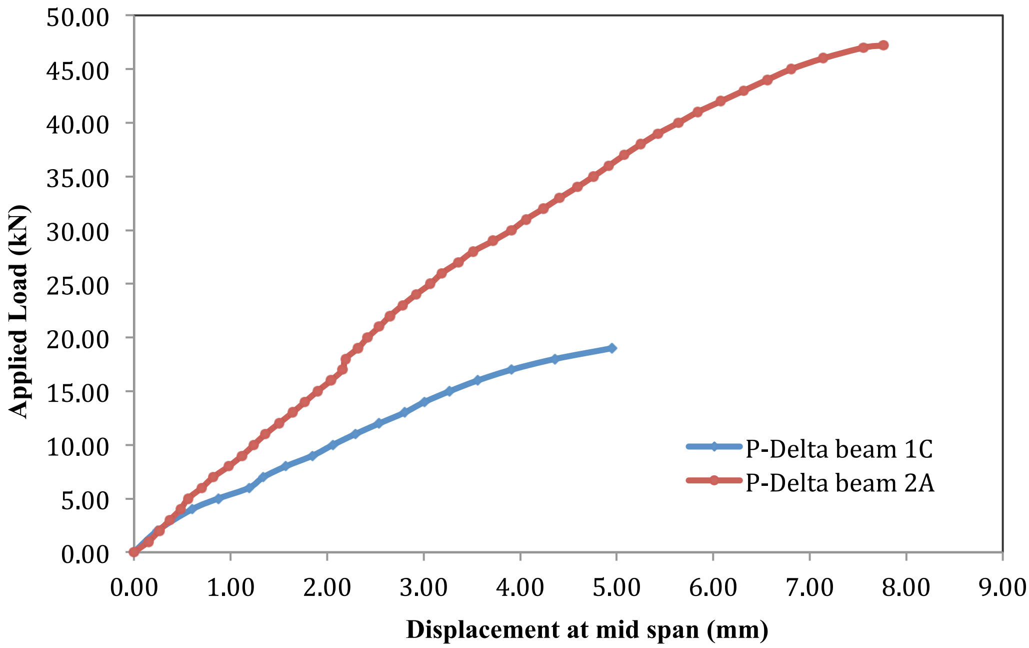


Figure 4. Load-displacement response for beam types 1C and 2A

Damage Scenario

Figure 5 shows the incremental static loads develop cracks damage progressively. Vertical small cracks associated with flexural cracks initially propagated at mid points along L_2 and continuously spread out at the tensile fiber concrete. When the applied load increased step-by-step, flexural cracks in combination with shear cracks were experienced along L_1. At the final stage of loading, long-line diagonal wide-cracks were dominated by shear force occurring at nearby both supports across the points loaded. Although the concrete contributes to resist small shear force, however the beam seriously suffers shear and flexural cracks damage.

It has been mentioned previously that the data processing of frequency response functions for all specimens was recorded at each applied load increased. The FRFs data collection was consistently conducted until maximum static load achieved. The dynamic impact loading was accomplished by hitting the hummer on the top specimen in the transversal direction. The resulted vibration signal was recorded with ICATS, and was subsequently analyzed by carrying out the program of ICATS developed by Jimin He (1997). The natural frequencies were based on the maximum natural frequency at node where the accelerometer was put in the same place with the applied impact load using the hummer. The captured FRFs data presents the best FRF signal at every applied static loads step. After extracting all FRFs, it has been found that the third mode shape is always the most sensitive to the damage due to the maximum natural frequency appear at the mode shape number three, except in the damage case of beam 1D where the fifteenth mode shapes show better identified failures. The rest problem was most likely affected by bad FRF data capturing. Whilst other maximum natural frequencies appear at modes 2, 4, 5 and 6, and this is still in normal condition. In addition, the maximum natural frequency at every applied load was recorded to prove that every static load increased the maximum natural frequency decreased and the damage developed from small to largest damages. In other words, only at the maximum natural frequency relating to mode shape number three could accurately detect the presence of damage due to the maximum natural frequency and maximum energy (E, σ or Amplitude). Based on the FRF curve approach, when the beam damage progressively succeeded the beam stiffness severely reduced resulting the residual strength remains very small.

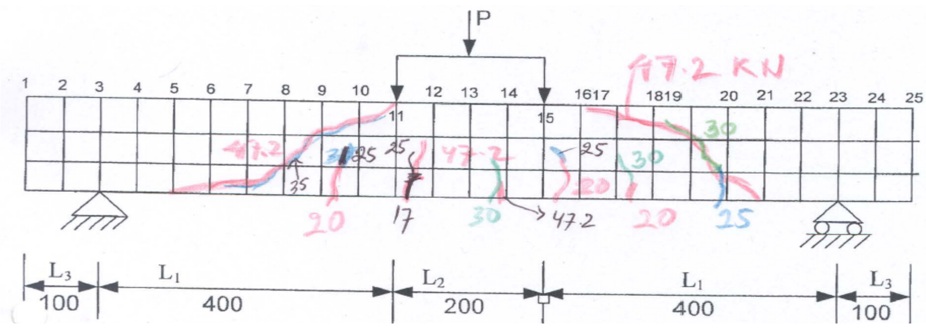


Figure 5. Crack propagation on beam 2A due to ultimate static loads

Damage Detection

It is obvious that a dynamic test of reinforced concrete is a complicated process with regard to measure frequency response functions in detecting structural damage. All the four natural frequencies are identified, however, in reality, the number of measured natural frequencies is always less than that of the unknown stiffness. Thus, in this study, the results for damage identification using only the changes of the first two natural frequencies were obtained and compared with those using all the three natural frequencies for the four damage scenarios.

As an example, Figure 6 shows a two dimensional plot at node 13 between magnitude FRF and frequency. Utilizing the method of FRF-MSCS difference, at frequency 734 Hz produced maximum magnitude FRF of 0.1104 m/N-s^2. Figure 6 depicts the results of damage detection for scenarios 1 (first highest frequency) and 2 (second highest frequency) where severity damage possibly occurs. Potential damage of the beam type 2A subjected to 4 kN applied static load, for instance, could be identified at the maximum frequency of 734 Hz. Based on this frequency, the damage location could be accurately figured out. Analogous procedures for other applied static loads; damage locations at each load could be plotted together as presented in two-dimensional representation (Figure 7). It can be noted from this figure that the locations of damage were occurred at mid span and nearby both supports. Using the same procedure, numerical computations were carried out by developed Matlab program resulting the damage location in three-dimensional representation as shown in Figure 8. It is obvious that the accurate results consistently present the same locations as predicted using different technique.

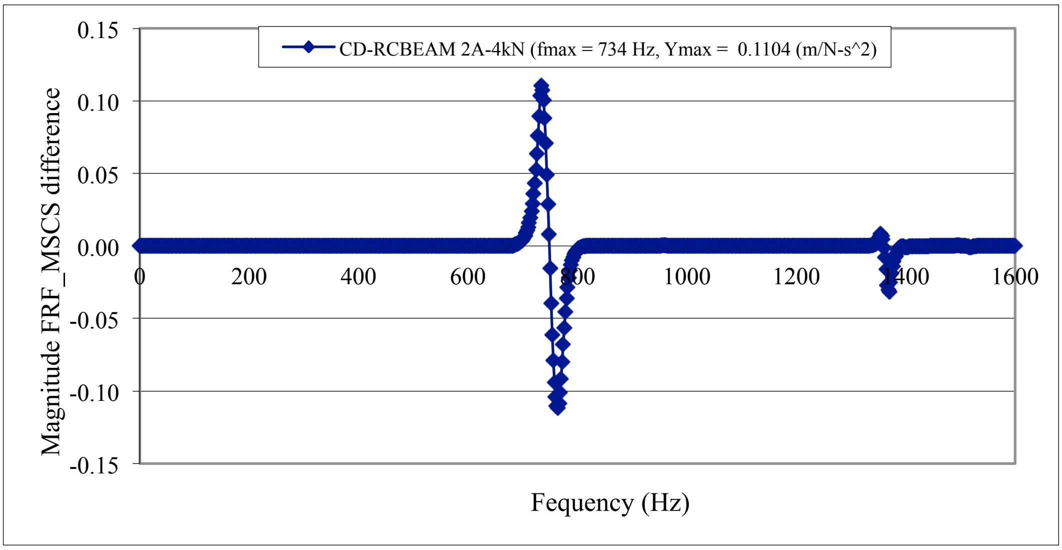


Figure 6. Relationship between magnitude FRF MSCS difference and frequency

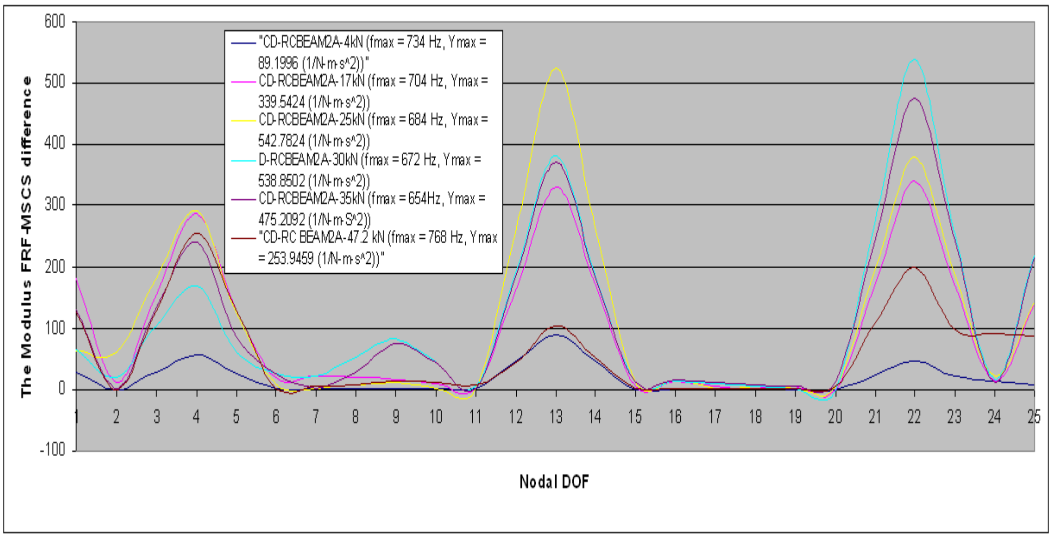


Figure 7. Damage locations on beam type 2A in 2D representation

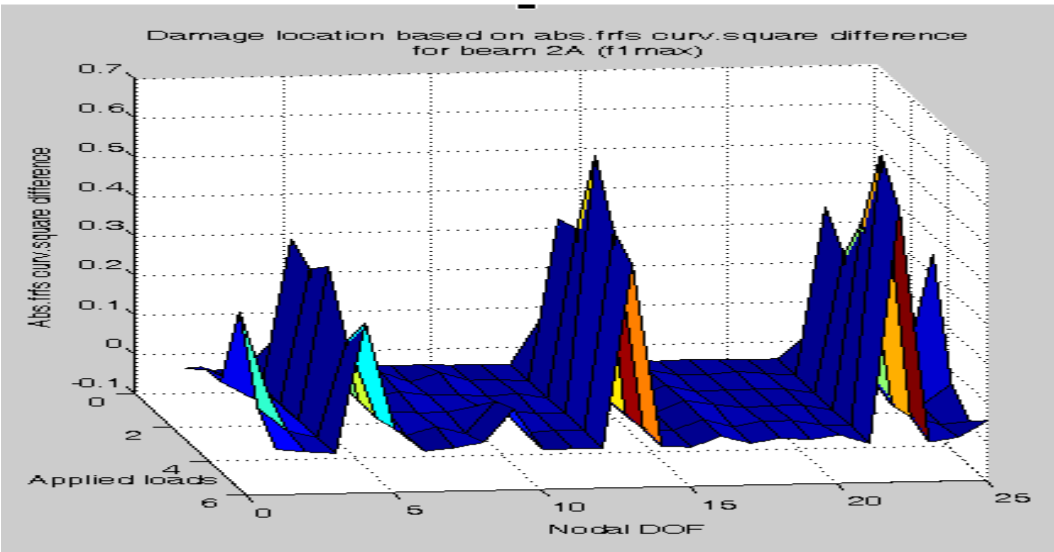


Figure 8. Damage location in 3D representation

Concluding Remarks

There are five common methods based on their mode shapes and derivatives consisting of flexibility index (FI), mode shape curvature (MSC), mode shape curvature square (MSCS), mode shape slope (MSS) and mode shape amplitude comparison (MSAC). This paper exploited the possibility to detect the damage of reinforced concrete beam structures by using only the changes of frequency measurements. A method used, namely, FRF-MSCS method was adopted to identify the magnitude and location of light and severe damages at one or more sites. It is obvious that the experimental test results on ten RC beam specimens show that the location of damage can be accurately identified by the method utilizing measured natural frequencies but the degree of accuracy for damage size detection depends on the used method. This method demonstrates that the accurate damage localization can be realized by using natural frequencies with a limited amount, and identification of the magnitude of damage can be achieved with a relatively high degree of accuracy if an appropriate method is adopted.

The results indicate that secant flexural stiffness of beam decreases with increasing static point load and therefore with increasing degree of cracking. The natural frequency of beam mostly decrease and its maximum amplitude of vibration increase with increasing eccentric mass and therefore with increasing dynamic load. The results indicate that maximum amplitude of vibration, bending stiffness and natural frequency of beam decrease and damping ratio increases with increasing degree of cracking.

Acknowledgement

The author would like to express her gratitude to A/Prof. Sam Fragomeni, Dr. Danh Tran, and A/Prof. Micahel Sek who have encouraged her and spent their valuable time to discuss her PhD research project at the School of Engineering and Science, Faculty of Health, Engineering and Science, Victoria University, Australia.

References

Battipede, M., Ruotolo, R. and Surace, C. (2001). "Damage Detection of Plate-like Structures", In *Proceedings of the 4th International Conference on Damage Assessment of Structures (DAMAS 2001)*, Cardiff Wales, UK, 27–34.

Capozucca, R. (1995). "Damage to reinforced concrete due to reinforcement corrosion", *Construction and Building Materials*, Vol. 9 (5), pp. 295-303.

Capozucca, R, Cerri, M. N. (2000). "Identification of damage in reinforced concrete beams subjected to corrosion", *ACI Structural Journal*, Vol. 97 (6), pp. 902-909.

Capozucca, R. (2008). "Detection of damage due to corrosion in prestressed RC beams by static and dynamic tests", *Construction and Building Materials*, Vol. 22, pp. 738-746.

Capozucca, R. (2009). "Static and dynamic response of damaged RC beams strengthened with NSM CFRP rods", *Composite Structures*, Vol. 91, pp. 237-248.

Casas J.R., Aparicio A.C. (1994). "Structural damage identification from dynamic - test data", *Journal of Structural Engineering,* Vol. 120 (8), pp. 2437-2450.

Cawley, P., Adams, R. D. (1979). "The location of defects in structures from measurements of natural frequencies", *J. Strain Anal. Engineering,* Vol. 14, pp. 49-57.

Cerri, M. N. (1997). Analysis of damage in vibrating beams: Direct and inverse problems. *PhD Thesis*, University of Rome "La Sapienza", (in Italian).

Daneshjoo, F., and Karimi, Y. (2000). "Investigation of Influence of Increasing Crack in dynamic behavior of Concrete Beams", *3rd International Conference on Concrete, Amirkabir University*, Tehran, Iran.

Doebling, S., Farrar, C., and Prime, M. (1998). "A Summery review of vibration-based damage identification methods", *Shock and Vibration Digest,* 30 (2), pp. 91–105.

Esfandiari, A. (2011). "Structural Damage Identification of Plate Structures based on Frequency Response Function and Natural Frequencies", *Journal of Structural Engineering and Geotechnics*, Vol. 1 No. 2, pp. 11-15.

Farrar, C. R., Sohn, H., Hemez, F. M., Anderson, M. C., Bement, M. T., Cornwell, P. J., Doebling, S. W., Lieven, N., Robertson, A. N. and Schultze, J. F. (2003). "Damage Prognosis: Current Status and Future Needs", Los Alamos National Laboratory, USA.

Fox, C. H. J. (1992). "The Location of Defects in Structures: A Comparison of the Use of Natural Frequency and Mode Shape Data", *Proceedings of the 10th International Modal Analysis Conference,* San Diego, California, Vol. 1, pp. 522-528.

Hi, Jimin (1997). The Imperial College Analysis & Testing Software (ICATS), Victoria University of Technology, Australia.

Ho, Y. K. and Ewins, D. J. (2000). "On Structural Damage Identification with Mode Shapes", *Proceedings of COST F3 Conference on System Identification and Health Monitoring,* Madrid, Spain, pp. 677-686.

Ndambi Mulambula J. M. (2002). "Damage assessment in reinforced concrete beams by damping analysis", *Ph.D. thesis*, Vrije University, Brussel, Belgium.

Pandey, A. K., Biswas, M., Samman, M. M. (1991). "Damage detection from changes in curvature mode shapes", *J. Sound Vib*., Vol. 145 (2), pp. 321-332.

Ren, W. X., and De Roeck, G. (2002). "Structural damage identification using modal data. I: Simulation Verification", *J. Struct. Eng.,* Vol. 128 (1), pp. 87-95.

Ren, W. X., and De Roeck, G. (2002). "Structural damage identification using modal data. II: Test Verification", *J. Struct. Eng.,* Vol. 128 (1), pp. 96-104.

Ratcliffe, C. P. (2000). “A Frequency and Curvature based Experimental Method for Locating Damage in Structures”, *Journal of Vibration and Acoustics*, Vol. 122, 324–329.

Ratcliffe, C. P. and Bagaria, W. J. (1998). “A Vibration Technique for Locating Delamination in a Composite Beam”, *AIAA Journal*, Vol. 36, 1074–1077.

Rytter, A. (1993). “Vibration based inspection of civil engineering structures,” *Ph. D. Dissertation*, Department of Building Technology and Structural Engineering, Aalborg University, Denmark.

Saleh, Fadillawaty (2010). “Curvature Mode Shape Changes to Detect Crack Damage in Non-Prismatic Reinforced Concrete Beams”, *Journal of Civil Engineering Dynamics (Dinamika Teknik Sipil),* Vol. 10, No. 3, pp. 273-279.

Salane H.J., Baldwin J.W. (1990). "Identification of modal properties of bridges", *Journal of Structural Engineering,* Vol. 116 (7), pp. 2008-2021.

Salawu, O. S. (1997). “Detection of Structural Damage through Changes in Frequency: A Review”, *Engineering Structures,* Vol. 19, No. 9, pp. 718-723.

Salawu, O. S. and Williams C, (1994), “Damage Location Using Mode Shapes,” *In proc. of 12th International Modal Analysis Conference*, pp. 933 – 939.

Spyrakos, C., H.L. Chen, J. Stephens, and V. Govidaraj (1990). "Evaluating Structural Deterioration Using Dynamic Response Characterization", *Proc. Intelligent Structures, Elsevier Applied Science*, pp. 137–154.

Thyagarajan, S. K., Schulz, M. J., Pai, P. F. (1998). “Detecting structural damage using frequency response functions”, *J. Sound Vib.,* Vol. 210, pp. 162-170.

Turner, J.D. and A.J. Pretlove (1988). "A Study of the Spectrum of Traffic-Induced Bridge Vibration", *Journal of Sound and Vibration,* 122, pp. 31–42.

Uhl, T. and Mendrok, K. (2004). “Overview of Modal Model based Damage Detection Methods”, In *Proceedings of the International Conference on Noise and Vibration Engineering (ISMA 2004)*, Leuven, Belgium, pp. 361–375.

Williams, C., Salawu, O.S. (1997). "Damping as a damage indication parameter", *Proceedings of 15th International Modal Analysis Conference, Orlando, FL, USA,* pp. 1531-1536.

Coping with Disaster in Urban Areas (Monitoring and Evaluation of the Implementation of the Disaster Management System In Indonesia)

H. Sarwidi[1]

Senior Professor at The Faculty of Civil Engineering and Planing,

The Islamic University of Indonesia (UII)

Email: sarwidi@uii.ac.id, sarwidi@yahoo.com

Abstract

It is very essential that urban and other human settlement areas must cope with disaster in order they become livable. The way to do that is to anticipate, alleviate, or reduce the disaster impacts. Urban areas generally have more complicated problems because of their people density.

Existing provisions of regulations of law concerning disaster management in Indonesia before 2007 was not sufficient yet to serve as a strong and overarching legal base and is ill-suited to emerging context of the people and needs of Indonesia's nation. Therefore, in 2007 Indonesia have enacted its management disaster law, called UURI No. 24/2007. The law mentions the base and the principle along with the system of disaster management in Indonesia.

In the implementation of the disaster management system, UURI No24/2007 has been accompanied by a series of related regulations, including the law of the establishment of the National Agency for Disaster Management (BNPB). BNPB is the government institution in the level of ministerial that primarily deals with disaster management implementation in the national level in Indonesia. BNPB comprises of steering and executing components.

A series of monitoring and evaluation (Monev) activities of the implementation of the disaster management law needs to be conducted to improve disaster management in Indonesia continuously. The paper reveals some results of the Monev activities by the Steering Component of BNPB. This paper will be more emphasized in the related issues of urban areas and natural disaster risk reduction.

Keywords: disaster management, disaster risk reduction, natural disaster, urban, city

BACKGROUND

Many kinds of natural hazard sources are found in Indonesia in high intensity and frequency. Therefore, the country is included in the countries that have high risk in natural disaster. There were huge natural disasters as well as a series of small scale natural 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 natural disaster in the 21st century started from Indonesia, which were the 2004 Aceh Earthquake and Tsunami. The disaster killed more than 200 thousand people and destroyed shores of 11 countries. Many kinds of other 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 has enacted the Law No 24/2007 (UURI No. 24/2007) concerning Disaster Management in Indonesia, sequencing by the establishment of **BNPB** (*Badan Nasional Penanggulangan Bencana* / National Agency for Disaster Management / National Disaster Management Agency) by the Presidential Regulation No. 8/2008. BNPB is a non-departmental body that is equal to a ministry. BNPB is responsible in the disaster management in the national level of Indonesia. BNPB comprises of steering and executing components.

In the implementation of the disaster management system, UURI No24/2007 has been accompanied by a series of related regulations as the formal written policies. A series of monitoring and evaluation (Monev) activities of the implementation of the disaster management law needs to be conducted to improve disaster management in Indonesia continuously. The paper reveals some results of the Monev activities by the Steering Component of BNPB. This paper will be more emphasized in the related issues of urban areas and natural disaster risk reduction.

THE EXPECTATION OF DISATER MANAGEMENT IN INDONESIA

Following short explanation is the expectation of disaster management in Indonesia based on Law No 24/2007 about Disaster Management in Indonesia and related regulations that includes disaster management paradigm, system, strategy, approach, and for urban areas (BNPB, 2009; BNPB, 2011; Carter, 1991; ECLAC, 2003; Indonesian Law No 24/2007; Indonesian President Regulation No 08/2008; Sarwidi, 2010; Sarwidi, 2011; Twig, 2004).

Paradigm

Before Law No 24/2007, the paradigm of disaster management in Indonesia was performed in the forms of incidental activities, more focused on the emergency response, and was done by sectors separately. The law directs to the disaster management that shall be performed in forms of comprehensive activities, more anticipative, and done by integrated coordination of sectors. The comparison between old paradigm and new paradigm in the disaster management can be seen in Figure 1. Comprehensive disaster management included three phases as seen in Figure 2.

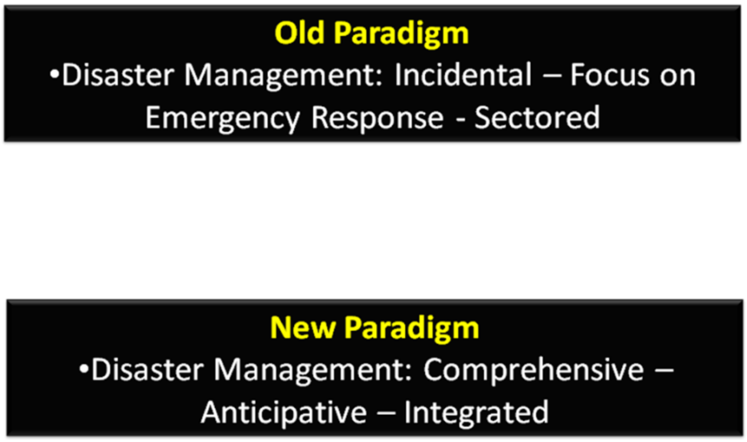


Figure 1. “Old and New” Paradigm in Disaster management

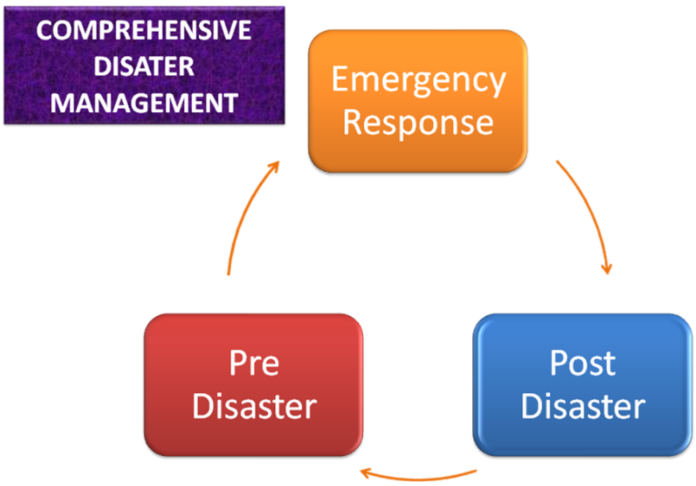


Figure 2. Comprehensive disaster management cycle consists of 3 steps: Pre Disaster, Emergency Response, and Post Disaster

Disaster Management System

The disaster management in Indonesia was done by persons or institutions stronger than by system. After enacting the Law No 24/2007, disaster management shall be lead by the system. Disaster management system in Indonesia has 6 components, namely, legislation, institution, planning, budgeting, science and technology and implementation, as shown in Figure 3.

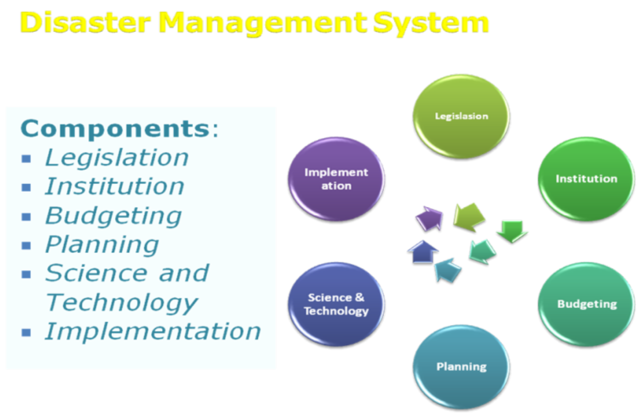


Figure 3. Components of disaster management system

Disaster Management Strategy

Disaster management strategy is not explicitly stated in the law. Later, after applying disaster management system several years, practices in the disaster fields lead to a disaster management strategy, although it is still in the form of informal conformity.

Disaster Management Approach using DRR Approach

Disaster management approach is not obviously stated in the Law No 24/2007. Later, disaster management approach in the field lead to disaster management approach using disaster risk reduction (DRR), although it is still in the form of informal decision. It has been widely accepted in Indonesia that performing disaster management utilizes DRR approach. Although there are variety definitions, a simple and general accepted disaster risk is the product of hazard and vulnerability divided by capacity.

Urban Disaster Management

Cities and other urban areas are different from rural areas, mainly lead by their inhabitant density. In cities, many people live in very limited areas. Consequently, the behavior and social condition of city inhabitants is different from the rural one, such as the type of occupation and social norms. Moreover, cities are not as flexible as rural area in managing the land by having limited space. This requires many different characteristics in coping with disaster between urban and rural areas.

FINDINGS AND ANALYSIS

Following short explanation is the findings from the activities of monitoring and evaluation of disaster management implementation in Indonesia after enacting on Law No 24/2007 by the Steering Component of BNPB to disaster locations in many provinces and regent/municipal in Indonesia (Maliki et. al., 2011; Sarwidi, 2011). Analysis is made, and it is based on the findings.

Paradigm

New paradigm in disaster management step by step is performed in Indonesia. BNPB personals are much easier to apply and they make a big progress on it. Such progress has not been automatically applied to staffs of Regional Disaster Management Agency (BPBD), since disaster management system in Indonesia is relatively young. Therefore, it requires time to propagate. BNPB has regional coordination partners in the level of province and regent/city, called Provincial BPBD and Regent/Municipal BPBD. Provincial BPBDs and Regent/Municipal BPBDs are forming step by step subsequent the establishment of BNPB. Even, some regencies and municipalities have not established BPBD yet. Many BPBD bureaucrats seem to be more difficult to change their old paradigm to the new one comparing to academic society and non government organization (NGO) members. This guides future priority in the effort of the changing paradigm of officials.

Incidental activities in disaster management are still stronger in urban, especially in remote areas. While, systemic activities in disaster management are more appear in cities and easily accessed locations. Although do not sufficient portion in the pre disaster activities, the implementation of disaster management has been not only in the emergency response. Post disaster activities tend to be run sufficiently even if it still has many obstacles.

Sectors in ministries and institutions are still dominant to carry out disaster independently. Coordination is still easier to be discuses than to be implemented due to insufficient knowledge in the disaster management law. It is needed to socialize the content of disaster management law to many parties.

Disaster Management System

In the component of legislation, it is still needed more regulations to support more aspects in disaster management, such as the status and level of disaster and settlement fire. The status and level of disaster regulation need to be formulated, because the regulation will lead more easily to handle the disasters. The settlement fires are going to increase, especially in urban areas, while the disasters are not clearly stated in the law. There are several disaster management regulations that are not congruent each other that make disaster management implementation more complicated. The regulations are not only by BNPB/BPBD but also have already come from other ministries and bodies.

In the component of institution, all provinces have had BPBD since last year. However, some regencies and cities have not formed BPBD. More over, if they do, their BPBD resources are generally very limited. This creates disaster management coordination in the plan and the field implementation harder. In the disaster management law, BPBD consists of steering component and executive component. They have their own duties. Recently, almost all BPBDs do not have steering component. Therefore, part of the disaster management mission is lost. This makes disaster management implementation neither effective nor efficient.

In the phase of planning as well as field implementation, coordination is still easier to discuss than to execute. This is caused by the mindset of many bureaucrats and community actors that prefer to act simple independently than interactive integrally. Since it is still not easy to reach optimum integrative disaster management planning, many planning revisions need to be made in the disaster management execution in the fields. Ocassionally, this will generate more problems than solutions.

It the component of budgeting, many officers and community actors still think that disaster management/DRR activities are more budget consumption than investment for better future. This makes sufficient budget in disaster management difficult to be fulfilled, either nationally or regionally. Moreover, it is difficult to integrate private sector budget in the official disaster management budget. Private and community usually feel easier to collect and distribute their fund independently. This will make the implementation of disaster management not comprehensively.

In the component of science and technology, its application in the disaster management is usually easier in urban area. This happens since urban inhabitants are usually more rational than rural inhabitants. The difficulty in the application of science and technology to cope with disaster in rural and remotes areas is stronger in the society having strong myths. This condition needs appropriate arts.

In the component of disaster management implementation, many still focus more on emergency response phase, and recently it is also in post disaster phase. However, pre disaster activities have not been in proper portion to be considered, especially by other ministries and agencies. Many relevant bureaucrats are still resistant to mass media and to NGO. They are also not so ready to be transparency. City bureaucrats are usually ready more for transparency in the implementation of disaster management that rural ones. Mass media need to work harder to access data and to educate rural inhabitants.

Disaster Management Strategy

Recently, the implementation of disaster management leads to a strategy, although it is still in informal forms. That disaster management strategy is as seen in Figure 4:

1. putting settlements far from disaster hazard sources,
2. making hazard sources far from settlements, and/or
3. inhabitants living in harmony with disasters.

Figure 4: General disaster management strategy

That disaster strategy will be mentioned in following DRR approach and urban disaster management.

DRR Approach

When disaster management strategy a disaster location is very difficult to be implemented for the first and second (Figure 4), the third strategy shall be applied. If this happens, disaster risk reduction (DRR) efforts must stick firmly in the process of both national and regional development (Figure 5).

In national and provincial levels, DRR planning has been already integrated in the development planning. National Development Planning Agency (Bappenas) has coordinated BNPB and other ministries and agencies as well as from the national community forum of disaster (Planas) to set disaster management planning consensus and to integrate to the national development planning.

Most of Regional Development Planning Agency (Bappeda) in the level of province has also coordinated provincial BPBD and other regional government units and agencies as well as the provincial community forum of disaster (FPRB) to set disaster management planning consensus and to integrate to the provincial development planning.

Only view regent/municipal BPBDs has done as intensive as provincial BPBDs in DRR effort. This causes by relatively young regent/municipal BPBDs, even, several regent/municipal BPBDs have not been established. Young BPBDs mean that they have very limited resources to perform disaster management comprehensively. This forces them to focus more on emergency response. The regents/municipals that have not had BPBD still perform old paradigm in disaster management.

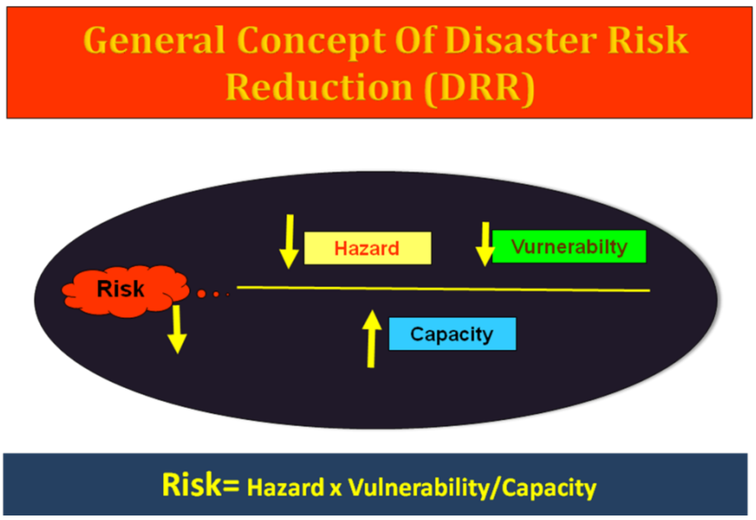


Figure 5: General concept of disaster risk

Urban Disaster Management

This paper focuses on natural disaster issues, and the following discussion is the comparison implementation of disaster management applied to urban and rural areas. Up to now, there is still no obvious different implementation of disaster management for urban areas and non-urban areas. Most applicable disaster management strategy is illustrated in Figure 6.

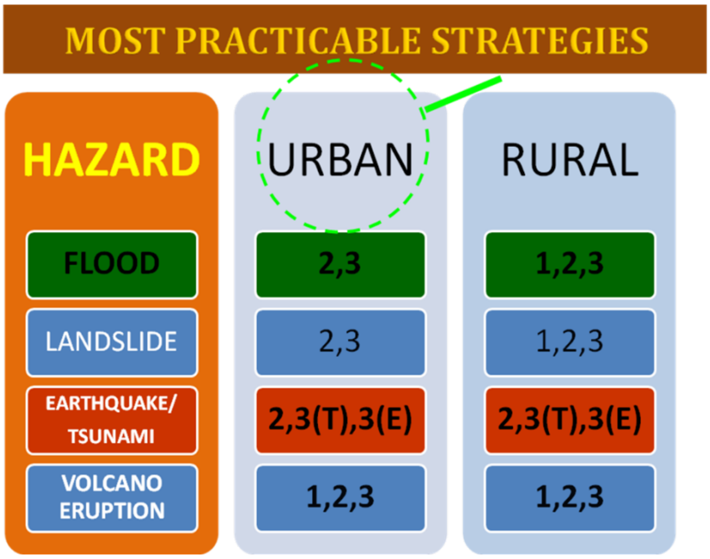


Figure 5: Applicable disaster management strategy for cities and other urban settlement.
see Figure 4 for the meaning of numbers 1, 2, and 3.

Figure 5 shows that it is generally easier to apply the first disaster management strategy, which is relocation, in rural areas. In the case of earthquake DRR (E), there is almost impossible to perform the first and second strategy. Therefore, the integrated earthquake DRR must stick firmly.

CONCLUSIONS AND RECOMMENDATION

Short conclusions and recommendation are followed.

1. **Paradigm**
   Old paradigm in disaster management is generally still dominant for officers as well as community actors. However, information technology will give much help to propagate new paradigm faster.
2. **Disaster Management System.**
   Step by step the system leads in disaster management. Development process in the disaster management will help the system stronger.
3. **Disaster Management Strategy.**
   Disaster management strategy has been found. The strategy needs to be tested in following implementations of disaster management.
4. **DRR**
   Disaster management implementation using DRR approach are accepted more widely from time to time, especially now in the planning phase. DRR concept shall be propagated faster through mass media.

5. **Disaster Management in Urban Areas.**
   Since their population density is high, a city disaster could be more fatal than a rural one for the same scale of a hazard. Therefore, application of DRR in disaster management for urban areas should be prioritized.

ACKNOWLEDGEMENT

The author thanks to the committee of 2nd ICSBE (International Conference on Sustainable Built Environment) and the Faculty of Civil Engineering and Planning for providing this excellent opportunity to present and share the knowledge and experience in this event. Data and experiences have been obtained through the teams of The National Agency for Disaster Management (BNPB) and the Islamic University of Indonesia (UII). Author also thanks to the team members. The help from BNPB, BPBDs, CEEDEDS UII and CEVEDS International, in helping to prepare the presentation materials is appreciated.

REFERENCES

BNPB (2009). "Rencana Nasional Penanggulangan Bencana (National Plan of Disaster Management)," National Agency for Disaster Management (Badan Nasional Penanggulangan Bencana, BNPB), Jakarta, Indonesia (Indonesian).

Carter, N. K. (1991). "Disaster Management: A Disaster Manager's Handbook," Asian Development Bank (ADB), Manila.

ECLAC (2003). "Handbook for Estimating the Socio-economic and Environmental Effects of Disasters," United Nations, Economic Commission for Latin America and the Caribbean (ECLAC) and International Bank for Reconstruction and Development (The World Bank).

Indonesian Law No 24/2007 concerning the Disaster Management in Indonesia (Indonesian).
Indonesian President Regulation No 08/2008 concerning The National Agency for Disaster Management (BNPB) (Indonesian).

Maliki, Z, Sarwidi, A. Prasetyo, D. E. B. Santoso, Tabrani, N. Kandun, Sudibyakto, Y. Reksoprodjo, S. Pranoto (2011). "Track Record Book of Steering Components of BNPB."

Sarwidi (2010). "National Plan of Disaster Management," The First Internationa1Conference on Sustainable Built Environment (1st ICSBE), 27 March 2012, UII, Yogyakarta.

Sarwidi (2011). "The Management Of Merapi Volcano Disaster Based On The National Disaster Management System," National Seminar on Merapi Volcano, 8 March 2011, UII, Yogyakarta.

Twigg, J. (2004). "Disaster Risk Reduction / Good Practice Review: Mitigation and Preparedness in Development and Emergency Programming," Humanitarian Practice Network (HPN), London.

Fire Resistance Performance of Profiled Steel Sheeting Dry Board Floor System with Concrete Infill

Harsoyo bin Muhammad Shodiq

Department Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Abstract

The Profiled Steel Sheeting Dry Board (PSSDB) system is a lightweight composite structural system constructed from profiled steel sheeting and dry board connected by self-drilling and self-tapping screws. All these materials are found in local market. The PSSDB system has been applied as flooring, walling and roofing panels in buildings. The objective of this research is to study methods of enhancing the fire resistance performances of the PSDDB floor system focusing on the influence of concrete infill on the system's behaviour. The fire resistance test results obtained from small-scale furnace have provided important data that has enabled prediction of fire resistance performance of floors with various spans and loadings to be developed theoretically. It has been proven experimentally that concrete as an infill material can increase the performance of the floor system compared to the original system without any infill material. Results found that with the use of concrete infill, the fire resistance of the PSSDB system with concrete infill improved with the resistance against fire by more than two hours compared with only one hour for the PSSDB system without any infill material. Although the research was conducted on specific proprietary profiled steel sheeting, dry board, connectors and infill material, the principles applied are completely general in nature and can be exploited to any PSSDB floor system of different of different properties.

Keywords: *Profile seating, dry board, self-drilling and self-tapping screw, concrete infill, fire resistance*

Introduction

Studies on the behaviour of the Profiled Steel Sheeting Dry Board (PSSDB) system as floor panel system with concrete infill have been conducted and reported in earlier publications (Harsoyo 2004, Shodiq, H.M 2010). 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 concrete infilling the normally voided PSSDB floor panels with infill materials in the trough of the profiled steel sheeting, when it exposes to fire.

At the recent fire happens everywhere much as we in the media either on TV or in newspapers. as big fires have occurred in the USA as in the state of Colorado, California and others. Therefore, the selection of building materials that are resistant to fire it is necessary to avoid casualties in the fire. An example of wildfire is the fire in Colorado (2012), as shown in figure 1.

Figure 1. Homes destroyed by the Waldo Canyon fire (www.latimes.com)

As the structure of the floor, the system needs to know for sure PSSDB behavior under the influence of fire. As usual, the design goal is to prioritize the safety of building users. Building safety includes the safety of the dead load, live load and impact of fire. Buildings must be able to withstand the dead load and live load without causing damage to buildings, as well as real changes may not be visible.

The fire safety means that the structure must be able to withstand the fire for a certain time (depending on the type of building) so that users can save themselves. Test fire should represent the actual burden of fire as when the structure caught fire. The first time, experiments to connect the test results using a furnace with a fire that was actually done in the USA in 1928 (Malhotra 1982). Heat load simulation has been done to match the fire offices, shops, warehouses and various buildings, and then suggested the fire load is associated with the use relau ujikaji fire. From those various test, then regulations and standards of the fire resistance of various types of buildings may be made.

Objective

The objective of this study 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 experimentally.

Research components

As it was used by the author (Shodiq 2010), 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 2 shows the cross-section of Peva 45 profiled sheeting.

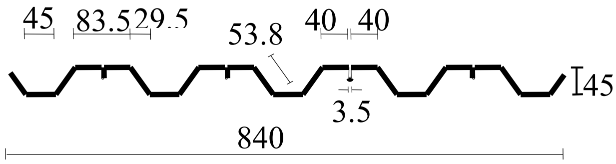


Figure 2. A cross-section showing Peva 45 of 1mm thickness (unit in mm)

Dry Board

Various types of boards are available in the market. For this study, a 16 mm thick cement board, Cemboard, manufactured by Hume Cemboard Berhad Malaysia has been used.

Connectors

Horizontal shear at the interfaces between Peva 45 and Cemboard were being transferred by means of self-drilling and self-tapping screws as shown in Figure 3.

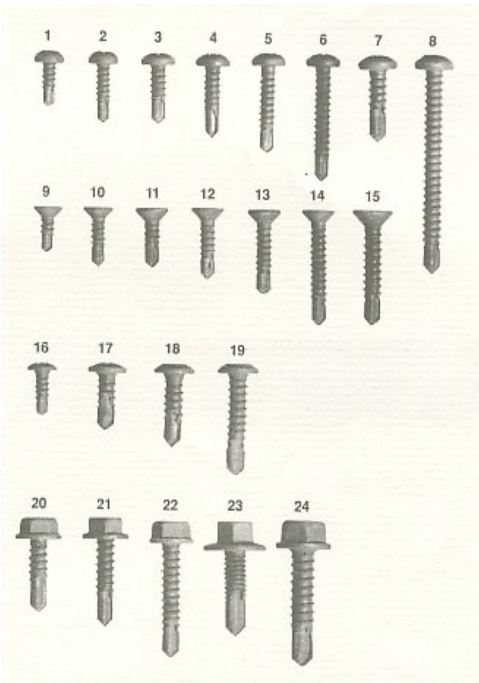


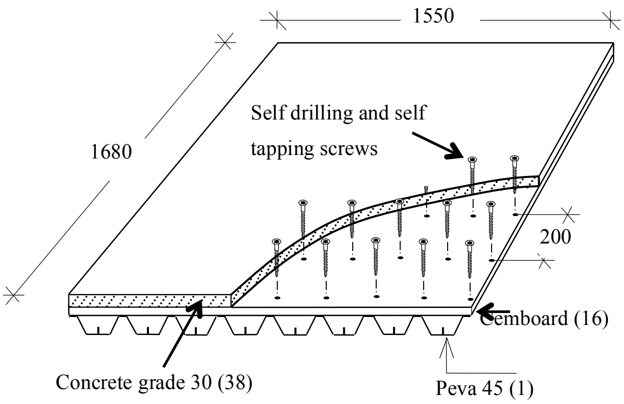
Figure 3. Types of Self Drilling and Self Tapping Screws

Concrete

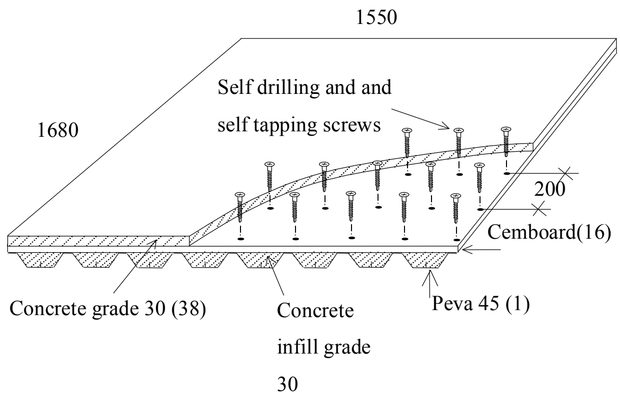
The topping and infill materials use concrete grade 30, it is used because it is easy to get this grade in a site, or in a concrete batching plan as a ready mix concrete.

Sample

There were two types of sample used in this research. The specimens were rectangular dimensions. Peva 45 of 1 mm thick and Cemboard of 16 mm thick, and self-tapping, self-drilling screws were selected for this purpose. All specimens had the dimensions of 1550 mm by 1680 mm, and concrete topping of 38 mm were constructed as single-skin panels. First, standard sample was used to control the effect of concrete infill to the fire. Second, sample was same as the first, except the through was filled with concrete infill. These samples can be seen in Figure 4.



(a) Standard Sample without infill



(b) Sample with concrete infill

Figure 4. Sample of PSSDB (unit in mm)

Loading System, Instrumentation, and Test Procedures

In accordance with the purposes of fire resistance tests on PSSDB floor system load on it, the test followed the BS 476 Part 20 and Part 21 (1987). To avoid damage to the furnace if the sample had an extreme failure, the load applied to the sample placed onto a frame load, as showed in Figure 5

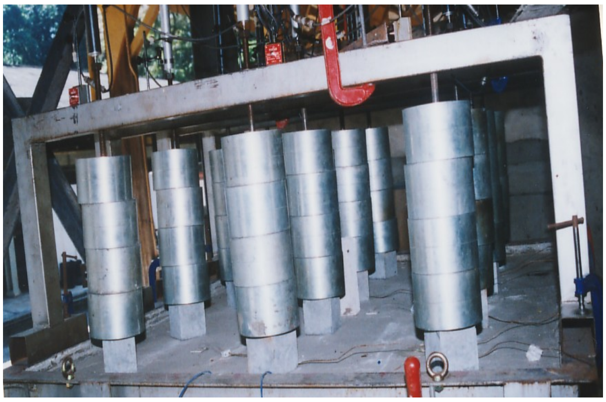


Figure 5. Loads onto Load Frame

The loads were placed on the floor surface uniformly in n the longitudinal and transverse directions as high as 4 kN/m^2. The placement of the loads was shown in Figure 6 below:

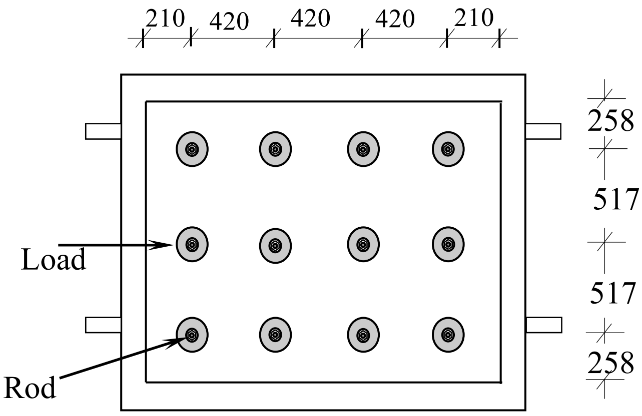


Figure 6. Load Placement

During the fire test, all the changes should be recorded from time to time using electronic equipments. 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. Thermo couples measuring temperatures on the unexposed to fire surface of the sample and inside the furnace were utilized to measure temperature change. The deflections were measured using displacement tranducers and temperature changes were measured by thermo couples. The transducers and thermo couples were connected to a digital portable electronic data logger. The initial values for deflections were zeroed on the measuring device once the panel, the temperature values of thermo couple was set as real temperatures. These conditions were then considered to represent the initial unfired state of the panel. Furnace was ignitated then applied incrementally based on BS 476 Part 20 (1987) as seen in formulae bellow:

$$T_f = T_o + 345 \log_{10}(8t + 1)$$

Where:

T_f = Furnace temperature

T_o = initial temperature

t = time in minute

After ignitating the furnace, the temperature values, time in minute and the corresponding deflection values are recorded. The temperature, time and the corresponding deflection measurements taken from the test were then used to investigate the performance of the panels.

Result and Discussion

The results obtained were the deflection and the surface temperature is not exposed to fire for each sample. The failure of the sample set according to BS 476 Part 20 (1987), a sample set failed on three (3) criteria of integrity (integrity), insulation (insulation) or retention of the load (load bearing).

1) Load Retention Criteria (BS476 Part 20, 10.2)
   This criterion is deemed to have been violated when:
   a) The deflection of the sample reached 1/20 times the range.
   b) After the deflection to 1/30 range, the speed of the deflection of more than L2/9000d mm / min, where L = length of the span and d = distance from the surface until the tension
2) Criteria of Integrity (BS476 Part 20, 10.3)
   This criterion is deemed to have been violated when:
   a) sample collapsed or burning with fire on the surface that is not exposed to fire more than 10 seconds.
   b) When used in tests of cotton, the cotton goes on.
   c) Formed allow gaps in the sample included 6 mm gap gauge can be moved no less than 150 mm, or 25 mm gap gauge can be inserted up into the furnace.

3) Criteria Insulation (BS476 Part 20, 10.4)
   This criterion is deemed to have been violated when:
   a) The average temperature of the surface is not exposed to the fire grew to more than 140° C from the initial temperature of the surface.
   b) The temperature at any point on the surface that is not exposed to fire up more than 180° C from the average initial temperature of the surface.
   c) The sample has failed the integrity criterion or criteria based on load retention.

Figure 7 shows the midspan deflection of sample 1 during the test from start to finish the test. Deflection increases gradually until cracking occurred at minute 42. In contrast to changes in temperature on the surface, these cracks are very influential on the deflection, the deflection of a sudden increase after a fracture occurs. The test is considered expired after the maximum deflection occurs beyond the limit, the 1/20 span equal to 84 mm.

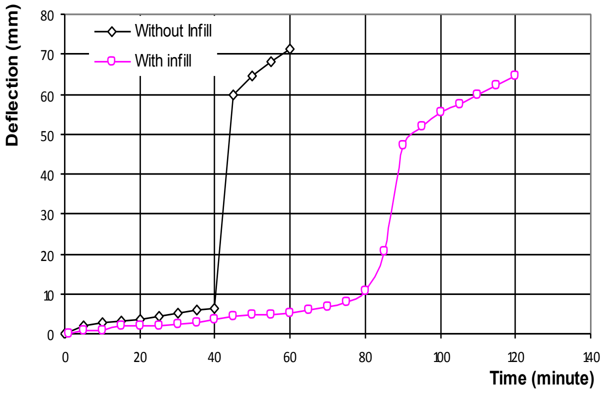


Figure 7. Mid Span Diflection

Figure 7 also shows the deflection at the midspan sample 2 which showed similarities with sample 1, the deflection increased slowly until a fracture occurs at minute 83, then followed by a sudden deflection increases. After that, the pace slowed again deflected to the extent that the failure of the sample. Until the test is terminated, the existing maximum deflection does not exceed the limit, ie 1/20 range is equal to 84 mm.

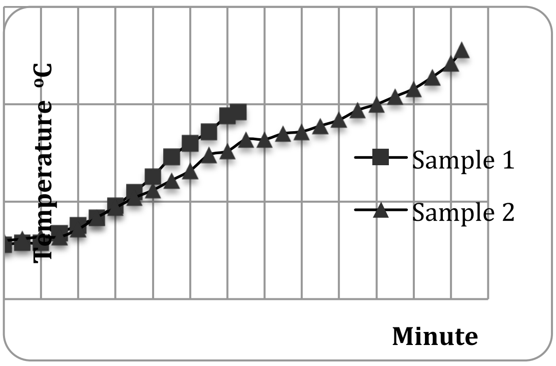


Figure 8. Temperature of unexposed surface

Figure 8 shows the insulation improvement of unexposed to fire surface of PSSDB. At the same time, the temperature of unexposed surface of PSSDB with concrete infill is lower than unfill one. It was caused by the insulator of concrete as an infill which placed in the through of profiled sheeting.

Table 1. Fire resistance prediction of PSSDB without infill material of Various Span

Load kN/m^2	Span (mm)				
	2000	2500	3000	3500	4000
1.0	158.2	53.1	44.1	42.0	41.4
1.5	86.6	43.6	42.0	41.2	40.7
2.0	50.7	42.6	41.3	40.7	
2.5	44.3	42.0	41.0		
3.0	43.4	41.5	40.7		
3.5	42.9	41.2			
4.0	42.4	41.0			

Table 2. Fire resistance prediction of PSSDB with concrete infill material of Various Span

Load kN/m^2	Span (mm)				
	2000	2500	3000	3500	4000
1.0	129.8	115.9	94.7	84.1	82.5
1.5	126.7	98.1	84.2	82.3	81.2
2.0	112.5	87.2	82.8	81.4	
2.5	102.4	84.1	81.9	80.8	
3.0	95.1	83.1	81.4		
3.5	89.3	82.5	81.0		
4.0	84.9	82.0	80.7		

To give a fire resistance prediction of PSSDB floor system designed as the samples but have different spans, using the assumption that the floor is as a simple beam structure, the forecast for mid-span deflection of the floor structure at room temperature according to BS 5950 1990 limits of the maximum deflection of the beam structure is 1/200 or 0.005 of the long span are shown in table 1 for PSSDB floor system without infill and table 2 for PSSDB floor system with concrete infill.

Conclusion and Recommendation

Based on the discussion above, it can be concluded as follow:

1. Concrete as an infill material to the PSSDB floor panel system not only increase its strength and stiffness values but also increases its fire resistance performance
2. PSSDB system for residential puspose is only suitable for span less than 4

meters.

References

British Standard Institution: BS 476: Part 8. 1972. *Test methods and criteria for the fire resistance of elements of building construction*. 2 Park Street, London W1A 2BS.

British Standard Institution: BS 476: Part 20. 1987. *Methods of determination of the fire resistance of elements of construction* (*general principle*). 2 Park Street, London W1A 2BS.

British Standard Institution: BS 476: Part 21. 1987. *Methods of determination of the fire resistance of loadbearing elements of construction*. 2 Park Street, London W1A 2BS.

British Standard Institution: BS 476: Part 22. 1987. Methods of determination of the fire resistance of non-loadbearing elements of construction. 2 Park Street, London W1A 2BS.

Harsoyo, 2004, Prestasi sistem baru lantai baja berprofil papan kering dengan isian beton, tesis Doktor Falsafah Universiti Kebangsaan Malaysia Bangi.

Shodiq, H.M, 2010, Performance Improvement of Profilled steel sheeting Dry Board Floor System by Concrete Infill, Proceeding of International Confrence on Sustainable Built Environment, p 109 – 113.

http://www.latimes.com/news/nation/nationnow/la-wildfire-20120530-photos

The Steel Construction Institute : 1989. *Design of Composite Slabs and Beams with Steel Decking.* SCI Publication 055.

The Steel Construction Institute : 1990. *Commentary on BS* 5950*: Part* 3*: Section* 3.1 *'Composite Beam'.* SCI Publication 078.

Sustainable Building Design in Earthquake-prone Areas of Indonesia

Mochamad Teguh

Department of Civil Engineering, Islamic University of Indonesia

Email: m.teguh@uii.ac.id

Abstract

Indonesia has unique geography and geology that is situated at the juncture of four major world tectonic plates and located on crossing three-mountain system affecting its prone to natural disasters, such as earthquake, tsunami, flood, landslide, cyclone, and volcanic eruption. An earthquake as one of the most frightening of natural disasters, for instance, leaves behind instantaneous destruction, loss of life and despair on a scale that is mind boggling and the most of it is due to collapsing structures and dwellings unable to withstand the tremors. The moderate quakes toppled buildings and started many landslides, smashing homes and swallowing up entire villages. After the earthquake, most of the built environment was ruined in the urban area showing that urban area was turned into a huge open space. This paper is based on research and site investigation dealing with urban renewal activities after the 2006 Yogyakarta and 2009 Padang Earthquake in the devastated areas. Sustainable urban and building design parameters and their technical application possibilities were extensively studied. Establishing sustainable and ecological building construction systems and qualified housing areas convenient for a settlement subject to earthquakes are discussed. The vernacular housing and building structure of the region was introduced to strengthen its structure in resisting to seismic actions. The hints for actual housing design from the traditional housing applications and the development of comfortable and safe reconstruction housing areas are proposed for such a sustainable and disaster managed urban environment both in general scales.

Keywords: sustainable building design, seismic, earthquake, construction, urban area

Introduction

Within a period of less than 10 years (2004-2009), three moderate earthquakes were occurred in different regions of Indonesia, i.e., the 2004 Aceh Earthquake and tsunami, the 2006 Yogyakarta Earthquake, and the 2009 Padang Earthquake. The scariest on natural disasters such as earthquake leaves behind prompt destruction; loss of life and despair on a scale that is mind-boggling and the most of it is due to collapsing structures and dwellings unable to withstand the tremors. People lucky enough to be outdoors manage to escape while people caught indoors get trapped or perish. Hence the importance of constructing earthquake resistant houses and buildings is known in earthquake-experienced areas where architects and civil engineers should plan accordingly to save life and environmental impact (Teguh, 2011). The earthquake is likewise thought to have been tectonic in origin and not directly associated with the eruption of nearby Mount Merapi in North Yogyakarta, although the earthquake is conveyed to have caused increased activity in the volcano. The island of Java lies on the boundaries of the Australian plate and the Eurasian plate. This position places it on the Ring of Fire and predisposes it to common earthquakes and other tectonic activity. The interaction of the two plates below the surface of the Earth caused this earthquake. In addition, the sea south of Java is historically associated with many earthquakes, as indicated in the Historic Seismicity map of the United State of Geological

Survey (USGS, 2006). During 2006, there were a couple dozen quakes of similar strength off the coast, but most of them were deeper or further from shore, thus less damaging to people and infrastructure. Post a number of severe earthquakes; numerous engineering inspections and investigations have been conducted in the devastated areas to assess the structural damage level and to evaluate the performance of various construction materials. Irrespective of such reviews, there is an ongoing need to assess acceptable performance and damage control for different structures during seismic events. As a result, failures of structural elements of multi-level buildings affected by the recent earthquakes of Yogyakarta and Padang have led to considerable effort being directed towards safer civil infrastructure to provide better livability in the seismic zones. Such natural disasters, and efforts to reduce their impacts, are therefore a development concern on sustainable building designs should be concisely prepared.

Table 1. Most livable city index 2009 and 2011 (Djonoputro, 2011)

No	City	Total Scores	
		2009	2011
1	Yogyakarta	65.34	66.52
2	Denpasar	-	63.63
3	Makasar	56.52	58.46
4	Menado	59.90	56.39
5	Surabaya	53.13	56.38
6	Semarang	52.52	54.63
7	Banjarmasin	52.61	53.16
8	Batam	-	52.60
9	Jayapura	53.86	52.56
10	Bandung	56.37	52.32
11	Palembang	-	52.15
12	Palangkaraya	52.04	50.86
13	Jakarta	51.90	50.71
14	Pontianak	43.65	46.92
15	Medan	52.28	46.67

A sustainable building creates structures utilizing available resources that are environmentally responsible and energy-efficient more practical concepts (NIST, 2007). The sustainable building is also known as a green building, which encompasses some factors such as internal and external design, construction, operation, maintenance, renovation, and deconstruction. To assess the green building, it uses a rating system. The aim of sustainable building design is to reduce the overall impact of the built environment on human health and the natural environment particularly in earthquake-prone area of Indonesia to achieve requirements of livable city. The rating system is a device containing the grains of which referred to aspects of the assessment rating, and each grain has the highest rating (credit point/points values) where a building successfully implements a rating point. The building will get the points value of the grain when the sum of all point values collected have achieved a specified amount in order to certify a certain level of certification. Every country has their own rating systems, for example the United States (LEED), Singapore (Green Mark), Australia (Green Star), etc. Green Building Council of Indonesia is currently drafting a rating system. According to the Green Building Council Indonesia/GBCI

(2012), greenship as a rating system is divided into six aspects as follows: appropriate land use (appropriate site development/ASD), energy efficiency & refrigerants (energy efficiency & refrigerant/EER), conservation of water (water conservation/WAC), source & cycle materials (materials & cycle resources/MRC), air quality & leisure air (water indoor health & comfort/IHC), and environmental management building (building & environment management). Each aspect consists of several credit ratings that describe charges of particular values in determining the building assessment. A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment.

In recent years after occurrence of great earthquakes, livability seems to be one of the indicators for assessing quality of living in cities around the world. In earthquake-prone area of Indonesia, for instance, there are several factors affecting directly to the livable cities. The selection conducted by the Economist Intelligence Unit was dependent on a combination of factors related to the environment, health care, culture and infrastructure systems. However, the results of such a survey suggest that none of the top ten most livable cities in the world are the cities of the fast-growing countries in the global south. With over one billion people in the world living in slums today, urban informality becomes part of everyday life in the urban global south. Therefore, the challenge of making a city livable in such a region is to bridge the gaps between formal/informal systems, rich/poor citizens, and healthy/unhealthy environment. The Indonesian Association of Urban & Regional Planners (IAP) (Djonoputro, 2011) has made some criteria and livability factors to review 15 selected cities in Indonesia. The criteria include physical and environmental aspects, transportation, public health and education, quality and availability of city infrastructure, economic condition, security and safety, and neighborhood, social and cultural interactions. The most important criteria in which correlates to the sustainability of building design, however, comprises the availability of green space and quality of urban design, security and safety of existing buildings. According to Djonoputro et al. (2011), the Indonesian Association of Urban & Regional Planners (IAP) recently selected Yogyakarta City as the first rank of livable city in Indonesia (Table 1) based on indicators aforementioned. In contrast, none of other cities (Aceh and Padang) in which moderate earthquakes occurring in these areas was selected as most livable cities in Indonesia.

With regard to reduce natural disaster risk, a mitigation plan should be taken into account such as sustainable building design. Disaster risk reduction, which refers to activities that aim to limit the negative impacts of disasters. Disaster risk reduction activities either reduce the likelihood of a disaster occurring (safe building practices), or strengthen a community’s ability to respond and cope with a disaster (disaster preparedness activities). The following section considers the impact of a catastrophic earthquake that devastated non-engineered houses and resulted in structural damage to multi-level buildings.

Seismic Impact on Urban Houses and Multi Story Buildings

Three moderate earthquakes hit the Provinces of Aceh, Yogyakarta and Padang in 2004, 2006 and 2009 and have come to represent the worst natural disasters in living memory. Figure 1 shows that the country of Indonesia has to challenge with frequent and powerful seismic activity. An evidence showed that its epicenter of the 2006 Yogyakarta Earthquake was close enough to the urban area of Bantul district, as a result, the seismic impact on urban houses, multi story buildings, and public facilities during severe ground shaking and large ground displacement were seriously experienced as listed in Table 2 (A.D.B.Report 2006). Nearly 40 thousands of non-engineered urban houses destroyed and over 20 thousands of building structures partially damaged. Similar condition was found during site investigation after the 2009 Padang Earthquake where most of non-engineered urban houses were totally collapsed and many multi story buildings located in the city were completely collapsed and partially damaged on its beam-column joint and other structural components. It was observed that all collapsed houses (Figure 2) were non-engineered structures; however, many multi level buildings were also seriously damaged, particularly around their main structural elements at beam-column joints (Figure 3b). In addition, inadequate structural elements caused urban houses damaged (Figure 3a). Figure 2 shows evidence that the traditional urban houses were not properly designed adopting a concept of earthquake resistant design. This is because of most urban houses were built long years ago when the seismic standard has not been developed yet. Figure 3 presents another evidence differently, because a new urban house is being built improperly showing that no reinforced concrete beams and columns as structural components have been found. As a result, the house was laterally deflected after the 2009 Padang Earthquake occurred. Similar condition was experienced in multi-story building (Figure 3b) depicting the beam column joint collapsed totally because of insufficient shear resistant strength.

Numerous engineering inspections and investigations in three different devastated locations have been performed to assess the degree of structural damage and to evaluate the performance of various construction materials. Irrespective of such reviews, there is an ongoing need to assess acceptable performance and damage control for different structures during seismic events. Subsequently, failures on beam-column joints, soft stories and other structural components of multi-level buildings affected by recent earthquakes (Figure 3b) have led to considerable effort being directed towards a sustainable building design to guarantee buildings and infrastructures safer and more livable.

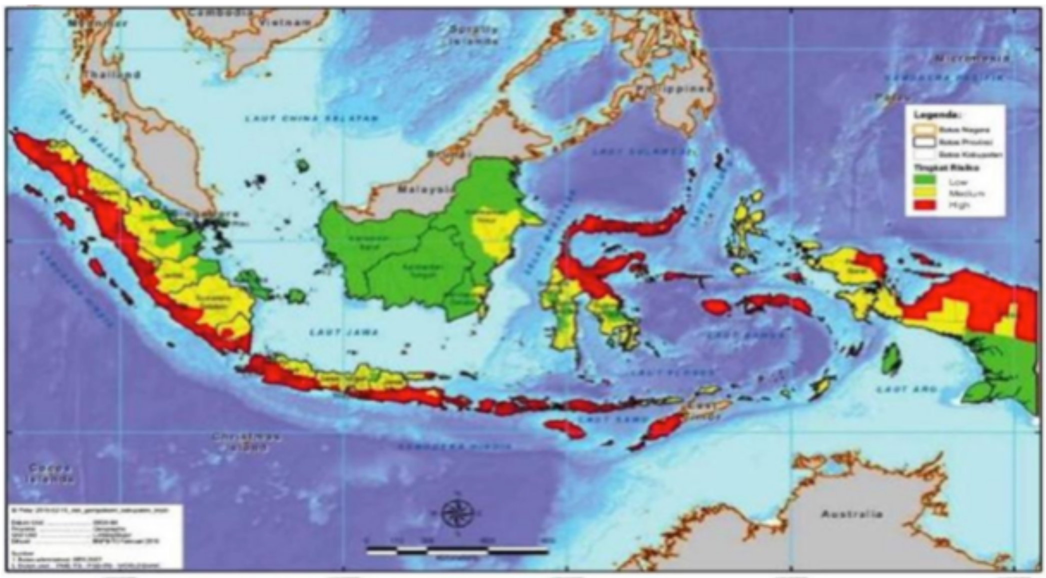


Figure 1. Potential earthquake-prone areas in Indonesia (Dep. of Public Works, Indonesia)

Table 2. Seismic Impact on Public Facilities in Yogyakarta (A.D.B.Report 2006)

Facility Category	Damage Identification	Action Status
Housing	39000 houses completely damaged 23600 houses partially damaged	Local authorities and the army had set up tents, and temporary shelters were constructed for emergency responses.
Power distribution	3 distribution towers damaged	Power supply was largely restored
Roads	Several roads and bridges were damaged	Repair and strengthening process were undertaken
Airport	Run ways cracked several parts Terminal building partially collapsed	Air traffic restored three days after disaster occurrence
Water supply	Bantul is the worst area affected by clean-water supply disconnection	Relief efforts focused on getting clean water
Hospitals and Schools	Public facilities suffered damage	Rehabilitation had been conducted
Cultural building	Historic Prambanan temple suffered minor damage; Borobudur reported to be intact	Reconstruction both historic temples were gradually undertaken

a. Collapsed house in Yogyakarta b. Collapsed house in Padang Pariaman

Figure 3. Collapsed urban house (CE Department Reconnaissance)

a. Improper built house in Padang Pariaman b. Damaged beam-column joint

Figure 4. Improper structural elements on urban houses and multi-story buildings (CE Department Reconnaissance)

Seismic Concept of Sustainable Building Design

A sustainable building is a new consideration in design, building construction, and buildings operation (GBCI, 2012). A sustainable design considers local heritage approaches and integrates them with new technological advances as resources of performance based to provide a quick overall assessment of performance on most critical parameters in building and enable comprehensive organization to report on its overall environmental improvement. Together with green policies as a written statement that clearly indicates the position and values of the organization on environmental and sustainability issues, reduce the life cycle and operating cost as the prime business reason for developing green building.

The section discuses a brief outline of the concepts involved in seismic design of sustainable buildings. According to PWD (2002), current Indonesia practice (SNI 03-1726-2002) is to design buildings to satisfy two sets of design criteria, namely the serviceability limit state (SLS) and ultimate limit state (ULS). The earthquake design actions for the two limit states are based on the predicted earthquake magnitudes that on average are expected to occur once in the given return periods. As noted later, the length of the return period used for the design limit states varies, depending on the importance of the building to the community. The SLS involves designing the building so it remains fit for use in the event of an earthquake with a magnitude of shaking that may be expected to occur once or twice during the design life of the building. If damaged in such an event it should be repairable at low cost. Structures required for essential services after a major earthquake or other major emergencies are designed to sustain a higher level of seismic actions in the SLS.

In the design of high-rise buildings (Deane, 2008; Elnimeri and Gupta, 2008), the design criteria considering the ULS have been developed to ensure that life is protected in the event of a major earthquake. This is achieved by requiring the building to have suitable levels of strength, stiffness and ductility to survive a major earthquake without collapsing as a result of structural failure. For commercial buildings of normal importance this major earthquake is assumed to have a return period of 500 years. Post-disaster structures, structures that are designed to contain significant numbers of people, and school buildings used for teaching are designed for earthquake actions with return periods of 2500 and 1000 years respectively (assuming a building design life of 50 years). Satisfying the design criteria for the ULS should enable building to be repaired after earthquakes that are more intense than those envisaged for the SLS. However, the ULS design criteria do not imply that repairs are possible after an ULS earthquake. These criteria match with requirements of FEMA 440 (2005).

It was clearly described that a concept on the sustainable building design (Moon, 2008) plays an important role in defining the structural behavior (before failure) and the earthquake vulnerability (sensitivity to damage) of buildings. The conceptual design includes the detailing of structural elements (walls, columns, slabs) and the non-structural elements (partition walls, facades). Errors and defects in the conceptual design cannot be compensated for in the following calculations and detailed design of the engineer. A seismically correct conceptual design is furthermore necessary in order to achieve the building more sustainable in the post earthquake occurrence without incurring significant additional costs. This principle is mainly applicable not only to new buildings but also to existing buildings for evaluation and possible upgrading (Bachmann, 2003). There are two simple concepts of earthquake resistant building design, which are suitable for urban houses and multi story buildings. An engineer should adopt this concept in designing for a new building and assessing an existing building. In this concept considers building material technology, earthquake resistant building design, and construction technology. Protection against collapse in most modern buildings is given provided by ensuring that in the event of a major earthquake the structures will behave in a ductile manner. This involves cracking of concrete and yielding of reinforcement in reinforced concrete buildings (Pentalla, 1997; Naik, 2008) and yielding of structural steel members in steel buildings. This causes damage to structural elements as well as damage to non-structural elements such as the linings in the building. A consequence of this is that protection against collapse and protection of life may be at the expense of the building, which may have to be demolished after the earthquake. Ensuring buildings have adequate ductility to satisfy the ULS is achieved through a process called capacity design.

It has been observed that the seismic wave due to the ground motion during an earthquake may transfer from the bedrock to the surface layers where the foundation system of building is applied. In the case of urban house, this will directly vibrate to super structural components such as beam, column, and masonry wall propagating small cracks to serious damages (Teguh and Makrup, 2012). For this condition, the structural system of urban house should be precisely strengthened utilizing the concept of earthquake resistant urban house. In this concept, all structural components such as tie beam, column, ring-beam, lintel-beam, and others should rigidly connect each other in unity. Furthermore, the structural component should be more ductile in order to reduce crack damages on masonry walls during the ground shaking.

Seismic Provision Codes

In the early 20th century, the first seismic provisions in building codes were very rare and have been introduced in a few countries with high seismicity. These early seismic codes have been periodically updated with increasing knowledge in earthquake engineering based mostly on researches. In the 1960's and 1970's, countries with moderate seismicity began to adopt seismic requirements in their building codes. In the same period, the better understanding of dynamic soil behavior as well as inelastic structural behavior led to the development of more advanced seismic codes. In Indonesia, however, the seismic code was firstly introduced in 1980’s and was recently adopted as a national standard (SNI 1726-2002).

The principles of capacity design combined with the concepts of ductile behavior allow a safe and cost effective earthquake resistant design. The latest efforts of seismic code development were mainly focused on internationally harmonized standards like ISO 3010, Eurocode 8, FEMA, and UBC (Shein, 1999). Unfortunately, even today, the seismic provisions of the building codes are not always respected; this is either due to ignorance, indifference, convenience, or negligence. Moreover, appropriate official controls and checks are lacking and some people think of making earthquake resistant buildings are very expensive and costly. Buildings that are very vulnerable and at risk from even a relatively weak earthquake continue to be built today. Investigations of existing buildings (Teguh, 2011) showed however, that enforcing the building code requirements makes it possible to significantly reduce the seismic vulnerability of buildings with no significant additional costs while improving their resistance against collapse.

The ignorance or disregard of the seismic provisions of the building codes, even if only partial, it produces in an inferior building (Shein, 1999). The reduction in value may include, among other things, the costs of retrofitting minus the additional costs that would have been incurred to ensure the seismic resistance of the building at its design and construction stage. The designers can be responsible for retrofitting costs, as well as jointly liable with the building owners for loss of life, injury or for any resulting material damage in the case of an earthquake. A retrofit generally costs several times more than what it would have cost to ensure adequate seismic resistance of the new building.

Considerable costs may also be incurred by disruptions of the building’s use, such as temporary evacuation and business interruption. Furthermore, determining the responsibility of the architect and engineer can necessitate lengthy and complex legal procedures. The building owner, the architect, the engineer, and the authorities therefore have a vested interest in ensuring that the seismic provisions of the building codes are strictly enforced, and that appropriate structural calculations and verifications are kept with the construction documents in order to sustain the constructed buildings when natural disasters occurred (Pearlson, 2012).

Discussion on Sustainable Building Designs Adopting Earthquake Resistant Concept

Development of earthquake engineering standards and practices in Indonesia dates back to the severe earthquakes, which claimed most dangerous to human lives and properties. These standards and practices have been continually upgraded as knowledge has developed and cited through research, earthquake events and international standards. Earthquake-resistant structural design over the past 50 years has sought to prevent the collapse of structures under strong earthquake shaking while recognizing that damage, even irreparable structural damage, could occur in such conditions. Over recent years designers have sought to produce greater resilience in key structural components, especially columns, beams, and walls, and to control damage to the building fabric generally.

Typically, buildings are designed for earthquake ground shaking intensities expected to occur, on average, not more than once every 500 years. Modern design standards (SNI 1726-2002) for multi-story building and urban house are such that design and construction to this level are intended to provide a significant margin of safety against collapse when subject to the design shaking. Many buildings would be expected to survive significantly stronger shaking without collapse and to sustain the existing structural components in an attempt to save live and property. However, damage to buildings, even those designed and built to the most recent standards, can be expected (Figure 3b). In "design-level" shaking, this damage may be beyond repair and thus require the demolition of the building (Figures 2 and 3). The underlying design philosophy is to focus on life safety and to accept, or at least tolerate, the possible need to replace the building after such a low probability event.

Despite the level of ground shaking in the devastated areas, many multi-story buildings in Aceh, Yogyakarta, and Padang Cities came through with damage but did not collapse, enabling people to escape. In these regions there are an enormous variety of buildings. Many types of buildings suffered different types of damage due to the differing factors from liquefaction to intense ground shaking. All of this information as a part of mitigation process will inform the repair and reconstruction standards and the direction of future development both in the three regions and across Indonesia.

The development and application of Indonesia earthquake standards has been a continuous process regardless of the building control system in place at the time. In Yogyakarta and Padang regions when the some multi-story buildings were designed and constructed, buildings were designed and built to the Indonesia Standards of the time, which were adopted as a bylaw by the consulting engineers or designers. If the some multi-story buildings had been built to current requirements, it is unlikely it would have collapsed in the way that it did as evidenced by the performance of the most modern buildings in the capital city of Jakarta.

In general, the capital city 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. In contrast, this condition makes the livable city reduced gradually. In other words, this is reasonable since the land prices surrounding the main business districts increase significantly. To overcome this situation, 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. The construction of high-rise building in capital city mostly utilizes general structural concrete because the price is much more competitive as compared to structural steel and less maintenance as well.

According to the Indonesian Seismic Resistant Code (SNI 03-1726-2002), the high rise building with a height of more than 40 m or with the number of stories exceeding 10, must be designed based on the results of dynamic response analysis, for which the method of response spectrum modal analysis using the above mentioned response spectrum may be used. Since in reality the structure behaves inelastically depending on its ductility, its inelastic response may be obtained from its elastic response as obtained above reduced by a seismic reduction factor.

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, for instance, 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 lifetime 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) (Teguh and Makrup, 2012).

The earliest earthquakes occurred in 2004, 2006 (USGS, 2006), and 2009. It was large and serious damage or death in Aceh, Yogyakarta (Table 2), and Padang because of the high density of traditional structures without having sufficient strength and stiffness in the urban area (Figure 2). In the following period, the rapid increase of the density of the high rise buildings and apartments in the city center caused the loss of old traditional houses of the region. So, by the earthquakes, three urban areas were ruined and after the removal of the ruins, the city became a huge open space. The mass housing and construction activities are continuing in the new settlement areas selected due to the ground qualities of the land outside the city center. In this research, sustainable urban and building design parameters and their application possibilities for urban center in the frame of urban renewal activities were studied. Establishing a sustainable and ecological building construction systems and qualified housing areas convenient for a settlement subject to earthquakes is discussed in elsewhere publication.

Concluding Remarks

Ways to design quality housing and lots in new urban centers linked with regeneration of the affected areas have been determined. The traditional/ vernacular housing and building structure of the region was introduced by taking into account the Indonesian and international standards. The hints for actual housing design from the traditional housing applications and the development of comfortable and safe reconstruction housing areas are proposed for such a sustainable and disaster managed urban environment both in general scale and for the three-zone cases considering earthquake resistant design concepts in order to meet the livable city requirements.

The policy concept of sustainable building design promotes the concept earthquake resistant building and educates people trough a formal education and training programs. The sustainable building technologies and techniques include material, design, and construction strategy. Based on the aforementioned discussion, the concluding remarks for earthquake prone promotes and implements measures associated with enforcements and incentives would result in:

1. improved definitions of earthquake-prone buildings and more effective implementation of strengthening measures, particularly for buildings likely to fail in a brittle manner,
2. a stronger appreciation of the (private and public) value of good seismic performance of buildings and the benefits of improvement action,
3. effective and economic retrofit strategies that improve the earthquake safety of buildings and save human life,
4. adoption by territorial authorities of strongly active policies to reduce the risk posed by buildings of low earthquake resistance,
5. improved public awareness that buildings not classified as earthquake-prone under the standard may nevertheless collapse in a major earthquake to achieve better sustainable built environment.

Acknowledgment

The author would like to express his gratitude to the Directorate of Research and Community Services, Directorate General of Higher Education, Ministry of Education and Culture who has sponsored this research under the multi-year grants (reference number 560.1/K5/KL/2012).

References

Bachmann, Hugo (2003). Seismic Conceptual Design of Buildings–Basic Principles For Engineers, Architects, Building Owners, and Authorities, Swiss Agency for Development Cooperation, BWG.

Deane, M. (2008). *The Builder's Role in Delivering Sustainable Tall Buildings*. The Structural Design of Tall and Special Buildings, Vol. 17, No. 5, pp. 869-880.

Djonoputro, B., Prasetyo, I., Muttaqin (2011). Indonesia Most Livable City Index 2011, Indonesian Association of Urban & Regional Planners (IAP), Jakarta.

Elnimeri, M. and Gupta, P. (2008). *Sustainable Structure of Tall Buildings*. The Structural Design of Tall and Special Buildings, Vol. 17, No. 5, pp. 881-894.

Federal Emergency Management Agency/FEMA (2005). Improvement of Nonlinear Static Seismic Analysis Procedures, Department of Homeland Security, FEMA, Washington D.C.

Green Building Council Indonesia/GBCI (2012). http://gbcindonesia.org/site/

Public Works Department/PWD (2002). Standard of Earthquake Resistant Design for Building (SNI 1726-2002), Research Institute and Development of Human Settlement, Bandung, Indonesia.

Moon, K. S. (2008). *Sustainable Structural Engineering Strategies for Tall Buildings*. The Structural Design of Tall and Special Buildings, Vol. 17, No. 5, pp. 895-914.

Naik, T. (2008). Sustainability of Concrete Construction. Practice Periodical on Structural Design and Construction, Vol. 13, No. 2, pp. 98-103.

National Institute of Standards and Technology/NIST (2007). Building for Environmental and Economic Sustainability Technical Manual and User Guide.

Pearlson, J. Craig (2012). 2020 Vision for a Sustainable Society, Melbourne Sustainable Society Institute, The University of Melbourne, Australia.

Penttala, V. (1997). *Concrete and Sustainable Development.* ACI Materials Journal, Vol. 94, No. 5, pp. 409-416.

Shea, G. Hynes (1999). Seismic Design Manual, Volume I: Code Application Examples, Structural Engineers Association of California, Sacramento, California.

Teguh, M. (2011). Sharing Experiences and Lessons Learned in Disaster Management System in Indonesia, *Journal of Asian Transaction on Engineering,* Vol. 1 Issue No. 05, pp. 35-44.

Teguh, M., Makrup, L. (2012). Investigation on Seismic Risk in Yogyakarta Region and Its Implication on Earthquake Resistant Building Design, *Research Report No. 560.1/K5/KL/2012,* sponsored by the Directorate General of Higher Education, Ministry of Education and Culture, Indonesia.

USGS (2006). http://neic.usgs.gov/neis/eq_depot/2006/eq_060526_neb6/neic_neb6_h.html

Validation of the Engineering Decision Support for Managing Conflict on Reducing Impact of Disaster

Christiono Utomo

Department of Civil Engineering, Institut Teknologi Sepuluh Nopember

Email: christionoutomo@gmail.com; christiono@ce.its.ac.id.

Abstract

This paper presents a model of validation process for a conceptual model of coalition formation to facilitate the solving of group choice engineering decision making problems on reducing impact of natural disaster. It contains of five stakeholders, three preferences and six alternatives. The methodology applied in this paper combines methods for decision process and coalition formation process. Analytical Hierarchy Process (AHP) is for decision process and coalition-based game theory is for coalition formation process. A group choice decision support is required to enable each stakeholder to evaluate and rank the solution alternatives before engaging into negotiation with the other stakeholders. Such engineering solutions as alternatives are referred to as agreement options that are determined by identifying the possible choice, followed by determining the optimal solution for each group of stakeholder. stakeholder Validation was conducted to a framework of coalition formation as a basis algorithm of decision support for multi person decision. A method of similarity index is conducted. Two others conventional model were compared with the coalition formation algorithms. This validation process reveals that the algorithms proposed is better than single weight factor and aggregation method in terms of closely to the best fit option, stakeholder satisfaction, and performance of the model.

Keywords: group decision support, engineering decision, and impact of disaster

Introduction

The validation process presented in this paper is the last stage of the research (Utomo and Idrus, 2008; Utomo et al, 2009; Utomo and Idrus, 2011) that is developing a conceptual model of negotiation support in sustainable construction. As the last stage of the research, the work presented on this paper presents the validation of the work earlier. There are many research on multi criteria decision making to solve research problem on environmental earth science and disaster management (Gobel and Coldewey, 2010; Donevska et al, 2011). Saongsupavanich et al (2011) argued that for group stakeholder participation, it should produce benefits that are greater than those accrued to individual group. Their research identified seven constraints to sustain successful stakeholder participants.

As a process of multi disciplines and teamwork, negotiation becomes an important role in the process of engineering decision for managing conflict on reducing impact of disaster. The decision is very complicated since many parties involved in a critical time. Where a number of stakeholders are involved in choosing a single alternative from a set of solution alternatives, a group decision support is required to facilitate the solving problems in selection the best alternative (Wanyama, 2006; Utomo and Idrus, 2011). In this situation there is a need to define a mechanism (a protocol) that allows stakeholders to resolve their conflicts and to reach a cooperative agreement (Kraus et al, 1995; Wanyama and Far, 2007). The mechanism facilitates the solving of Group Choice Decision Making (GCDM) problems in selection the best alternative decision for reducing impact of disaster. It is based on a hybrid of analytic and artificial intelligent techniques that similar to the strategic negotiation proposed by Kraus (2001). The coalition formation model proposed in this paper was tested for solving group choice decision making problems to reduce the impact of mud volcano disaster in Sidoarjo, Indonesia.

Background

On May 29 2006, a mud volcano started gushing from the ground less than 200m from the Banjar Panji I gas exploration well in the Brantas Production Sharing Contract area, spilling up to 150,000 m^3 of hot mud on the surrounding area daily. Establishing the cause of the eruption has been a highly controversial issue. Lapindo Brantas Inc., the operator of the Banjar Panji I gas exploration well, claims that the eruption is a natural disaster, triggered by an earthquake two days earlier near Yogyakarta, South Java. Geologists, however, dismiss this as the natural cause, judging that the earthquake is merely coincidental and is unlikely to have caused the eruption. Figure 1 illustrates the background of the disaster.

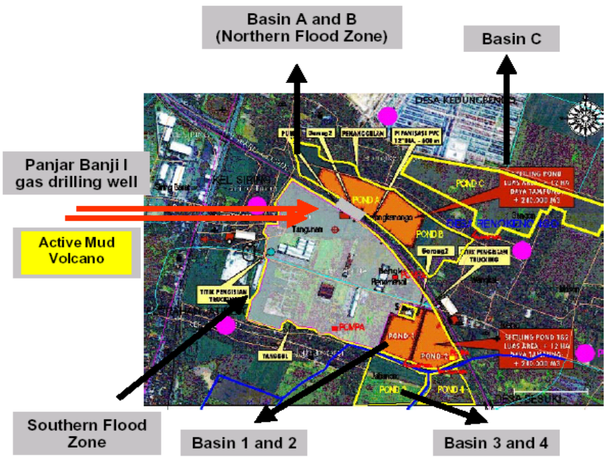


Figure 1: Background of the mud disaster (United Nation, 2006)

The mudflow disaster has implicated many parties. For five years, a sea of hot mud has been gushing from the ground in Sidoarjo, East Java. The Friends of the Earth International (Pohl, 2007) reported that infrastructure has been damaged extensively, including power transmission systems, toll roads, gas pipelines and national artery roads. Approximately 600 ha of land and villages are submerged, farmland is ruined, businesses and schools are closed. Moreover, irrigation channels are swamped by the mud, and drainage and drinking water pipes are affected.

Impact

There are at least four impacts have been existing in this disaster, that are health, environmental, infrastructure, and flooding and displacement (Pohl, 2007 and WHO, 2006). Small amounts of H2S continue to escape from the site, at levels to make the air smell foul. World Health Organization (2006) reported that so far the government has not officially requested any international aid. The local authorities, with support from central government and ministries, are trying their best to manage the situation. Whether or not the mud itself is considered toxic, it certainly has impacts on the environment. The disposal into the Porong river and the sea affects the river ecosystem and the aquaculture industry (Pohl, 2007 and WHO, 2006), and the high level of salinity (akin to seawater) makes overflow land infertile. Mud and water from the basins has already leaked into surrounding paddies (rice fields), destroying the income of many rice planters. Rice fields and fish and shrimp ponds have been destroyed, threatening Sidoarjo's status as one of the biggest shrimp producer in Indonesia.

Emergency Situation Report #6 by WHO (2006) wrote that the mud flood has presently engulfed 1810 houses as well as 18 schools, 2 government offices, 20 factories and 15 mosques. Recently, the flow has reached 126 000 cubic meters a day. To date, an estimated 3000 families, or about 10 000 people, have been displaced. The mud, gushing at a rate of 50 000 cubic meters (1.75 million cubic feet) a day, has now covered about 450 ha of land, which includes the six villages, paddy fields and sugarcane plantations as well as part of the Sidoarjo highway south of Surabaya. Infrastructure was damaged extensively, including toll roads, power transmission systems, gas pipelines and national artery roads. The highway to Gempol is definitively blocked, while the mainroad along Porong is occasionally inundated by the mud. This affects traffic from Pasuruan to Surabaya and back. Moreover, irrigation channels 38 have been swamped by the mud, and drainage and drinking water pipes affected (Pohl, 2007).

Engineering Effort

Friends of the Earth International and WALHI (Pohl, 2007) reported that the authorities' response to the immediate question of what to do with the mud was to build containment 'basins' or 'ponds' by enclosing areas of land. The United Nations Disaster Assessment and Coordination (UNDAC) team found that the 2m high earth dams had indeed helped limit the damage, but were not a sustainable solution as heavy rains in the rainy season would cause the walls to collapse and ponds to overflow. As it became clear that construction of containment ponds couldn't keep up with the rate the mud was gushing from its underground source, it was decided to channel the mud into the Porong river and on to the sea.

Concept and Methodology

Cooperative game theory concepts have been used for the group decision support. The concepts are suited to decentralized multitask environment (Zarour and Bouzidi, 2006). Decision makers may choose to cooperate by forming coalitions. Coalition is formed in order to benefit every member of the coalition so that all might receive more than they could individually on their own. Coalition has been used in many researches in multi person decision and negotiation (Kraus, 2001) and cooperative games such as for transmission planning in power system by Contreras (1997), for cooperative information agent-based systems of Zarour and Bouzidi (2006), and for COTS selection (Wanyama, 2006). Each of decision-maker uses an alternative solution as a baseline. They usually use the best for the decision-maker. However they can also provide other solution as the baseline performance. Formation of coalition for executing tasks is useful for distributed problem solving (DPS) environments (Kraus, 2001). It is common for decision makers to form coalition during negotiation in order to increase their individual welfare. Work in game theory describes which coalition will form in n-person games under different setting and how the players will distribute the benefits of the cooperation among themselves. Instead of the strategic approach that uses equilibrium analysis, coalition formation is often studied in a more abstract setting called a characteristic function game (Sandholm and Lesser, 1997). Coalition formation in characteristic function game includes coalition structure generation (Kahan and Rapoport, 1984). In this paper with five decision makers, there are 24 possible coalitions which are {1}, {2}, {3}, {4}, {5}, {1,2}, {1,3}, {1,4}, {1,5}, {2,3}, {2,4}, {2,5}, {3,4}, {3,5}, {4,5},{1,2,3}, {1,2,4}, {1,2,5}, {1,3,4}, {1,3,5}, {1,4,5}, {1,2,3,4}, {1,2,3,5}, {1,2,3,4,5}.

Methodology

The objectives of this validation is to determine how much the primary goal of the coalition formation algorithms proposed was achieved by pointing out the differences among three decision models of technical solution selection method, and by determining the user satisfaction and confidence in the results of the decision model with respect to each model. The methodology combines methods for decision process and coalition formation process. Analytical Hierarchy Process (AHP) by Saaty (2004) is for decision process and coalition-based game theory (Kelly, 2003) is for coalition formation process. Figure. 2 presents the process of the methodology applied in this paper.

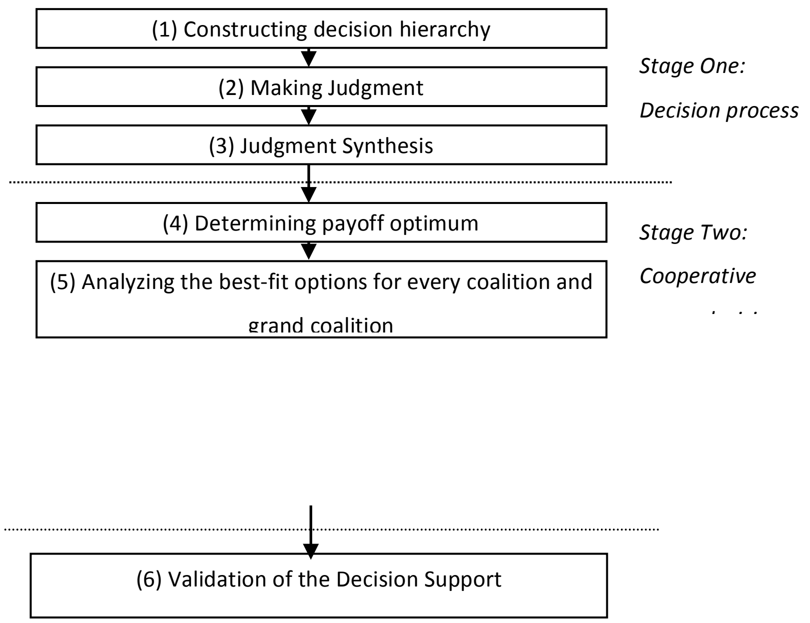


Figure 2. The methodology for cooperative group decision

Result and Discussion

Two stages were conducted which are decision process and cooperative group decision.

Stage One: Decision Process

AHP (Saaty, 2004) is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and its quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of one-on-one comparison, then synthesizing a result, AHP provides a clear rationale for it being declared the best decision. AHP is a framework of logic and problem resolving achieved by organizing perceptions, feelings, judgments, and memories into a hierarchy of forces that influences decision result (Dey, 2006). The AHP also can be used successfully with a group (Wanyama, 2006) and negotiation Wang and Zionts (2008).

Construction Decision Hierarchy

Figure. 3 shows the goal of the problem (G ="to select the best alternative decision for reducing impact of mud disaster") that is addressed by some alternatives (A = a1; a2; a3; a4; a5; a6) i.e. possible solutions. Each alternative are presenting combination of preference, + means good, - means bad and 0 means average. In this decision, +C1 means that the alternative is technically good, +C2 means that the alternative is not expensive, and +C3 means that implementation of the alternative will give good impact socially and environmentally. The problem is split into sub-problems (C1; C2; C3) which are criteria evaluating alternatives.

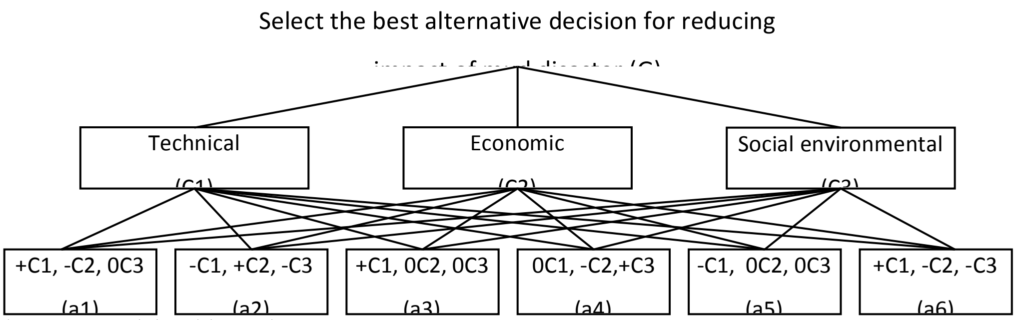


Figure 3. Decision hierarchy

Making Judgments

The relative importance of pair-wise comparison (Saaty, 2004) of decision input could be: equal (1), moderate (3), strong (5), very strong, demonstrated (7) or extreme (9). Sometimes one needs to compromise judgments (2; 4; 6; 8) or reciprocal values (1/9; 1/8; 1/7; 1/6; 1/5; 1/4; 1/3; 1/2). There are two judgments involved in this decision - the first is criteria judgment for each stakeholder (See Figure. 4) and the second is technical solution judgment for each criterion. Figure. 4 presents that each stakeholder (SH) has their own preference. Observe that stakeholder 3 (SH3) and stakeholder 4 (SH4) contrast in preferences. SH3 argues that c1 is the most important criterion, whereas SH4 puts c2 as the highest priority on the decision to reduce impact of the disaster.

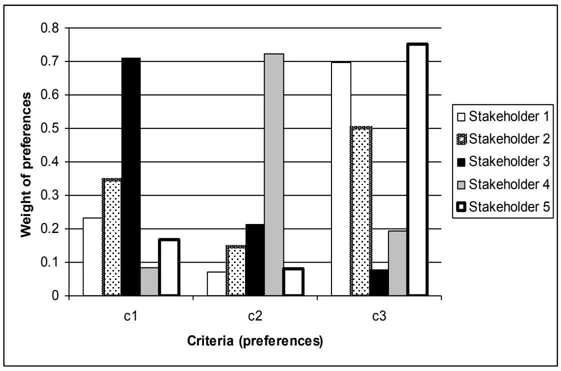


Figure 4. Weighting factor of every stakeholder for each criterion

Judgments Synthesis

The AHP measures the overall consistency of judgments by means a consistency ratio (Saaty, 2004): CRA_{ck} = CIA_{ck} =RC_n. The higher the consistency ratio, the less consistent the preferences are. The value of the consistency ratio should be 10% or less. Under this condition the priorities can be calculated. According to the AHP, the best alternative (in the maximization case) is indicated by the following relationship.

$$A*_{AHP-score} = \max_i \sum_{j=1}^{n} a_{ij} w_j, \quad \text{for } i = 1,2,3,\ldots,m$$

Figure 5 shows that stakeholders have different best option as a solution alternative. Only three alternatives are considered as the best options which are a1, a2, and a4.

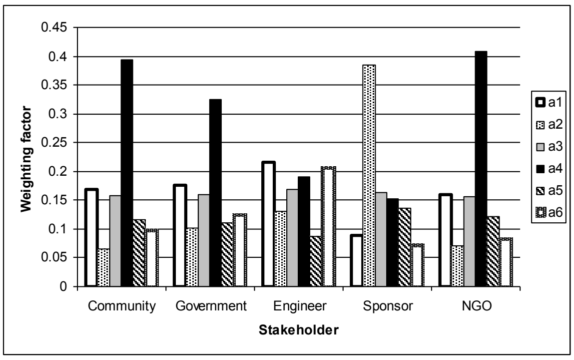


Figure 5. Weighting Factor of Every Alternative for Each Stakeholder

Stage Two: Cooperative Group Decision

Determining Payoff Optimum for Coalition

The determination of the optimal solution for each stakeholder in a coalition is based on a cooperative multi-person games with complete information in which coalition-formation among sub-group members are allowed (Morge and Beaune, 2004 and Matsatsinis et al, 2005). In the context of Game Theory, the formation of coalitions among subsets of negotiating entities (stakeholders) provides a means for achieving Pareto optimality, since every member in a coalition acts in such a way to benefit the entire coalition (Wanyama and Far, 2007). The value of (max-min) payoff for a stakeholder is used to determine the payoff optimum by applying the coordinating scenario. This means that no one stakeholder has higher importance than others. The sample payoff optimum for every stakeholder and every alternative on each coalition is determined on Table 1.

Table 1. Payoff Optimum for Each Coalition

Coalition		Alternatives						Payoff Optimum	
All stakeholders SH1+2+3+4+5		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH1	0.031	0.088	0.145	0.270	0.246	0.308	0.276	0.123
	SH2	0.282	0.251	0.220	0.263	0.205	0.030	0.253	0.282
	SH3	0.295	0.29	0.285	0.197	0.202	0.021	0.274	0.295
	SH4	0.203	0.21	0.217	0.243	0.218	0.120	0.124	0.243
	SH5	0.249	0.25	0.251	0.220	0.210	0.070	0.180	0.251
		1.060	1.0885	1.117	1.194	1.080	0.548		1.194
Sample of coalition two stakeholders									
Coalition		Alternatives						Payoff Optimum	
SH1+2		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH1	0.031	0.088	0.145	0.270	0.246	0.308	0.276	0.251
	SH2	0.282	0.251	0.220	0.263	0.205	0.030	0.253	0.282
		0.313	0.339	0.365	0.533	0.451	0.337		0.533
SH4+5		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH4	0.203	0.21	0.217	0.243	0.218	0.120	0.124	0.243
	SH5	0.249	0.25	0.251	0.220	0.210	0.070	0.180	0.224
		0.452	0.4595	0.467	0.464	0.427	0.190		0.467
Sample of coalition three stakeholders									
Coalition		Alternatives						Payoff Optimum	
SH1+2+3		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH1	0.031	0.088	0.145	0.270	0.246	0.308	0.276	0.154
	SH2	0.282	0.251	0.220	0.263	0.205	0.030	0.253	0.282
	SH3	0.295	0.29	0.285	0.197	0.202	0.021	0.274	0.295
		0.608	0.629	0.650	0.730	0.653	0.359		0.730
SH3+4+5		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH3	0.295	0.29	0.285	0.197	0.202	0.021	0.274	0.258
	SH4	0.203	0.21	0.217	0.243	0.218	0.120	0.124	0.243
	SH5	0.249	0.25	0.251	0.220	0.210	0.070	0.180	0.251
		0.746	0.749	0.752	0.661	0.629	0.211		0.752
Sample of coalition four stakeholders									
Coalition		Alternatives						Payoff Optimum	
SH1+2+3+4		a1	a2	a3	a4	a5	a6	Max-min	Optimum
	SH1	0.031	0.088	0.145	0.270	0.246	0.308	0.276	0.154

	SH2	0.282	0.251	0.220	0.263	0.205	0.030	0.253	0.282
	SH3	0.295	0.29	0.285	0.197	0.202	0.021	0.274	0.295
	SH4	0.203	0.21	0.217	0.243	0.218	0.120	0.124	0.243
		0.811	0.839	0.867	0.974	0.871	0.478		0.974
SH2+3+4+5		a1	a2	a3	a4	a5		Max-min	Optimum
	SH2	0.282	0.251	0.220	0.263	0.205	0.030	0.253	0.282
	SH3	0.295	0.29	0.285	0.197	0.202	0.021	0.274	0.252
	SH4	0.203	0.21	0.217	0.243	0.218	0.120	0.124	0.243
	SH5	0.249	0.25	0.251	0.220	0.210	0.070	0.180	0.251
		1.028	1	0.972	0.925	0.834	0.241		1.028

Analyzing the Best-fit Options for Every Coalition

By adapted model of coalition formation from Wanyama (2007) and Wanyama and Far (2006), on this paper, coalition formation model works in the context of multi-criteria group decision making. In the context of Game theory, Bialas (1998) present proof that the information of coalition among stakeholders provides a means for achieving Pareto-optimality, since every member of a coalition acts in such a way as to benefit the entire coalition. The result is presented in Table 2, which shows the priorities that follow the best-fit options process and coalition algorithm.

Table 2. Weighting factor of each alternative and coalition

	Alternative ranking and coalition	Alternatives					
		a1	a2	a3	a4	a5	a6
1	0	0	0	0	0	0	0
2	SH 1 (Community)	2^{nd}	6^{th}	3^{rd}	1^{st}	4^{th}	5^{th}
3	SH 2 (Government)	2^{nd}	6^{th}	3^{rd}	1^{st}	5^{th}	4^{th}
4	SH 3 (Engineer)	1^{st}	5^{th}	4^{th}	3^{rd}	6^{h}	2^{nd}
5	SH 4 (Sponsor)	5^{th}	1^{st}	2^{nd}	3^{rd}	4^{th}	6^{h}
6	SH 5 (NGO)	2^{nd}	6^{h}	3^{rd}	1^{st}	4^{th}	5^{th}
7	Coalition SH1 and SH2	1^{st}	6^{th}	2^{nd}	4^{th}	3^{rd}	5^{th}
8	Coalition SH1 and SH3	3^{rd}	4^{th}	1^{st}	2^{nd}	6^{th}	5^{th}
9	Coalition SH1 and SH4	4^{th}	5^{th}	1^{st}	2^{nd}	6^{th}	3^{rd}
10	Coalition SH1 and SH5	3^{rd}	4^{th}	2^{nd}	1^{st}	5^{th}	6^{th}
11	Coalition SH2 and SH3	3^{rd}	2^{nd}	1^{st}	5^{th}	4^{th}	6^{th}
12	Coalition SH2 and SH4	3^{rd}	6^{th}	1^{st}	5^{th}	2^{nd}	4^{th}
13	Coalition SH2 and SH5	3^{rd}	6^{th}	1^{st}	5^{th}	2^{nd}	4^{th}
14	Coalition SH3 and SH4	3^{rd}	6^{th}	1^{st}	2^{nd}	4^{th}	5^{th}
15	Coalition SH3 and SH5	3^{rd}	6^{th}	1^{st}	5^{th}	2^{nd}	4^{th}
16	Coalition SH4 and SH5	4^{th}	6^{th}	1^{st}	5^{th}	3^{rd}	2^{nd}
17	Coalition SH1, SH2, SH3	2^{nd}	4^{th}	1^{st}	5^{th}	3^{rd}	6^{th}
18	Coalition SH1, SH2, SH4	4^{th}	5^{th}	1^{st}	6^{th}	2^{nd}	3^{rd}
19	Coalition SH1, SH2, SH5	2^{nd}	5^{th}	3^{rd}	1^{st}	4^{th}	6^{th}
20	Coalition SH1, SH3, SH4	3^{rd}	5^{th}	1^{st}	6^{th}	2^{nd}	4^{th}

21	Coalition SH1, SH3, SH5	4th	3rd	1st	6th	2nd	5th
22	Coalition SH1, SH4, SH5	4th	5th	1st	6th	2nd	3rd
23	Coalition SH2, SH3, SH4	4th	2nd	1st	5th	3rd	6th
24	Coalition SH2, SH3, SH5	3rd	4th	1st	6th	2nd	5th
25	Coalition SH2, SH4, SH5	4th	5th	1st	6th	2nd	3rd
26	Coalition SH3, SH4, SH5	3rd	5th	1st	4th	2nd	6th
27	Coalition SH1,2,3,4	4th	5th	1st	6th	2nd	3rd
28	Coalition SH1,2,3,5	6th	3rd	1st	5th	2nd	4th
29	Coalition SH1,2,4,5	2nd	4th	1st	6th	5th	3rd
30	Coalition SH1,3,4,5	3rd	4th	1st	6th	2nd	5th
31	Coalition SH2,3,4,5	3rd	5th	1st	4th	2nd	6th
32	Coalition SH1,2,3,4,5	2nd	5th	1st	6th	4th	3rd
	RESULT	3rd	4th	1st	2nd	-	-

The coalition table (Table 2) reveals the start of the first negotiation round. Some solutions are not an option if no individual stakeholder or coalition of stakeholders desires to select it. In this case, alternative solution a5 and a6 are not options. The Table also indicates the alternative solution that will be determined the best fit solution. In this problem, in the first negotiation round, a3 is the 'best-fit' solution**.**

Validation

Validation was conducted to a framework of coalition formation as a basis algorithm of group decision support for engineering decision. A similarity index (Lu et al, 2006; Du and Chen, 2007) was conducted. Two others conventional model were compared with the algorithms. The objectives of this validation is to determine how much the primary goal of the coalition formation algorithms was achieved by pointing out the differences among three decision models of engineering solution selection method. The three models are;

MODEL 1: Single Weighting Factor (Davey and Olson, 1998).

MODEL 2: Aggregation Value (Gargallo et al 2007; Vaníček et al, 2009). The aggregation combines the performance ratings for all attributes with respect to each alternative (Chuu, 2009).

MODEL 3: Coalition Formation Algorithms (Thompson, 1966; Schmitendorf and Moriarty, 1976; Wanyama, 2006; Westwood and Allan, 2007; Utomo and Idrus, 2010). It consists of the two stages and algorithm which are determination of optimal solution (payoff optimum) and fitness factor of an alternative solution.

In this research, the index was used to measure how closely the best-fit option in the first negotiation matches the expectations of each stakeholder. The criterion value $P = \frac{X_i - B_a}{B_b - B_a}$ was normalized into a range between 0 and 1. The data can be converted by:

$$P = \begin{cases} O, & if \quad P < 0 \\ 1 & if \quad P > 1 \\ \dfrac{X_i - B_a}{B_b - B_a} & if \quad 0 \le P \le 1 \end{cases}$$

Where, B_a is the lowest criterion value, B_b is the highest criteria value, X_1 is the best fit solution for all stakeholders. The result of similarity index is presented in Table 3. The closer is the value of an individual stakeholder to the best-fit of the group; the more satisfactory is the model to every stakeholder.

Table 3 Similarity Index

	Model 1: Single weighting	Model 2: Aggregation	Model 3: Coalition algorithm
Stakeholder 1	>1=1	>1=1	0.466823
Stakeholder 2	>1=1	0.660666	0.151679
Stakeholder 3	1	0.664501	0.199419
Stakeholder 4	>1=1	>1=1	0.008331
Stakeholder 5	>1=1	0.79176	0.142212

This validation process reveals that the algorithms proposed in this research (Model 3) is better than single weight factor (Model 1) and aggregation method (Model 2) in terms of closely to the best fit option, stakeholder satisfaction, and performance of the model**.**

Conclusion

The coalition formation can help stakeholders to evaluate and rank the solution alternatives before engaging into negotiation with the other stakeholders. Based on a cooperative environment, a negotiation support can be developed. Future research in the application of this methodology in many field of engineering decision will build a wide range of knowledge to solve the theoretical and practical gap in decision and negotiation on the nature of group decision in managing conflict on reducing impact of disaster.

References

Bialas WF (1998) Cooperative n-person stackelberg games. Proceeding of the 28th IEEE Conference on Decision and Control, May.

Contreras J (1997) A cooperative game theory approach to transmission planning in power system. Dissertation, University of California Berkeley.

Chuu SJ (2009) Group decision making model using fuzzy multiple attribute analysis for the evaluation of advance manufacturing technology, Fuzzy Sets and Systems 160 (5): 586-602.

Davey A and Olson D (1998) Multiple criteria decision making models in group decision support. Group Decision and Negotiation 7: 55-75.

Davey A and Olson D (1998) Multiple criteria decision making models in group decision support, Group Decision and Negotiation 7: 55-75.

Dey PK (2006) Integrated project evaluation and selection using multi attribute decision making technique. International Journal Production Economics 103: 90-103.

Donevska KR, Gorsevski PV, Jovanovski M, and Pevevski I (2011) Regional non-hazardous landfill site selection by integrating fuzzy logic, AHP and Geographic Information Systems. Environmental Earth Sciences, Springer-Verlag.

Du TC and Chen H-L (2007) Building a multiple criteria negotiation support system. IEEE Transactions on Knowledge and Data Engineering 19(6): 904-817.

Gargallo P, Moreno-Jiminez JM and Salvador M (2007) AHP-group decision making: a Bayesian approach based on mixtures for group pattern identification. Group Decision and Negotiation 16: 485-506.

Gobel P and Coldewey WG (2010) Concept for near-natural storm water control in urban areas. Environmental Earth Sciences, Springer-Verlag.

Kahan JP and Rapoport A (1984) Theories of coalition formation. Lawrence Erlbaum Associates Publishers.

Kelly A (2003) Decision making using game theory: an introduction for managers. UK Cambridge: Cambridge University Press.

Kraus S (2001) Strategic negotiation in multi-agent environments. MA: the MIT Press.
Kraus S, Wilkenfeld J, Slotkin G (1995) Multi-agent negotiation under time constrains. Artificial Intelligence 75: 297-345.

Lu C, Lan J and Wang Z (2006) Aggregation of fuzzy opinions under group decision-making based on similarity and distance. Journal of Systems Science and Complexity 19(1): 63-71.

Matsatsinis NF, Grigoroudis E, Samaras A (2005) Aggregation and desegregation of preferences for collective decision making. Group Decision and Negotiation 14: 217-232.

Morge M and Beaune P (2004) A negotiation support system based on multi-agent system: specify & preference relation on arguments, in Proc. ACM Symposium on Applied Computing, Nicosia, Cyprus, March 14 – 17, pp. 474 – 478.

Nazari A, Salalirad MM, and Bazzazi AA (2012) Landfill site selection by decision-making tools based on fuzzy multi-attribute decision-making method. Environmental Earth Sciences 65(6): 1631-1642. Springer-Verlag.

Pohl C (2007) Lapindo Brantas and the mud volcano Sidoarjo, Indonesia. Friends of the Earth International.

Saaty TL (2004) Decision making: the analytical hierarchy process and network process (AHP/ANP). Journal of System Science and System Engineering 13(1): 1-34.

Saengsupavanich C, Gallardo WG, Sajor E, Murray WW (2011) Constraints influencing stakeholder participation in collective environmental management. Environmental Earth Sciences, Springer-Verlag.

Sandholm TW and Lesser VR (1997) Coalitions among computationally bounded agents. Artificial Intelligence 94(1): 99-137. Special issue on Economic Principles of Multi Agent Systems.

Schmitendorf WE and Moriarty G (1976) A sufficiency condition for coalitive pareto-optimal solutions. Journal of Optimization Theory and Application 18(1): 93-98.

Thompson EA (1966) A pareto optimal group decision process. Public Choice 1.

United Nation (2006) Final Technical Report: Environmental Assessment Hot Mud Flow East Java, Indonesia. Joint UNEP/OCHA Environment Unit.

Utomo C and Idrus A (2008) Automated negotiation protocol for civil engineering decision in reducing impact of natural disaster. International Conference on Civil Engineering. Universiti Malaysia, Pahang Kuantan, Malaysia. May 12-14.

Utomo C and Idrus A (2010) Value–based group decision on support bridge selection. International Journal of Business, Economics, Finance and Management Sciences 2(2): 107-112.

Utomo C and Idrus A (2011) A Concept toward negotiation support for value management in sustainable construction. Journal of Sustainable Development 4(6): 56-66.

Utomo C, Idrus A, Napiah M, and Khamidi MF (2009) Agreement options on multi criteria group decision and negotiation. World Academy of Science, Engineering and Technology 50: 443-447.

Vaníček J, Vrana I, Aly S (2009) Fuzzy aggregation and averaging for group decision making: a generalization and survey. Knowledge-Based System 22(1): 79-84.

Wang J and Zionts S (2008) Negotiating wisely, considerations based on MCDM/ MAUT". European Journal of Operation Research 188: 191-205.

Wanyama T (2006) Decision support for COTS selection. Dissertation, University of Calgary.
Wanyama T (2007) Static and dynamic coalition formation in group-choice decision making in V. Torra, Y. Narukawa, and Y. oshida (Eds.): MDAI 2007, LNAI 4617, Springer-Verlag Berlin Heidelberg, pp. 45–56.

Wanyama T and Far BH (2006) Negotiation coalitions in group-choice multi-agent systems. AAMAS'06, Hakodate, Hokkaido, Japan, pp. 408-410.

Wanyama T and Far BH (2007) A protocol for multi-agent negotiation in a group-choice decision-making. Journal of Network and Computer Applications 30: 1173-1195.

Westwood K and Allan V (2007) Who works together in agent coalition formation?, in: M. Klusch et al. (Eds.): CIA 2007, *LNAI 4676.* Springer-Verlag Berlin Heidelberg, pp. 241–254.

WHO (World Health Organization (2006) Emergency Report#6: Hot Mud Flood, Sidoarjo, East Java.

Zarour NE and Bouzidi S (2006) Coalition formation for cooperative information agent-based system. International Journal of Computers, Communications & Control 1(3): 85-92.

Understanding Social Recovery Process in Pangalengan Community after the 2009 West Java Earthquake: Challenges to Post-Disaster Recovery Planning

Ramanditya Wimbardana and Saut Sagala

Rural and Regional Planning Research Group

School of Architecture, Planning, and Policy Development

Bandung Institute of Technology, 40132, Indonesia

Email: ramandityawimbardana@gmail.com

Abstract

The process of recovery from disaster is usually considered by the government and many donors as physical recovery process. Sometimes, the social impact of disaster is difficult to be seen and its recovery is not fully considered within the recovery activities by government, donors, and development planners. However, recovery activities maybe unsustainable when the social aspect in community is not taken into account. Since a strong earthquake 7.3 on the Richter scale shook and struck on 2nd September 2009, community of Pangalengan Sub-District, Bandung Regency, West Java Province, Indonesia, has received many humanitarian aid relating livelihood recovery assistance. Indonesia government had completed housing reconstruction phase but Pangalengan community, especially children and elderly, still has received traumatic feeling since the disaster event. This paper provides the understanding of social recovery process in Pangalengan Sub-District after the earthquake. It is important to develop a systematic framework and experience by in depth learning and exploration on how community is recovered socially from disaster. Thus, our research applied qualitative survey by in-depth interview to vulnerable group that affected by the earthquake, NGOs, and local governments who involved into the recovery process in Pangalengan Sub-District. Observation and secondary data analysis provides social situation, recovery aid, and social assistance information that occurred in study area. . Trauma and conflict raised as the impact of the earthquake need a long term recovery process in order to return to the level of the previous condition or even difficult to achieve the same level.
Keywords: West Java Earthquake, Pangalengan Community, Social Impact, Social Recovery, Vulnerability.

Introduction

An earthquake hit and shook the southern part of Tasikmalaya District, West Java Province, on 2nd September 2009 by a magnitude 7.3 Richter scale (Bappenas, 2009). The impacts of earthquake are multifaceted, including loss of family members, loss of homes, properties, livelihoods and community infrastructure, displacement and relocation in temporary homes and shelters. This earthquake event resulted 81 people were killed, 1,287 people were injured, 194,719 people were left homeless, and 259,926 houses were damaged in West Java Province (Bappenas, 2009). The earthquake caused an estimated Rp 7,9 billion in damage which the worst damage and loss suffered by the housing sector with total damage and losses of Rp 6,9 billion (Bappenas, 2009). Many infrastructure units and public facilities suffered minor damage and severe damage in all districts/cities of

West Java: 1,221 units of schools, 2,859 religious buildings, 202 units of health facilities, and 325 units of office buildings (WHO, 2009). Felt hardest in Bandung District, the earthquake resulted in 23 deaths and over 771 injuries, and 51,102 dwelling units' uninhabitable (Bappenas, 2009).

Many people survive the initial disaster, but then suffer after it, as the economy stagnates, social networks weaken, and health care and support services decline (Olshansky and Chang, 2009). To prevent this, *Badan Perencanaan Pembangunan Nasional – Bappenas* (National Development Planning Agency) made an action plan of post-disaster reconstruction and rehabilitation that aimed to provide the same brief for every recovery program from all stakeholders (Bappenas, 2009). Unfortunately, the implementation phase of West Java's post-disaster reconstruction and rehabilitation action plan just took a short term time or it was less than three years (2009-2011). Many researchers argues recovery is not only a process with short term restoration, but also it need long-term restoration of the community to get back to normal function (Olshansky and Chang, 2009; Tobin, 1999). It must be considered by planners who will plan recovery planning because the physical and economic recovery from disasters may take a couple of years, but the psychological trauma can last for decades. What is needed is a greater understanding of social impacts and how to community recover from it (Aldrich, 2008; van Hoebrouck and Sagala, 2010). A better understanding of disasters social impacts and its recovery can provide the development of recovery plans to prevent long-term consequences from occurring (Lindell and Prater, 2003; Olshansky et al., 2006). It is important because effective recovery from disasters depends not just on physical impacts of the event but also on how the social environment supports the complex and protracted process of recovery (Johnston et al., 2009).

Ironically, there have been lacks of data that provide information about social recovery in West Java community since the implementation phase of action plan finished in the end of 2011. The only one of social recovery data in West Java community is a community recovery service of psychosocial and economic household for earthquake victims that held by *Badan Penanggulangan Bencana Daerah - BPBD* (Regional Disaster Management Agency) of West Java and *Institut Pertanian Bogor - IPB* (Bogor Institute of Agriculture) in 2011. Unfortunately, not all community in affected area received it. Community of Pangalengan Sub-District in Bandung District is one of them, whereas they are the highest number of Internally Displaced Person (IDP), almost 46,000 people, among another sub-district in West Java (UNOCHA, 2009). The number of housing units damaged by the earthquake in Pangalengan Sub-District resulted 1,810 were destroyed, 6,375 units were severely damaged, and 13,730 were minor damage units (Bandung District Disaster Management Task and Coordination Force, 2010). In fact, the amount of damage suffered by a community, which could determine the pace of recovery (Aldrich, 2008). The harder impact areas will recover more slowly than they have only minor devastation who require less time to so.

However, the key question is: how Pangalengan communities recover from their social impact that caused by the 2009 West Java Earthquake? The purpose of this study is to understand social recovery in Pangalengan community after the 2009 West Java earthquake. First, our research explores the social impact of Pangalengan community that caused by the earthquake disaster. Second, our research explores how Pangalengan community recovers from their social impact. It is important to understand how to Pangalengan community could recover from the social impact of the disaster, because they can give us about problems that they faced to recover widely and how the most suffered community can recover from their impacts. Our findings are useful to answer about speed and deliberation in post-disaster recovery planning. Our research gives new perspective in recovery process, because almost recovery process has been concentrated on physical or structural recovery (Aldrich, 2008). This article proceeds as follows: First, this paper outlined some theoretical background that focused in social impact and social recovery. The third part of this paper gives information of study location. Then, the fourth part of this paper discusses our findings in Pangalengan community. The article concludes the findings and some policy recommendations for governments and non-governmental actors.

Social Recovery Framework

Vulnerability has been proposed by many scholars as the key to understand the scale of disaster impact and the root of changed condition after disaster that cause by natural hazard (Bankoff, 2003; Cutter et al., 2003; Morrow, 1999; Nigg, 1995; Wisner et al., 2004). Vulnerability involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk o by a discrete and identifiable event (or series or 'cascade' of such events) in nature and in society (Wisner et al., 2004). It is inferred with a condition of community for potential for disaster impact that caused by natural event. Unsafe condition is not only the influence of physical, economic, and social susceptibility in community, but also there is an exposure from natural hazard (Cutter et al., 2003; Lindell and Prater, 2003; Wisner et al., 2004).

Morrow (1999) and Wisner et al., (2004) said that the impact of natural event is determined by access to resources stratification in pre-impact condition. It is influenced by dynamic process of society environment that related to past and present socio-economic process and political decision making. Access involves the ability of an individual, family, group, class or community to use resources which are directly required to secure a livelihood in normal, pre-disaster times, and their ability to adapt to new and threatening situations (Wisner et al., 2004). Morrow (1999) categorized four resources that influence community vulnerability: economic resources, personal resources, family and social resources, and political resource. However, there are some social group who has limitation to access these resources, so it put them in risk situation. Access to such resources is always based on social and economic relations, including the social relations of production, gender, ethnicity, status and age, meaning that rights and obligations are not distributed equally among all people. People earn a livelihood with differential access to material, social and political resources to get back to "normal life" after disaster. Wisner et al., (2004) drew this concept as "Access Model".

Lindell and Prater (2003) drew a model to described impact of disaster. In this model, the physical impact of disaster is the primary forms of devastation – causalities and damage – by natural hazard and this it is more observable than social impact. The physical impacts of disasters include casualties (healthy, deaths, and injuries) and structural damage (infrastructure, public facilities, properties, etc) (Lindell and Prater, 2003; Wisner et al., 2004). The physical impacts of a disaster are the most observable and easy to measure, whereas social impact can develop over a long period of time and can be difficult to assess when they occur (Lindell and Prater, 2003). Our research explores the social impact of disaster and gets depth learning how community recovers from it. Thus, our research developed a framework of social recovery for our research that adapted from Lindell's and Prater's (2003) Disaster Model Impact, Morrow's (1999) vulnerability resource categories and Wisner's et al., (2004) Access Model (Figure 2).

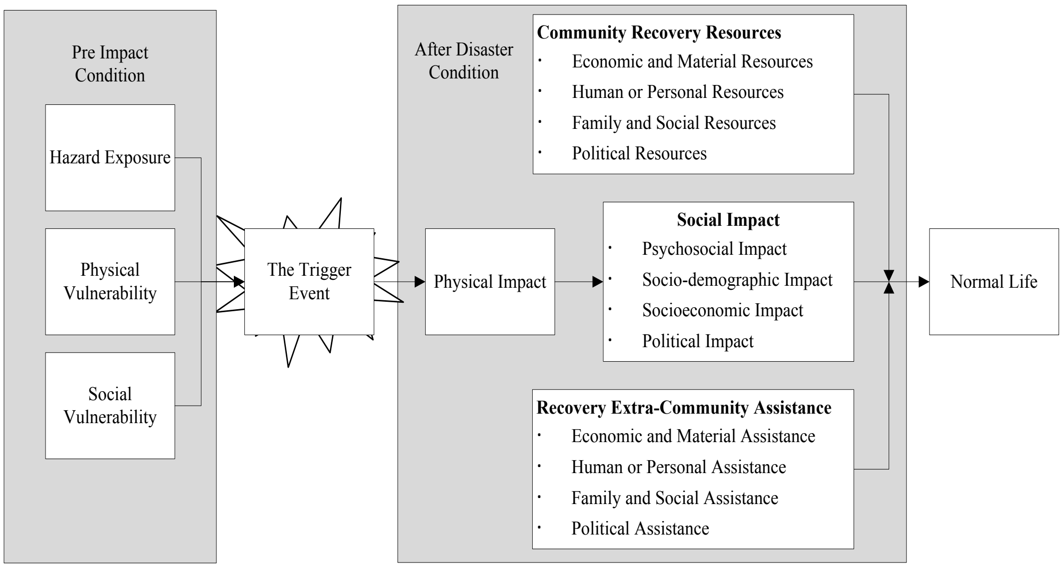


Figure 1 Social Recovery Frameworks *(Source: Adapted from Lindell and Prater (2003), Morrow (1999), and Wisner et al., (2004))*

1. Social Impact

Lindell and Prater (2003) categorized their social impacts into psychosocial, demographic, socio-economic, and political impacts. Despite it is difficult in measuring the social impacts, it is nonetheless important to monitor them because they can cause significant problems for the long-term functioning of specific types of households and businesses in an affected community (Lindell and Prater, 2003). Psychosocial impact includes fatigue, gastrointestinal upset, confusion, impaired concentration, attention deficits, anxiety, depression, and grief. They also include behavioural effects such as sleep and appetite changes, ritualistic behaviour, and substance abuse. There are population segments requiring this special attention. These include children, frail elderly, and people with pre-existing mental illness, racial and ethnic minorities, and families of those who have died in the disaster (Lindell and Prater, 2003). Since six years after devastating tsunami in 2004, Aceh's and Nias's community still have felt traumatic feeling of losses and disaster event, especially IDPs group who experienced more substantial post-disaster changes in life circumstances (impact) (Irmansyah et al., 2010).

The main demographic impact of disasters is destruction of household dwellings (Lindell and Prater, 2003). They have to face many problem during they build back their house, such living in temporary shelters, logistic and aid distribution problem, living in temporary house with non-preferred location and structures, and limitation of resources for building back permanent house (Lindell and Prater, 2003). There are also an increase number of emigrations of population segments that have lost housing (Cutter et al., 2003). In many cases, people who lost their home sometimes left their neighbourhood - leading to "ghost town" for temporary reason, such traumatic feeling, loss of job or community assistance, and conflict. It can be circumstances for housing reconstruction. This is currently particularly visible in New Orleans following Hurricane Katrina which 30% of the population of New Orleans has not yet returned for three year since Katrina, and permanent repairs to infrastructure have just begun after they came back (Olshansky and Chang, 2009).

The main socio-economic impacts of disasters are direct economic losses in damaged properties or assets (Lindell and Prater, 2003). Some of these cannot be replaced, so their loss causes a reduction in consumption (a decrease in the quality of life) or a reduction in investment (a decrease in economic productivity). Other assets are replaced—either through in-kind donations (e.g., food and clothing) or commercial purchases. There are indirect losses that occur from the interdependence of community subunits. The relationships among the social units within a community can be described as a state of dynamic equilibrium involving a steady flow of resources, especially money (Lindell and Prater, 2003). The relationships among the social units within a community are defined by the money it must pay for products, services, and infrastructure support. This money is obtained from the wages that employers pay for the household's labour. Similarly, the linkages that a business has with the community are defined by the money it provides to its employees, suppliers, and infrastructure in exchange for inputs such as labour, materials and services, and electric power, fuel, water/wastewater, telecommunications, and transportation. Conversely, it provides products or services to customers in exchange for the money it uses to pay for its inputs.

There are some cases that disaster impact can cause dynamic social activism that bring it to political disruption during period of disaster recovery (Lindell and Prater, 2003). Many cases of political impact is related to social relationship conflict between people at different level, such relation within household, between men and women, children and adults, and between citizens and their government (Wisner et al., 2004). Some victims usually attempt to recreate pre-impact housing patterns, but it can be problematic for their neighbours if victims attempt to another housing patterns. Conflicts arise because such housing usually is considered to be a blight on the neighbourhood and neighbours are afraid the "temporary" housing will become permanent (Lindell and Prater, 2003). After the disaster, many communities were divided into tented camps, host communities and barracks, which contributed to an erosion of community cohesion (Steinberg, 2007). Just when it was most urgently needed, the capacity of communities to come together, comfort each other, and start the rebuilding of lives was badly battered. There are exceptions to this generalization because some ethnic groups have very close ties to their neighbourhoods, even if they rent rather than own (Lindell and Prater, 2003). Vietnamese community in Village de L'est, New Orleans, showed a community with deeper connections which stay in touch during and after the disaster are more likely to work together to rebuild their neighbourhoods *(Aldrich, 2008).* Attempts to change prevailing patterns of civil governance can arise when individuals sharing a grievance about the handling of the recovery process seek to redress that grievance through collective action (Lindell and Prater, 2003). Usually, community action groups pressure government to provide additional resources for recovering from disaster impact.

2. Social Recovery

Lindell and Prater (2003) categorized resources that they are used recovery process into community recovery resources and extra-community assistance. Community recovery resources can come from a variety individuals and Community Based Organizations (CBO). The victim might have financial asset (e.g. savings and insurance) and tangible asset (e.g. property) that undamaged by hazard impact. Lindell and Prater (2003) said there are also another way to bring additional resource through overtime employment and freeing up the needed finds by reducing their consumption. Friends, relatives, neighbours and CBO can contribute financial resource and help the victim with in-kind contribution. Extra-community assistance can come from NGOs, regional governments, national government, and foreign government. They can provide financial resource and financial assistance that do not need repaid by the victim or loans that might be offered at below market interest rates.

Morrow (1999) categorized resource that community need to recover socially: economic resources, personal resources, family and social resources, and political resource. These are used by household, government, and NGO to marshal the necessary resource to respond the impact of disaster (Morrow, 1999). Economic resources related the poor household who has limited economic and material resources. They commonly have insufficient financial for buying service and materials aftermath. The poor typically builds house poorly and insufficient material house, moreover they have to place their house in vulnerable location and less access to relief supply depots and disaster assistance centres (Morrow, 1999). Number of unemployment also increases when many business close or move after disaster, so low-income workers are difficult to get new job (Lindell and Prater, 2003; Morrow, 1999; Olshansky and Chang, 2009). Economic resource can be recovers with financial assistance through grants for buying service and materials in aftermaths. Some of the specific mechanisms for financing recovery include obtaining tax deductions or deferrals, unemployment benefits, loans (paying back the principal at low- or no-interest), grants (requiring no return of principal), insurance payoffs, additional employment, depleting cash financial assets (e.g., savings accounts), selling tangible assets, or migrating to an area with available housing, employment, or less risk (in some cases this is done by the principal wage earner only) (Lindell et al., 2006).

Household possess different personal resources: health, physical ability, personal experience, education, time, and skills (Morrow, 1999). The elderly is more likely to need disaster-related assistance with health, physical ability, and economic resources, because they are frail and/or poor and be slower to recover. Children also lack adequate for family supports, because they parents loss time and money caring for children. Physical and mentally disabled group has disability work, mobility disability or self-care limitation. These groups are likely to get psychological effect of disasters. These groups require psychiatric diagnosis and most benefit more from a crisis or trauma counselling (Lindell and Prater, 2003; Morrow, 1999). Single parent families and large families are likely to love on the economic margins and the rising cost of recovery. The personal experience, education and skills possessed by household can significantly influence it recovery, such as better preparedness and appropriate behaviour for future disaster response, gaining access to resources, better employment opportunities, dealing with bureaucracies and many more (Morrow, 1999).

Family and social resources related with social networks and kinship embeddedness (Morrow, 1999). Disaster may disrupt social cohesion and social networks among member of community (Aldrich, 2008; Lindell and Prater, 2003; Steinberg, 2007). Lack of family and social networks can be a limiting factor to seek recovery assistance. New emergence of recovery concept brings social capital into community recovery process (Aldrich, 2010; Nakagawa and Shaw, 2004). It brings the potential role of social networks and civil society in explaining the speed of post-crisis recovery. Recently, scholars have sought to link the speed and effectiveness of the process of recovery to levels of trust and social capital—that is, the resources available to individuals through their social networks. In some cases, the amount of social capital most strongly determines recovery rates (Adger, 2003; Aldrich, 2008). Social capital can serve as informal mechanisms allowing victims to support networks for the sharing of knowledge, the sharing of financial need, the sharing of market information, the sharing of logistic and physical assistance, and claims for reciprocity in times of crisis (Adger, 2003; Aldrich, 2010). Furthermore, social capital may drive into community collective action for recovery, although capable agencies are also required (Nakagawa and Shaw, 2004). The disaster recovery period is the source of victim dissatisfaction and this creates many opportunities for community conflict. This conflict typically manifests itself indifferences in emphasis regarding a task (material/economic) versus social-emotional (interpersonal relationships/emotional wellbeing) orientation toward recovery activities (Lindell and Prater, 2003). In many cases, recovery of this political impact is facilitated when neutral recovery organizations hire local mediator to provide a link between these conflicted communities (Berke et al., 1993).

Methodology

1. Location

Pangalengan Sub-District is a highland area (1400 m) where it is located in southern part of Bandung District, 40 km from capital city of West Java Province, Bandung. It has 13 villages: Wanasuka, Banjarsari, Margaluyu, Sukaluyu, Warnasari, Pulosari, Margamekar, Sukamanah, Margamukti, Pangalengan, Margamulya, Tribaktimulya, and Lamajang, where they are surrounded by four mountains: Mt. Malabar (2,321 m), Mt. Wayang (2,182 m), Mt. Windu (2,054 m), and Mt. Tilu (2,042 m). According to the *Badan Pusat Stastik – BPS* (Centre of Statistic Agency) Bandung District in 2010, the population was 146,578 and population density is concentrated in Pangalengan and Sukamanah Village. Pangalengan Sub-District area (27,294 Ha) has characteristic of rural area which the majority of inhabitant's occupations are farmer and it is popular agricultural area with milk, tea, and coffee for economic primary production in West Java area. There are also several private industries related gasoline and geothermal mining in Pangalengan Sub-District.

West Java Province is prone to tectonic stress on region offshore and on the land of Java, thus causing the formation of earthquake to fault zones to accommodate the plate movement (Abidin et al., 2009). There are three active faults in mainland of West Java, namely Cimandiri, Lembang and Baribis faults and it is located near subduction-zone of Australian-Oceanic plate in the southern part. There is several large earthquakes happened in West Java. The 2006 Pangandaran Earthquake triggered a tsunami wave and it hit along southern West

Java coastal area. On 2nd September 2009, an earthquake shook West Java by a magnitude 7.3 Richter scale. The most devastated significant damaged area is Bandung District and Tasikmalaya District where the epicentre of earthquake is located near southern part of Tasikmalaya on region offshore (Bappenas, 2009).

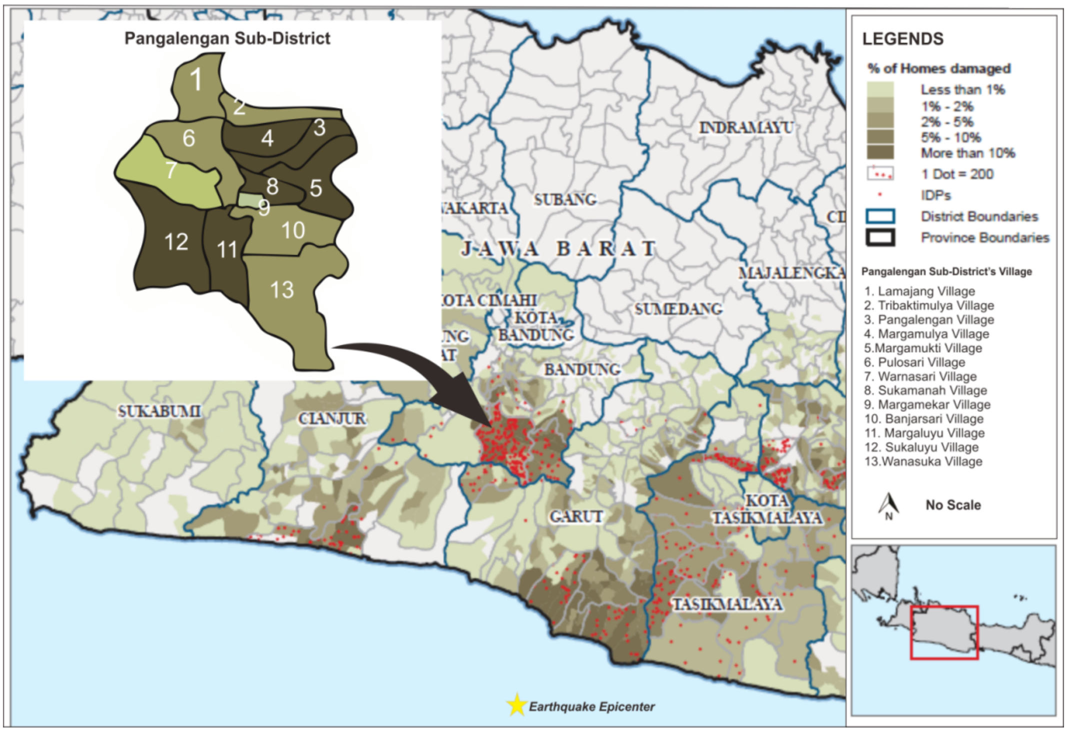


Figure 2 Percentage of Homes Damaged *(Source: Modified from UNOCHA (2009) and Bandung District Disaster Management Task and Coordination Force (2010))*

Our research took in four villages: Sukamanah, Pangalengan, Margamulya, and Margamukti. Those villagers suffered housing units damaged heavier (Margamukti: 1,631 houses, Sukamanah: 4,028 houses, Pangalengan: 4,231 houses, and Margamulya: 2,521 houses) than others village in Pangalengan Sub-District that caused by the 2009 West Java Earthquake (Figure 3). They are also the highest density area in Pangalengan Sub-District area and they are passed by Bandung – Garut main road. The current study want to understand how the most suffered community can recover from their social impact, so we chose those villages.

2. Data Collection and Analysis

To understand social recovery process within Pangalengan community from the 2009 West Java earthquake event that had not been discovered before, our research applied qualitative survey by in-depth interview to the members of community, NGOs, and local governments who involved into the social recovery process in Pangalengan community. The rationale reason our research applied qualitative study because it shares a common flexibility and deep understanding about what is happening in a setting or how the participants perceive of their world. It was considered because some regions may be more or less susceptible to the impacts of hazards than other places based on the characteristics of the people residing within them (Cutter and Emrich, 2006). Each community also has different ways to recover from their impact which they can recover quickly or slowly (Aldrich, 2008).

This research applied macro level approach where the information sources were based from mass media (online, local, and national newspaper), studio survey report which it conducted by undergraduate students of ITB Urban and Regional Planning program in Pangalengan Sub-District on 23 - 28 April 2012, and governmental documents (Fife, 2005). Governmental documents include The Post-Earthquake Disaster Action Plan for Regional Rehabilitation and Reconstruction in West Java Province and Cilacap Districts in Central Java Province by Bappenas (2009) and Psychosocial and Economic Assistance for the 2009 West Java Earthquake Victims Report by IPB and BPBD of West Java. Micro approach data gathered through field observation and in-depth interview. On 1st March 2012, a preliminary observation of the area was conducted for understanding of the specific locality and social situation information after the earthquake event. In this preliminary observation, we interviewed a NGO official, village officials, and local community members. They were very helpful to discover early finding about social impact of Pangalengan community and their approach to recover from it. Their information was useful to set a semi-structured interview for the field work. Primary data collection method is conducted on 8 - 10 May 2012 through in-depth interviews and field observation.

Our research explores the social impact of Pangalengan community that caused by the earthquake disaster. Further, we related the numerous social impacts within Pangalengan community based on at-risk group (Morrow, 1999) and their vulnerability characteristics by Morrow (1999) and Cutter et al., (2003). Purposive sampling technique was used to discover social impact within Pangalengan community members that caused by the earthquake event in 2009. The participants were chose from social group in Sukamanah, Pangalengan, Margamukti, and Margamulya Village who reflects highly vulnerable characteristic. We also consulted with local leaders and leader of village officer to recruit potential participants in each village. Recruitment strategies are determined by the type of at-risk group and characteristic of earthquake victims in their reports. Unfortunately, we could not find all of at-risk group because there was lack of information about their existence in each village from our key informants as well as we looked for them alone then. For the result, we found several at-risk groups: elderly (n = 8), children or youth (n = 8), poor household (n = 24), large household (n = 24), and single parent household (n = 12).

The interviews were semi-structured, open-ended, and directly related to main information which gave the interviewees more freedom to narrate their experience with flow. Based on our social recovery framework, we made our interview into two sections: social impact and social recovery. In the social impact section, we asked: (1) What did you feel after the earthquake event? Did you feel any traumatic feeling and health problem? (2) What is your main problem when you built back your livelihood after the earthquake event? Have you ever thought that you want to migrate to another place since the earthquake event? (3) What are your financial, economic, and material losses that cause by the earthquake event? (4) How was your relationship with others in the village and office village after the earthquake? Was there a problem of communication and trust for each other after the earthquake? In the social recovery section, we asked: (1) How did you do to recover from your traumatic feeling and health problem? (2) How did you do to build back your livelihood after the earthquake event? (3) How did you do to recover and resolve financial and economic problem after the earthquake event? (4) How did you do to fix your relationship with others in the village and office village after the earthquake?

In-depth interview result recorded by tape recorder and systematically arranged in transcript then. Because of the broad nature of the qualitative data, a sorting process followed, with segments of each interview placed in various content categories. We did a triangulation of different data resources, because it may also enhance the quality and reliability of the data. The qualitative data analysis focused on the content of participant statements. The final goal is to combine information patterns into wider and more objective analysis patterns.

Findings: Social Impact and Recovery

Psychosocial

Our research indicate that all of participants are still suffering traumatic experience that caused by the 2009 West Java Earthquake. There are many typical traumatic experiences, such as fear and anxiety of future earthquake likelihood, concentrate problem, blank feeling, grief, and depression. All of households feel afraid, fear, and worry about future earthquake, includes children and elderly. Some of participants feel much better within three-six months after the event, but others recover more slowly, and some of them showed that they do not recover enough without help. Becoming more aware of the changes you've undergone since your trauma is the first step toward recovery. There are many behaviours that they showed about traumatic of earthquake past experience and anxiety of future earthquake:

"There is always a ground shaking when a big truck passed away in front of our house. We are panic and afraid if that vibration is an earthquake." Man. 73. Elderly. Sukamanah Village.

"When there a big truck passes away near our school, there is always a strong shaking. Without realizing it, we always jump out of the classroom. We fear that the 2009 earthquake event will happen again" Girl. 14. Junior High School Student. Margamulya Village *(Source:(Inilah.com, 2011)*

There are also victim who feel increased arousal. This includes feeling jumpy, jittery, shaky, being easily startled and having trouble concentrating or sleeping. Continuous arousal can lead to impatience and irritability.

"I and my family have never slept in bedroom since the earthquake event. We always take a sleep in living room, because we are afraid that future earthquake will occur when we take a sleep..." Man. 42. Poor Household in Sukamanah Village.

"I could not concentrate in working when I was in the field for three months since the earthquake event. I was very worried about of earthquake likelihood and I left my family in home. When I felt like this, I decided to go home earlier" Man.46. Large household. Sukamanah Village.

"I used to feel blank in my mind for six months after the earthquake event" Woman. 32. Poor household. Pangalengan Village

Grief and depression are also common answers of participants. This can include feeling down, sad, hopeless or despairing. Some of them lose interest in people and activities you used to enjoy. They feel that plans you had for the future don't seem to matter anymore, or that life isn't worth living.

" I have had liver sick since the earthquake event. I do not have any money to go to the doctor because my savings is used to buy material and build back our house. I confuse how to get money for heal my sickness, so I just wait for miracle in home" Man. 52. Poor Household. Sukamanah Village.

There are many ways for community to recover from their psychosocial impact. Since there has been lack of psychosocial recovery assistance in Pangalengan community, they strive with self-help method to recover from it. Almost participants try to close with their God. They usually pray to forget the earthquake event and calm down their traumatic feeling. However, there are the only one NGO's who is still doing their psychosocial recovery program in Sukamanah Village, namely Hope Asia Foundation. They have three social workers who work for children and elderly psychosocial recovery from earthquake traumatic feeling. They help elderly and children with traumatic assistance every day. Many of them are victim by their household. They lack adequate for family supports, because their household or parents loss time and money caring for them.

"Since the earthquake event, I have felt trauma of it. To forget it, I always go to Mosque every Adzan (call for praying). I had rarely gone to Mosque for praying before the earthquake event. When I am there, I have more peaceful feeling and I forget about my traumatic feeling slowly." Man. 73. Elderly. Sukamanah Village.

"We help children and elderly who had have lack adequate for family supports since the earthquake event. Their household or parents loss time and money caring for them. They are too busy to look for some money to get recover from the disaster. We help these group to recover from their traumatic feeling that they do not have adequate traumatic feeling assistance." Social Worker. Man. 23. Hope Asia Foundation.

However, there is positive impact of the disaster event. There are many changed behaviours to face and prepare future earthquake that they did not do it before the 2009 West Java earthquake.

".... If we sleep in living room and there is an earthquake, we could run outside house quickly" Man. 42. Poor Household in Sukamanah Village.

"I made a simple earthquake warning system alarm with my electronically skill. It was ringing when there was a ground vibration or an earthquake" Man. 48. Large Household. Sukamanah Village

Socio-Demographic

The main Pangalengan community's demographic impact is destruction of household dwellings. There also problems that there were some people in the study locations who wanted to relocate (Yasaditama and Sagala, 2012). Their traumatic feeling brought them to migrate to another area. However, they have limitation with their capacity and opportunities, so they are very hard to leave their place. Further there are almost no more options to move their house location if they still survive in their each study locations. For that, people tend to re-build their houses in the same location or at least next to the remnant of their damaged old building which cannot be totally cleaned.

"Soon after the earthquake, there is a strong desire to move out from Pangalengan. It is caused by how such big impacts that we had received by the 2009 earthquake. But in line with the running time, that feeling disappear significantly because we finally realize with our limitation of financial and capacity-opportunity to get work." Beneficiary (Source: Yasaditama and Sagala, 2012)

Different cases are only found in Sukamanah Village, Pangalengan. Until now even some refugees are still living in temporary relocation place there, at the Walatra plantation land owned by government (PTPN Walatra) (Yasaditama and Sagala, 2012). In the other side, in 2011 government actually had provided a permanent relocation place not far from the current location, even though at this time there are some refugees who had been occupied. Those people do not want to occupy the provided location because of the incompatibility reason (Yasaditama and Sagala, 2012). They assumed that the location is less access and steep in some area, so it has potency for landslide in the future. In the other side, the District Government stated that the choice of location is had been preceded by the study. This confusion, according to some informants is more because there were some decisions maker were took in hurry condition and they not involved targeted people.

"Actually, our land has been preceded through an initial review and study, even the provision of the settlement facilities and infrastructures has also been planned at that location. Indeed, in many times we had ever been recommended or even accused by some sides to immediately provide the permanent location."
Pangalengan Sub-District Secretary (Source: Yasaditama and Sagala, 2012)

However, there are some cases of pillage after the earthquake event that several victims took everything in many people's damaged house graveyard, such as a door, bricks, a couch, a cupboard, electronic device (such as television, radio, etc), and another home furnishing that it can be used again. They took this for their material and resources for build back their house or they sold it to get some money from it. Several participants realized that they could not prevent this crime, because they knew everybody needed it in that time and there was chaos condition after the earthquake event.

" When the emergency time, there was very dark in the night because the electricity had not turned on yet. In that time, there are many victims who took home furnishing in people's damaged house. They are my neighbors and I know them very well. Before I built a tent, I saw that they was taking my home furnishings and I have lost my door, some wood material, and some roofs. I could not prevent it, because I realized that we needed it in that time. But I wanted to protect my properties more, so I built a tent to protect my home furnishing in front of my damaged house and I had lived in it for two months." Women. 49. Poor Household. Pangalengan Village

Socioeconomic

The main problem of Pangalengan community's socio-economic impacts are direct economic losses in damaged properties, mainly house. Since the 2009 earthquake, West Java community has received financial assistance for housing damage by Indonesia government. Applied mechanism is with dividing the impacted people into three categories based on high level of damaged house, namely heavy damaged, moderate level and minor damaged. Further, each victim has different amount of received financing assistance based on their level of housing damaged: (1) Heavy damaged house victim got Rp 15.000.000, (2) Moderate damaged house got Rp 10.000.000, and (3) Minor damaged house got Rp 1.000.000 (Bappenas, 2009). Yasaditama and Sagala (2012) found demographic impact in Pangalengan community. In their findings, Pangalengan community regret that the amount of received assistance is still lacking for every category. Although damaged category based on observations both by government and also researchers, the amount of received assistance was relatively enough. Community is used to hope that it was included non-housing. However, it did not like community expected. It was realized that government wanted the affected population could rebuild their own house as soon as possible, but, in other side, government have problem in recovery funding.

"The financial assistance for damaged house was only as a stimulant for impacted people in order to be more motivated them to rebuild their damaged houses. In addition definitely government has no capability in covering all of this housing financing assistance alone." Pangalengan Sub-District Secretary (source: Yasaditama and Sagala, 2012)

The other assistance mechanism, which divides the distribution into 2 phases (9 months and 15 months after the disaster, for moderate and high damage categories only), also often create problem among the beneficiaries (Yasaditama and Sagala, 2012). For most people in the study area, this phased mechanism can be severely hampered their house reconstruction process. People have a preference to be able to quickly re-occupy their houses, so in the end they unconsciously tend to not only depend on government assistance alone. For small portion people, this can then be handled through self-financing mechanism:

"We can't build a house by half to half, how could it be? for example in phase 1 we build wall first, then in phase 2 a few months later we had already added our house with a roof. In other side we also can't continue for more time to wait in refugee camps because we can't did our activities normally. To anticipate this, we sometimes borrow amount of money from relations and also as could as possible to set apart our income". Beneficiary (source: Yasaditama and Sagala, 2012)

In study locations there are only found a few donors who participated in the housing recovery process (Yasaditama and Sagala, 2012). In District Pangalengan for example some donors involved include the Habitat Indonesia, ITB, and Yayasan Ibu. Especially Habitat Indonesia, their contribution was even in the direct form of totally housing units rebuilding to several beneficiaries who meet their criteria. This is quite different with the other donors who only give indirect assistances such as building materials, equipment and technical guidance.

Pangalengan community seems unprepared to face this disaster. It can be seen that almost participants do not have any savings account or asset which it can be used when the disaster occurred. Whereas, their expenditure for buying service and material was increase when the recovery process too. They had two choices to recover from financial impact: they waited for financial assistance from government first, or they looked another financial resources, such from their relation or credit scheme from the bank. They also have lost many home furnishing that broken by earthquake or struck down by building construction. They replaced it with the new one or repaired it. Even they have to buy new one, they bought it with credit scheme. Participants who is not a farmer, such merchants and businessman, need some financial capital for their business recovery. They also used credit bank scheme or relation financial resources. They must pay back for those financial resources in the future. Unfortunately, they have not had any saving since the earthquake yet. It can be financial susceptibility for the future disaster.

"I bought new to replace my ex-home furnishing which it cannot be repaired and I repaired one which it can be repaired. Unfortunately, I bought or fixed it with credit scheme from the bank by my relation network, because I did not have any money or saving and any collateral at that time. I did it too for deficit financial of housing reconstruction." Man. 48. Large Household. Sukamanah Village

"I used credit scheme from the bank to get a new financial capital by my relation network. I need this resource to open my store in Sukamanah market again after the earthquake event. The market was empty from buyers and I did not received any money for three months " Man. 48. Large Household. Sukamanah Village

Political

In the logistic distribution process, there are some distrust between residents and local leaders. Since the material distribution was limited, there are some perceptions by the victims that the materials were kept by the local leaders which was only distributed among their family members. Conflict is also found in the use of land for relocation that we discussed in socio-demographic section. While some people were given temporarily location by government owned plantation company for shelter, the residents kept staying in the relocation since the land is better than their previous location. This has caused some conflicts between the residents and the plantation company. There is also a conflict related to the distribution from some NGOs that are from different religious organization. Due to the belief of some leaders, the residents were forbidden to receive relief distribution.

"When we informed logistic distribution through Mosque's speaker, there were many miss understanding between member of community. In this neighborhood, there is a Moslem CBO who take a role as leader. They replaced the role of our neighborhood leader to manage logistic distribution. Christian community did not allow to get any logistic, because there was an issue many that Moslems in our village have changed their religion into Christian since the earthquake. There was a Christian organization who wanted to give 60 house unit to our villagers, but a community in our village rejected them. Finally, several household migrated to another area because this situation." Women. 49. Poor Household. Pangalengan Village

In the recovery process, the role of government as the main actor is very important. This also includes role of government in coordination with other stakeholders, such as communities, NGOs and private actors. Conflicts normally occur when there mis-understanding and not clear collaboration and agreement between actors. In the case of land conflict, government should have had provided the clear agreement between the residents and the plantation company that the land can only be used temporarily. In mis-understanding on the relief distribution, government can take role as the main actor to collect the aid and distribute it to the communities. Unfortunately, we cannot find evidence in Pangalengan Sub-District that some political assistance to solve this problem.

Conclusion

The paper has discussed that the social impact of earthquake in Pangalengan Sub-District and some strategies that can be used for lessons learned. The social impacts experienced by the community were assessed from psychosocial, socio-demography, socio-economic and political impacts. These kinds of impact in many cases are often omitted since many stakeholders focus much on physical and economic (*livelihood*) recovery. Trauma and conflict raised as the impact of the earthquake need a long term recovery process in order to return to the level of the previous condition or even difficult to achieve the same level. Understanding this information will help government and development planners to create some basic guiding principles for recovery process after a disaster. Based on this research, this paper suggests including social assessment of the earthquake prior to the logistic delivery that is through the involvement of social capital e.g.: trust & leadership, indigenous knowledge, collective works and social networks. In addition to that, the roles of local leaders, both formal and informal are needed in order to smoothen the process of goods and material distribution. This is also important to maintain the social capital that exist in the society as condition before the earthquake disaster. Role of NGOs and local governments can be enhanced when integrated with this existing social capital.

References

Abidin, H. Z., Andreas, H., Kato, T., Ito, T., Meilano, I., Kimata, F., Natawidjaya, D., and Harjono, H. (2009). "Crustal Deformation Studies in Java (Indonesia) Using GPS." *Journal of Earthquake and Tsunami* 3(2), 77-88.

Adger, N. W. (2003). "Social Capital, Collective Action, and Adaption to Climate Change." *Economic Geography*, 79(4), 387-404.

Aldrich, D. P. (2008). "The Crucial Role of Civil Society in Disaster Recovery and Japan's Preparedness for Emergencies." *Japan Aktuell*, 3, 81-96.

Aldrich, D. P. (2010). "The Power of People: Social Capital's Role in Recovert from the 1995 Kobe Earthquake." *Nat Hazards*, 56, 595-611.

Bandung District Disaster Management Task and Coordination Force. (2010). "Number of Housing Damage in Pangalengan Sub-District." Bandung District Disaster Management Task and Coordination Force, ed., Soreang, Bandung District.

Bankoff, G. (2003). "Vulnerability as a Measure of Change in Society." *International Journal of Mass Emergencies and Disasters*, 21(2), 5-30.

Bappenas. (2009). "The Post-Earthquake Disaster Action Plan for Regional Rehabilitation and Reconstruction in West Java Province and Cilacap Districts in Central Java Province *(in Bahasa)*." Bappenas, ed., Jakarta.

Berke, P. R., Kartez, J., and Wenger, D. (1993). "Recovery after Disaster: Achieving Sustainable Development, Mitigation, and Equity." *Disasters*, 17(2), 93-109.

Cutter, L. S., Boruff, B. J., and Shirley, W. L. (2003). "Social Vulnerability to Environmental Hazards." *Social Science Quarterly*, 84, 242-261.

Cutter, S. L., and Emrich, C. T. (2006). "Moral Hazard, Social Catastrophe: The Changing Face of Vulnerability along the Hurricane Coasts." *The ANNALS of the American Academy of Political and Social Science*, 604, 102-112.

Fife, W. (2005). *Doing Fieldwork: Etnographic Methods for Research in Developing Countries And Beyond*, Palgrave Macmillan, Hampshire, England.

Inilah.com. (2011). "Junior High School Students of SMP 1 Pangalengan Haven't Forgetten Trauamatic Feeling about the 2009 West Java Earthquake." Inilah.com, Bandung.

Irmansyah, I., Dharmono, S., Maramais, A., and Minas, H. (2010). "Determinants of psychological morbidity in survivors of the earthquake and tsunami in Aceh and Nias." *International Journal of Mental Health System*, 4(8), 1-10.

Johnston, D., Becker, J. S., Saunders, W., M., W., Commer, M., Leonard, G., and Paton, D. "Surviving Future Disasters in New Zealand." *New Zealand Society for Earthquake Engineering Conference*, Christchurch, New Zealand.

Lindell, M. K., and Prater, C. S. (2003). "Assessing Community Impacts of Natural Disasters." *Natural Hazards Review*, 4, 176-185.

Lindell, M. K., Prater, C. S., and Perry, R. W. (2006). *Fundamentals of Emergency Management*, USHDS/FEMA Emergency Management Institute, Emmistburg MD.

Morrow, B. H. (1999). "Identifying and Community Vulnerability." *Disasters*, 23(1), 1-18.

Nakagawa, Y., and Shaw, R. (2004). "Social Capital: A Missing Link to Disaster Recovery." *International Journal of Mass Emergencies and Disasters*, 22(1), 5-34.

Nigg, J. M. (1995). "Disaster Recovery as Social Recovery." Wellington After the Quake: The Challenge of Rebuilding Cities, Wellington Commission and the Centre for Advanced Engineering, Wellington, New Zealand.

Olshansky, R., and Chang, S. (2009). "Planning for Disaster Recovery: Emerging Research Needs And Challenge " *Progress in Planning*, 72, 200-209.

Olshansky, R. B., Johson, A. L., and Topping, K. (2006). "Rebuilding Communities Following Disaster: Lessons from Kobe and Los Angeles." *Built Enviroment*, 32(4), 354-374.

Steinberg, F. (2007). "Housing Reconstruction and Rehabilitation in Aceh and Nias, Indonesia - Rebuilding Lives." *Habitat International*, 31, 150-166.

Tobin, G. A. (1999). "Sustainability and Community Resilience: The Holy Grail of Hazard Planning." *Environmental Hazards*, 13 - 25.

UNOCHA. (2009). "West Java Earthquake: IDPs per Sub-District." UNOCHA, Jakarta.

Vanhoebrouck, P. and **Sagala, S.** (2010), Not so helpless victims: Social Capital Roles in the 2009 West Sumatra Earthquake Recovery, Research Report of International Federation of Red Cross and Red Crescent (IFRC), Indonesia.

WHO. (2009). "Emergency Situation Report: Earthquake in Tasikmalaya, West Java Province, Republic of Indonesia." World Health Organization Indonesia, Jakarta.

Wisner, B., Blakilie, P., Canon, T., and Davis, I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters*, Routledge, New York.

Yasaditama, H., and Sagala, S. (2012). "Rebuilding Settlements: Learning from Housing Reconstruction Process after 2009 West Java Earthquake." International Conference on Sustainable Built Environment Faculty of Civil Engineering and Planning, Universitas Islam Indonesia, Yogyakarta, 10-12 July.

Preliminary Study on Vulnerability of Common Residential Houses from Earthquake Shaking: An Assessment of Several Houses in Bantul Regency, Indonesia

Setya Winarno

Civil Engineering Department, Universitas Islam Indonesia

Email winarno@uii.ac.id

Lizda Iswari

Informatics Engineering, Universitas Islam Indonesia

Email lizda@uii.c.id

Abstract

Seismic risk of any region can be factored from its hazard and vulnerability. Currently, Indonesia is well known as one of the earthquake countries characterized by high hazard, community exposure, and vulnerability of settlements (particularly residential houses). Bantul, Indonesia earthquake in 2006 has clearly showed this disastrous phenomenon. To reduce the seismic risk in Indonesia, a study on earthquake vulnerability is important. This study provides a preliminary assessment of structural vulnerability of common residential houses from earthquake shaking. Forty common houses reinforced by practical column and beams balk in Bantul Regency were chosen as data. The houses were assumed as Reinforced Masonry Bearing Walls or RM2L (Hazus category) and situated in Alam Citra, Sewon Indah, and Sewon Asri. House owners were interviewed to collect qualitative information on their house condition before and after the earthquake in 2006. The qualitative data were then analyzed via Fuzzy Analythic Hierarchi Process (FAHP) to get the probability of their house damages, consisting criteria of slight, moderate, extensive, and complete. Combining the probability damages and its relevant peak spectral displacement (Sd) as earthquake hazard due to the Bantul earthquake, it can be depicted a common vulnerability of the RM2L common houses. The study reveals that the peak spectral displacement among the houses is relatively same. The average peak spectral displacement is 2.05 inch. The average assessment of damage probability shows 0.86 of slight damage, 0.72 of moderate damage, 0,41 of extensive damage, and 0.11 of complete damage. These figures are 14.11% higher (more vulnerable) than that of RM2L by Hazus category.

Keywords: earthquake damage, vulnerability, common house.

Introduction

Looking at the last few decades, the losses caused by natural catastrophes have increased dramatically in Indonesia, particularly due to earthquakes. Based on the Indonesian Seismic Zonation, Indonesia has almost 60% of the cities and urban areas located in the relatively high to very high seismic zone, around 290 cities out of 481 cities in Indonesia (IUDMP 2001). The losses have been particularly inflicted by the collapsed house, which is claimed more than 55% in total. Bantul and Padang, Indonesia earthquake in 2006 and 2010 respectively, which destroyed more than hundreds houses in average, has demonstrated that large numbers of houses in Indonesia are not earthquake resistant (BAPPENAS 2006).

In general, reasons for the increased losses certainly include the increase in Indonesia population and the high demand of residential houses. Many of which are located in zones of high seismic hazard. Additionally, the seismic risk is much higher for residential houses due to an incompatibility of structural vulnerability with local earthquake hazard.

In order to reduce the risk, a reliable earthquake vulnerability model for houses under consideration needs to be compiled, in such that the future losses due to earthquakes can be determined with relative accuracy. In developed countries, the study of seismic vulnerability is relatively mature. In USA, Federal Emergency Management Agency (FEMA) has made HAZUS (Hazard US) to be a valuable tool in promoting a broader understanding of earthquake vulnerability and potential earthquake losses and in helping to build a community consensus for disaster loss prevention and mitigation (FEMA and NIBS, 1999).

The understanding of house earthquake vulnerability is not only of interest for an earthquake loss model for a given houses, but also for predicting the economic impact of future earthquakes and for the importance for risk mitigation. Furthermore, the vulnerability that allows the damage to the built environment to be predicted for a given scenario can be particularly important for emergency response and disaster planning by an authority. Additionally, the understanding can be used to ultimately mitigate risk through the calibration of seismic codes for the design of new buildings; the additional cost in providing seismic resistance can be quantitatively compared with the potential losses that are subsequently avoided. At last, the loss model can be used to design retrofitting schemes by carrying out cost/benefit studies for structural intervention schemes (Calvi et.al., 2006). As one of earthquake countries, a study on earthquake vulnerability in Indonesia is very important. This study provides a preliminary assessment of structural vulnerability of common residential houses from earthquake shaking.

Methodology

The seismic vulnerability of a house can be described as its susceptibility to damage by ground shaking of a given intensity (Calvi et.al., 2006). In this study, strong ground shaking is the only hazard considered in loss assessment methods; this is commonly an acceptable approach because as the size of the loss model increases, the relative influence of the secondary hazards such as liquefaction and landslides decreases (Bird and Bommer, 2004).

The aim of seismic vulnerability assessment in this study is to obtain the probability of a given level of damage to RM2L common house type due to a scenario earthquake. The methods are through empirical, in-depth interview to the house owners, and expert opinion. By “empirical”, this study performs analysis on historical data that include shaking intensity and loss on RM2L basis. Data of shaking intensity uses Bantul earthquake in 2006 in which Pariatmono (2008) has develop microzonation of Bantul as depicted in Figure 1.

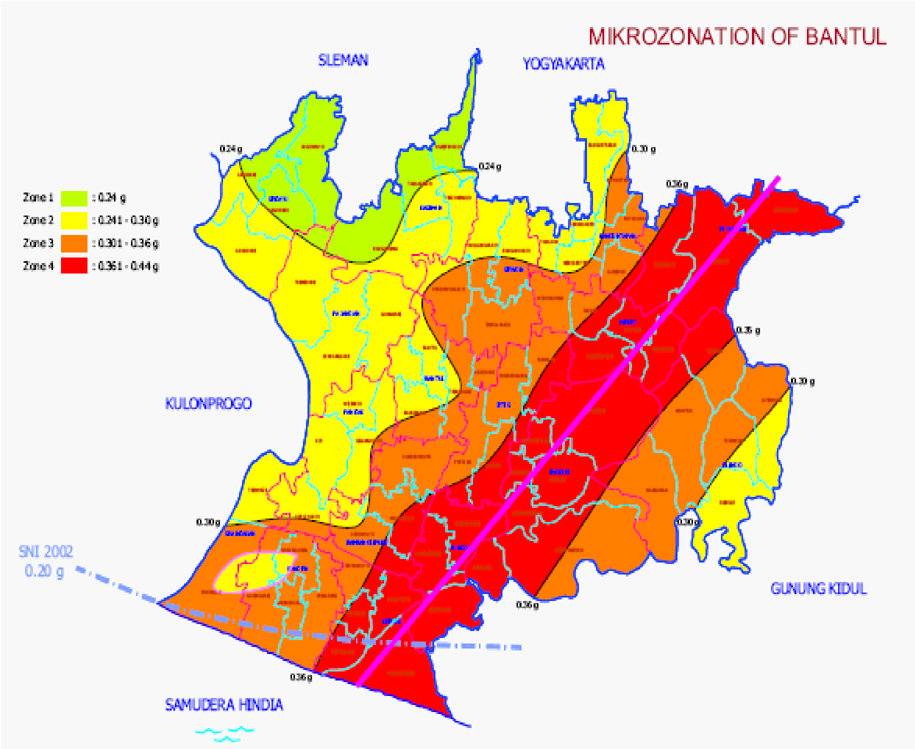


Figure 1. Microzonation of Bantul (Pariatmono, 2008)

In general, there are four steps to measure building response (peak spectral displacement, S d) of RM2L in Bantul, i.e.:

- Step 1. Input requirement as per HAZUS methodology
- Step 2. Generation of Response Curve for study ward at 0.3 second and 1.0 second
- Step 3. Generation of Capacity Curve of RM2L model building type
- Step 4. Calculate peak building response (peak spectral displacement, S d)

In addition, the probability damage is based on the expert judgment and interviews. The analysis uses Fuzzy Analytical Hierarchy Process (FAHP). In a typical AHP method, experts have to give a definite number within a 1–9 scale to the pair-wise comparison so that the priority vector can be computed. Assume two factors of F1 and F2, if F1 and F2 are equally important, then it has a scale of 1; if F1 is weakly more important than F2, then it has a scale of 3; scales of 5, 7 and 9 are used to describe strongly more important, very strongly more important and absolutely more important, respectively. Even scales of 2, 4, 6 and 8 are used to compromise slight difference between two classifications. The corresponding reciprocals 1, 1/2, 1/3, . . ., 1/9 are used for the reverse comparison, i.e. F2 comparing to F1. However, factor comparisons often involve certain amount of uncertainty and subjectivity. For example, an expert E1 knows factor F1 is more important than factor F2, however, the expert cannot give a definite scale to the comparison because the expert is not sure about the degree of importance of F1 over F2. The expert probably provides a range of 3–7 to describe these two factors, e.g. F1 is between weakly more important to very strongly more important than F2. Sometimes, experts cannot compare two factors due to the lack of adequate information. In this case, a typical AHP method has to be discarded due to the existence of fuzzy or incomplete comparisons. A fuzzy AHP approach may therefore be expected (Zeng et.al., 2007).

The expert judgment is to fulfill the weighting factors in FAHP. Through this event, five experts shared in a focus group discussion. The experts who took part in these events had an earthquake academic background and held, at least, master degree in Civil Engineering, in order to achieve the best result.

Forty common one-floor houses i.e. half-brick thick masonry houses built with reinforced concrete framing, consisting of the so called "practical columns and beams", as often called 'a new culture' (Boen 2006a and 2006b), in Bantul Regency were chosen as data. The houses were assumed as Reinforced Masonry Bearing Walls or RM2L (Hazus category) and situated in Alam Citra, Sewon Indah, and Sewon Asri.

The house owners were interviewed to collect qualitative information on RM2L loss basis by comparing their house condition before and after the earthquake in 2006. The qualitative data were then analyzed via Fuzzy Analythic Hierarchi Process (FAHP) to get the probability of their house damages, consisting criteria of slight, moderate, extensive, and complete.

Combining the probability damages and its relevant peak spectral displacement (Sd) as earthquake hazard due to the Bantul earthquake, it can be compared the common vulnerability of the assumed RM2L in Bantul and the exact RM2L in USA.

Results and discussion

Typical data of capacity curve and vulnerability curve of RM1L is described in Table 1 tabel 2 respectively. Typical linguistic scale of the experts is in Table 2. Linguistic scale is categorized in four damage states, i.e. slight, moderate, extensive, and complete.

Table 1 Capacity curve of several types of building (FEMA and NIBS, 1999)

Building Type	Yield Capacity Point		Ultimate Capacity Point	
	Dy (in)	Ay (g)	Dy (in)	Ay (g)
RM1L	0.16	0.133	1.6	0.267
RM1M	0.35	0.111	2.31	0.222
RM2L	0.26	0.133	4.9	0.267
RM2M	0.35	0.111	2.31	0.169
RM2H	0.98	0.085	4.9	0.4

Table 2 Typical vulnerability curve of several types of buildings (FEMA and NIBS, 1999)

Building Type	Median Spectral Displacement (median) and Lognormal Deviation (Beta)							
	Slight		Moderate		Extensive		Complete	
	Median	Beta	Median	Beta	Median	Beta	Median	Beta
RM1L	**0.72**	**1.11**	**1.15**	**1.10**	**2.89**	**1.10**	**7.88**	**0.92**
RM1M	1.20	0.87	1.92	0.84	4.81	0.79	13.12	0.96
RM2L	0.72	1.05	1.15	1.07	2.89	1.09	7.88	0.91
RM2M	1.20	0.84	1.92	0.81	4.81	0.77	13.12	0.96
RM2H	1.73	0.69	2.77	0.72	6.93	0.87	18.90	0.96

Table 2 Typical linguistic scale of the experts

	Slight	Moderate	Extensive	Complete
Slight	1	1/PAd	1/PAd	1/Pad
Moderate	Pad	1	1/SLd	1/SLd
Extensive	Pad	SLd	1	1/SMd
Complete	Pad	SLd	SMd	1

Based on Table 2, Figure 2 presents vulnerability curve of the exact RM1L in USA.

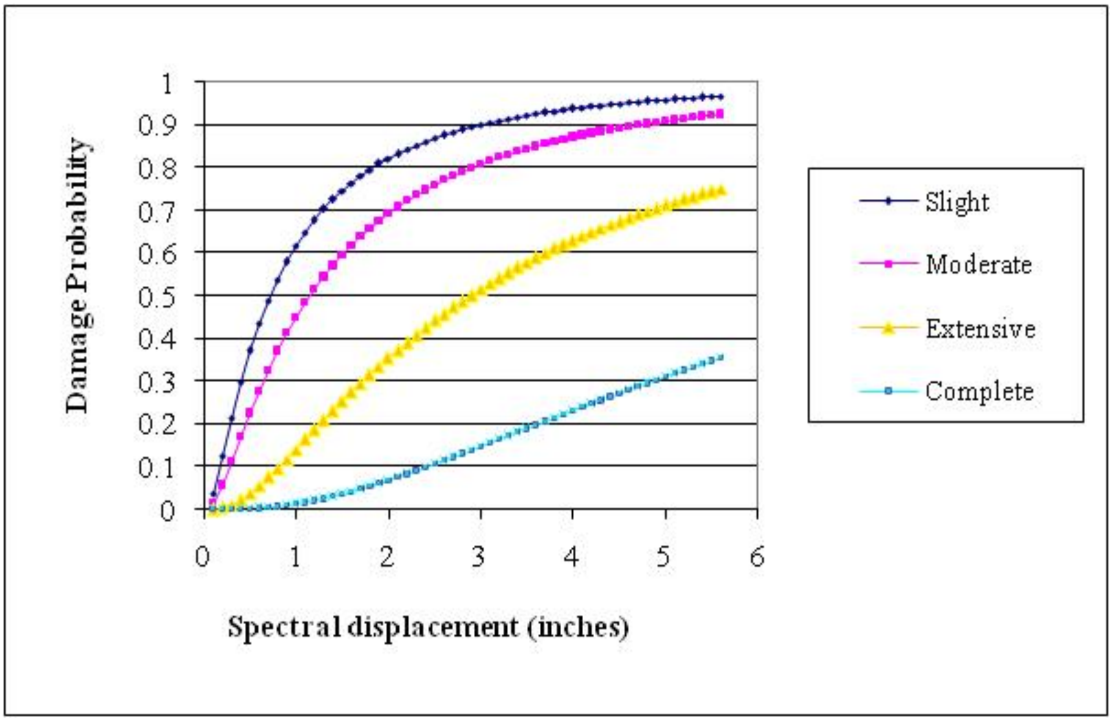


Figure 2. The vulnerability curve of the exact RM1L in USA (FEMA and NIBS, 1999)

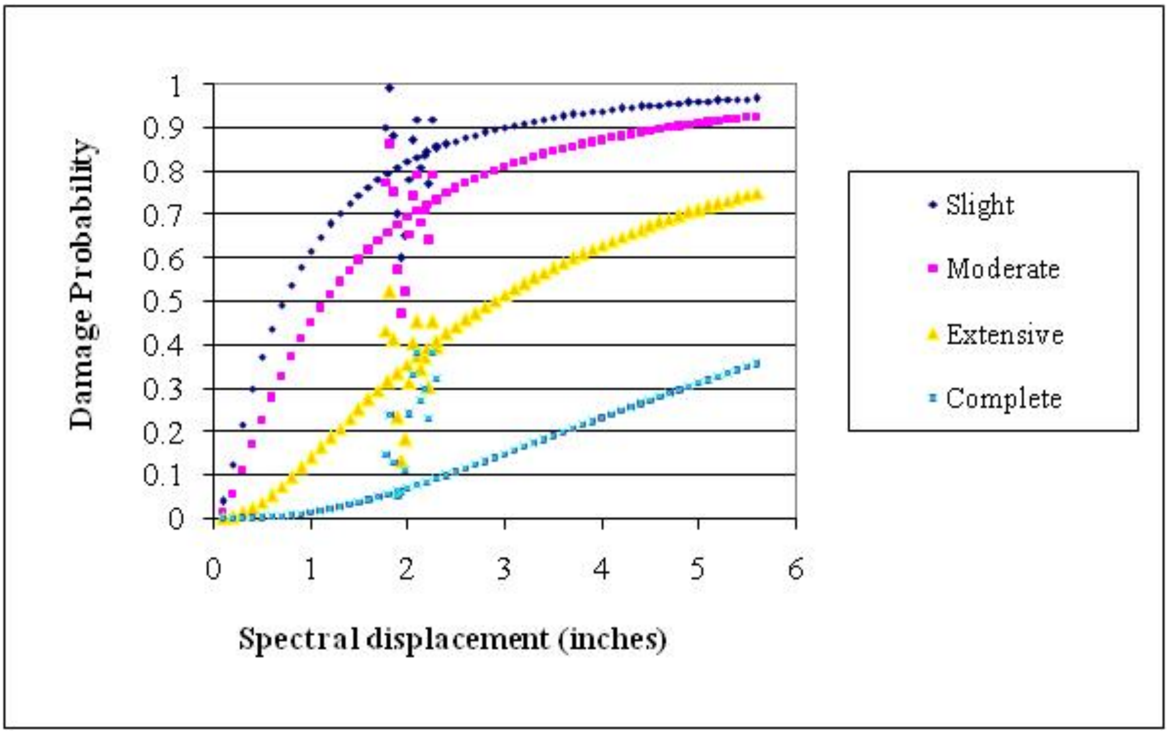


Figure 2. The scatter data of vulnerability level of the assumed RM1L in Bantul

Conclusions

The seismic vulnerability of houses is becoming increasingly complex and dynamic in their nature. This is determined by numerous factors. The study findings indicate that there is the high level of uncertainty involved in the risk data available. This paper presents a preliminary study on vulnerability assessment of common houses in Bantul. Since the location of the house data is relatively close to each other, thus the average peak spectral displacement is 2.05 inch and deviation standard is 0.82 inch. The average assessment of damage probability shows 0.86 of slight damage, 0.72 of moderate damage, 0.41 of extensive damage, and 0.11 of complete damage. The overall damage is 14.11% higher (more vulnerable) in average than that of RM1L by Hazus category.

Acknowledgement

Some works contributed to this paper are funded by Competent Research Grant 2012 (Hibah Penelitian Kompetensi 2012), Directorate General of Higher Education, Ministry of National Education.

References

Bird, J.F. and Bommer, J.J. (2004). Earthquake Losses due to Ground Failure. Engineering Geology, Vol. 75, No. 2, pp. 147-179.

Calvi, G.M., Pinho, R., Magenes, G., Bommer, J.J., Restrepo-Vélez, L.F., and Crowley, H. (2006). Development of Seismic Vulnerability Assessment Methodologies Over the Past 30 Years. Journal of Earthquake Technology, Paper No. 472, Vol. 43, No. 3, September 2006, pp. 75-104

Edwards, M. (2011) . The Role of Earthquake Vulnerability Research in Risk Mitigation. Proceedings: The Second International Conference on Earthquake Engineering and Disaster Mitigation (ICEEDM-2), 19-20 July 2011. Surabaya, Indonesia.

FEMA and NIBS. (1999). Earthquake Loss Estimation Methodology HAZUS®99

Hsieh, T.Y., Lu, S.T., and Tzeng, G.H. (2004). Fuzzy MCDM Approach for Planning and Design Tenders Selection in Public Office Buildings, International Journal of Project Management 22 (2004) pp. 573–584

Pariatmono. (2008). Science and Technology Role in Earthquake Mitigation, Workshop on Housing Construction on the High-Risk Earthquake Zone, Jakarta, March 18, 2008

Porter, K. (2011). Some Methods to Develop Seismic Vulnerability Functions for Loss Modeling. Proceedings: The Second International Conference on Earthquake Engineering and Disaster Mitigation (ICEEDM-2), 19-20 July 2011. Surabaya, Indonesia.

Zeng, J., An, M., and Smith, N.J. (2007). Application of a Fuzzy Based Decision Making Methodology to Construction Project Risk Assessment, International Journal of Project Management 25 (2007), pp. 589–600.

Rebuilding Settlements: Learning from Housing Reconstruction Process after 2009 West Java Earthquake

Hadian Idhar Yasaditama* and Saut Sagala

Regional and Rural Planning Research Group
School of Architecture, Planning and Policy Development
Institute of Technology Bandung, Bandung, Indonesia

*Corresponding Author: hadian.idhar@gmail.com

Abstract

On 2 September 2009, a 7,3 Richter earthquake hit West Java causing approximately 210.000 people were evacuated and caused over 10.000 housing damaged in various conditions. As the reconstruction process has taken place for more than two years, this research attempts to identify its whole lessons learnt. This paper argues that reconstruction is not only about physical rebuilding, but also is related with social and livelihood matter. For this type rebuilding purpose, some literatures then suggest that there are 3 main factors; financing scheme, construction techniques, and location selection. Financing scheme is the most important, because of having influences both in speed and quality factor for housing rebuilding. Differently with construction technique, which have objection most in quality factor and future disaster risk reduction. In the other hand, location selection is also an important consideration for people's livelihood development in post disaster. Three representative areas were selected in this study: Pangalengan (Bandung District), Panjalu and Pangandaran (Ciamis District). This research uses analytical qualitative approaches which consist of desk study from secondary information, observation to the affected areas, and also interview to respondents from local people, NGO, and government using snowball sampling method. Some early lessons learnt finding identify that there are many financing schemes in the reconstruction process, such as the government assistance, NGO assistance, self financing, and even mixed scheme. In terms of construction technique, some findings indicate that not all of people would change their house construction into the earthquake resistant construction. It really depends on several supporting factors such as knowledge and their financing resources. In the other side, also people still tend to rebuild closer from their previous damaged house to avoid loss of livelihood, social, and cultural ties. While these findings share similar information, founded empirical data in this research will help for the development of post-disaster reconstruction knowledge and with regional and city planning field.

Keywords: *Earthquake, Rebuilding, Reconstruction, Settlement*

Introduction

A 7,4 Richter scale of West Java Earthquake on 2 September 2009 had many impacts ,damages and casualties in 15 Districts / cities in West Java Province. This tectonic earthquake mostly gave the worst impact at Tasikmalaya District, Cianjur District, Bandung District, Sukabumi District, Ciamis District, Garut District, Bogor District and Sukabumi District.

Approximately, 81 people became casualties, while 1.917 people injured, 50.964 families were evacuated (194.719 inhabitants) and over 10.000 housing had damaged in various conditions. The worst damage and loss after the earthquake was in the component of housing sector. Estimation on damage and losses in this component reached Rp 6.9 trillion of the total damage and losses, which are about Rp 7.9 trillion. These impacts of damage in the housing sector on each disaster event could potentially cause vulnerability of people life in the future (Gordon et al, 1998; Webb, Tierney, & Dahlhamer, 2000 in Olshansky and Chang, 2009).

In order to establish good disaster management system, the recovery process has become one of the crucial steps that must be implemented after the disaster, in which particularly it should take priority for the housing sector. It is based on the fact that some prioritized in housing reconstruction process can significantly prevent the impacted people in having issues on psychological trauma, cultural identity, social structure, and economic impact (Barakat, 2003). On the other hand, Coppola (2008) explained definition of recovery phase as a recondition process of the victim life until back into normal in accordance with the given impacts. Associated with the housing reconstruction process, currently some disaster researchers have formulated many approaches on this (Jha, 2010), which consist of: cash approach, own-driven approach, community-driven approach, agency-driven approach in-situ, and agency-driven approach ex-situ. On the other hand Chang (2011) also formulated his stakeholder-based approaches; government driven, donor-driven, market driven, and own driven.
Basically, the purpose of the recovery process is to restore the level of economic functions and to rebuild the damaged houses (Olshansky et al, 2006). In the implementation, the replacement of housing units actually was not just a simply re-supply in quantity.

It has to take into account the option of financing scheme, housing construction, and housing location especially in reduce the future risk in prone areas (Comerio, 1998; Koura & Murosaki, 2003 in Olshansky and Chang, 2009). It is based on the understanding that post-disaster recovery activities should ideally be able to restore the affected area into a better condition than the previous one (Carillo, 2010). To achieve this understanding, quantity factor becomes not only the main solution in recovery process, but also to the sustainability of the process represented by previous three terms namely the financing scheme, construction, and housing location. These three terms even could shape their own urgency because often potentially lead to the housing reconstruction process dilemma (Barakat, 2003).

Financing scheme usually becomes the main classic reason for implementing a planning, especially in this post-disaster recovery planning, which faces the speed and deliberation issues as a main driving force factor. Disaster management law of Indonesia (UU no. 24 of 2007) actually mandated that every disaster relief effort is the government responsibility. However, to achieve more effective results, this effort of implementation should also be able to empower the various stakeholders, including communities (Eyte, 2004). In accommodating both of these considerations, further Barakat (2003) provides several financing scheme options that can be used in housing reconstruction process through outright gift, partial contribution through self help, and loans scheme. Outright gift scheme only give the target as a fully recipient object of housing unit without any kind of refund potency in the future. This is in contrast to the partial contribution scheme which allows the target only receive building materials or/and construction technical guidance or/and other partial assistances, in which on the other side the loans scheme target can make a kind of long term special loan and/or without interest.

Housing construction becomes one of the main dilemmas in post-disaster housing reconstruction process. The common specific obstacle is related to the quality or quantity of material and construction specifications, which is also primarily caused by funding limitations, the people knowledge as well as the phenomenon of unplanned housing (Steinberg, 2007). In terms of construction, Olshansky et al (2006) also explain that in some cases and conditions, the reconstruction process through the partial type of housing construction (improvement) were considered to be more efficient compared with totally type of housing construction (totally rebuilding). During its development, housing construction in the context of post-disaster recovery further is not only always identified through the technical approach, but also by the perception approach. This is supported in research conducted by Green (2008) in Istanbul, which states that externally, the confidence level to the various stakeholders such as governments, NGOs, and even engineer could ultimately affect the perception of impacted people in determining their own construction planning.

The housing location is also one of post-disaster recovery instrument that can also provide opportunities for the future of disaster risk reduction effort (Usamah and Haynes, 2011). On the other hand, impacted people certainly have their each discretion to determine the location of their damaged housing rebuilding, ranging from financial ability to even the possession of social capital. In some cases and post-disaster conditions, housing site selection may become a full responsibility of the government. It means that the government has the authority to choose the location of their housing rebuilding and also re-settlement, which it is better known as relocation terminology. However, regardless of this government role, in fact there are still many cases related to the rejection of the relocation, with several contributing factors such as incompatibility livelihood, limited access, or inappropriate condition to conduct every economic activity (Dikmen, 2002). In order to support the successful relocation activity, as proposed by Ozden (2006) that public involvement should be considered as a key factor in its planning and development.

This paper tries to review several housing reconstruction process of post-2009 earthquake at several study location in West Java, particularly in relation to the three main focuses; financing scheme, housing construction, and location. Hopefully some lessons learnt can be generalized in order to create a better recovery process which more sustainable or even disaster mitigation based in the future. Besides that at this time, current researches on the identification of post-disaster recovery activities are still not many developed yet, which more specific and distant, are still very less focusing on the context of housing recovery process (Olshansky and Chang 2009).

Study Location

Study location for this research was conducted in three locations at West Java Province, affected by September 2009 West Java Earthquake, which include Pangalengan (Bandung District), Pangandaran (Ciamis District), and Panjalu (Ciamis District) as shown in figure 1 below. Pangalengan is chosen because it is one of the worst impacted areas by the 2009 earthquake disaster. While the others location Pangandaran and Panjalu are being an extension study of the second author previous research (Sagala, 2010).

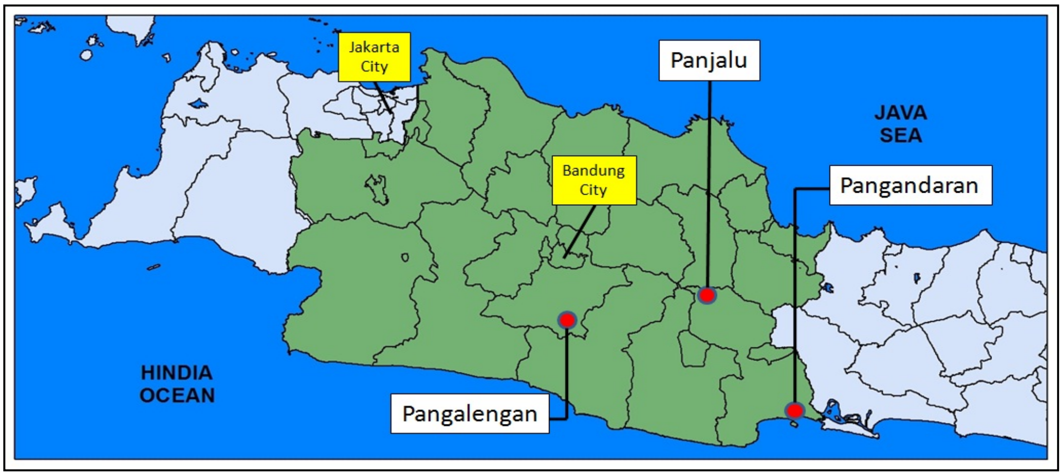


Figure 1 Map of Study Location. Pangalengan, Panjalu, and Pangandaran study locations

Pangalengan Sub district is one of the districts in the southern part of Bandung District, West Java. Administratively consist of 13 villages, while this study only use the 4 villages study location, namely Margamulya, Pangalengan, Margamukti, and Sukamanah as the fourth worst impacted villages in Pangalengan by 2009 earthquake disaster. Most of Pangalengan topography is a slope or ridge with the rest of the plains. Morphologically, Pangalengan area lies in a plateau with an altitude of 1400 m high surrounded by a series of mountains such as Mt. Malabar (2321), Mt. Wayang (2182), Mt. Windu (2054), and Mt. Tilu (2042). As in general, the main type of activities in this area are in the form of horticulture, tea and cinchona plantations, tourism activities in Situ Cileunca and Cibolang hot water, and also Wayang-Windu Geothermal Power Plant.

Pangandaran Sub District is a coastal area with an average altitude about 611, 25 m high and located approximately 90 km south of the Banjar City. Administratively consists of 8 villages with great potential of agricultural and plantation resources. But mostly, the tourism economy is still the main sector in providing good income for local people even regional income for Ciamis District. The Pangandaran Tsunami in 2006 is still causes a long term of traumatic effects for the Pangandaran people, so it tends to give effect to their views in response any disaster events later, including earthquakes in West Java in 2009.

Panjalu Sub District is located in the northwest of Ciamis District, next to the Tasikmalaya District. This area is one of main areas of chicken farms production and tourism sector, as its type of landscape and historical strategic value of the Panjalu Kingdom existence hundred years ago, especially related with the initial formed of Ciamis District. Topographically, District Panjalu has similar type with Pangalengan district, which is mostly consist of fertile hills and surrounded by several mountains such as Mt. Syawal, Mt. Bitung, Mt. Cendana and Mt. Cakrabuana. In terms of disaster, the District Panjalu is also categorized as a prone area of soil movement and landslide disasters (RTRW Ciamis District 1999-2009).

Research Method

Field survey in the study area Pangandaran and Panjalu, Ciamis District, was conducted in May of 2010 through observation, interviews, as well as questionnaires filling. Observation was held on some places which various government and NGOs programs were implemented and several impacted locations by the 2009 earthquake. The interviews and questionnaires filling were carried out to the government institutions, NGOs, and program beneficiaries (impacted people). On the other side, interviews at the national level were conducted through institutional visits method, email, or telephone. In addition to confirm the obtained findings, a workshop activity was held in Ciamis on June 7, 2010.

For Pangalengan study area, primary data collection method is prepared by the initial survey on March 1, 2012 and continued by main survey on 8-10 May 2012 through interviews and observation activities. Interviews were conducted within 80 respondents consist of the impacted people, engineers, material shops, and the government at the village level, sub district until district (Regional Planning Agency-BAPEDA, Regional Disaster Management Agency-BPBD, Regional Spatial Planning Department-Dispertasi). Respondents were divided into three categories of people, namely people with high level of damage house, moderate level and light level. Each category took five respondents in each village. This divide based that each category may represent different conditions and perceptions of each other against the relief activities of 2009 earthquake disaster. Each of engineer and material shop respondents, are represented by 1 and 2 respondents for each village. Selection of impacted people respondents is divided into two methods, first by using village data, which mean initially the village government provides recommendations list of people names for each category. It is used to make the searching process become easier and on target, because the earthquake crisis had already been long time ago. In addition the social problems related to the earthquake disaster relief are still being a pretty sensitive issue among Pangalengan people. In fact, in the field not all of recommended people by the village government are on their own home, so ultimately there is also the using of snowball methods, through the sequence recommendation from respondents.

The analytical method uses Qualitative Content Analysis, in order to sort out the relevant data and clarify the information obtained from different sources. This analysis includes summarizing, explicating, and structuring (Flick 2006:313), and will be used to take the learning of housing reconstruction, the supporting policies, and development strategies of post disaster resettlement. For that purpose, some relevant taped interviews data are transcribed and sorted based on the needs of the analysis presentation.

Findings

Financing Scheme

The province scale of earthquake impacts in 2009 causes the presence of some similar mechanism in disaster management process in all three study location, particularly in financing mechanism, some of strategic policies and the public perception generally. The finding in all three study areas is when most dominant financing resources of housing reconstruction there come from the government. Applied mechanism is with dividing the impacted people into three categories, namely people with high level of damage house, moderate level and light level. Further, each category have different amounts of received financing assistance, which light level damage compensation for 1 million, moderate level for 10 million, and light level damage for 15 million (West Java Earthquake Action Plan, 2009).

In response, most of people believe that the amount of received assistance is still lacking for every category. Although for the light damage category, based on observations both by government of village and district, and also researcher, actually the amount of received assistance is relatively enough. The problem is when this category of people is likely to include non-housing needs as well as entities that must be compensated by the government financing assistance. Jha (2010) have predicted the emergence of this problem using in his cash-type approach, although the case of West Java earthquake is more suitable for his owner driven construction-type. This is because the type of received assistance by people there not only in the form of cash money, but also in technical assistance and the use of local engineer in the rebuilding process.

The government at the village to district level admitted if this scheme applied financing mechanism of housing reconstruction, especially in term of amount for each category, more likely for stimulant than fully compensation aim. It was realized that government wanted the affected population to rebuild their own house as it should be and as soon as possible, beside the government classic reason in lack of funding. In this case it means the government tried to implement the financing schemes of partial contribution through self help, in which further expected the cooperation and participation of the beneficiaries as one of this scheme advantages (Barakat, 2006).

> (Pangalengan Sub-District Secretary) *"The amount of housing assistance consisted of IDR 1 million for light damage, IDR 10 million for moderate damage, and IDR 15 million for heavy damage were actually more only as a stimulant for impacted people in order to be more motivated them to rebuild their damaged houses. In addition definitely government has no capability in covering all of this housing financing assistance alone."*

This finding is consistent with the opinion of local engineer who received training guidelines of earthquake resistant housing construction. In rebuild the earthquake-resistant house, they said that the amount of government assistance is still very far away, even to rebuild the previous-non earthquake resistant-house. The real needed cost can sometimes reach 2 to 4 times higher than the assistance amount, depending on the building area and construction quality which was demanded.

> (Engineer) *"As my knowledge in the construction techniques, the amount of government assistance is still less in order to build a house that follows the earthquake resistant-house guideline. Perhaps this amount is just enough to buy the iron's column only. In the fact, the overruns of cost can reach approximately IDR 30-60 million per house."*

The other assistance mechanism, which divides the distribution into 2 phases (9 months and 15 months after the disaster, for moderate and high damage categories only), also often create problem among the beneficiaries. For most people in the study area, this phased mechanism can be severely hampered their house reconstruction process. People have a preference to be able to quickly re-occupy their houses, so in the end they unconsciously tend to not only depend on government assistance alone. For small portion people, this can then be handled through self-financing mechanism. As the other most people can usually use loan mechanisms to their relatives.

(Beneficiary) *"We can't build a house by half to half, how could it be? for example in phase 1 we build wall first, then in phase 2 a few months later we had already added our house with a roof. In other side we also can't continue for more time to wait in refugee camps because we can't did our activities normally. To anticipate this, we sometimes borrow amount of money from relatives and also as could as possible to set apart our income".*

This mechanism of assistance phasing is actually not intended as an effort to create a stimulant for the people, but purely due to bureaucratic factors in budgeting regulation of central government. In the fact, financing assistance for the tight damage category which was sourced by Government District (District of Bandung and Ciamis) for $ 1 million per family can be allocated in only 1 phase.

In study locations there are only found a few donors who participated in the housing recovery process. This is contrary to some media such as Antara (2011) who had said that Pangalengan is an area that receives the most assistance than the others. Such this triangulation can be caused when most of those assistances were humanitarian type. This finding is also supported by commonly fact that there is still a problem in the inadequate number of donor agencies focusing on post-disaster housing sector recovery (Barakat, 2006)

In District Pangalengan for example some donors involved include the Habitat Indonesia, ITB, and Yayasan Ibu. Especially Habitat Indonesia, their contribution is even in the direct form of totally housing units rebuilding to several beneficiaries who meet their criteria. This is quite different with the other donors who only give indirect assistances such as building materials, equipment and technical guidance.

Housing Construction

Basically people in study locations have a strong desire to rebuild their homes better, in this context into earthquake resistant housing. This is considered just mostly because they have had highly impacts by the 2009 earthquake, so in the future surely they don't want the same thing happened again. In the fact later, this worried feeling becomes worsen by the traumatic factor. For example in Pangalengan, they said that Pangalengan become more vulnerable to ground shaking hazard especially after the earthquake in 2009, as well as several earthquake later which had hit Pangandaran area. In other word, these examples of event really make them very traumatic and want to have such better houses construction. In addition impacted people, particularly the head of family, at least have known a general overview of the government directions about earthquake-resistant housing technical guidance.

Some findings indicate that almost all of high and moderate damage level respondents have followed the earthquake-resistant housing technical guidance in their own house rebuilding process. Contrary to their previous opinion which often complain if the amount of government assistance is still far away to rebuild their houses. Majority of detailed information shows that their current houses have implemented *footplat* or well stone foundation as well as columns on the wall (Figure 2). Further people full believe on the engineer who had rebuilt their houses, because the engineer usually still come from as well as recommended by people in the same village. Both of those considerations-the people risk perception on disaster and financial condition-could ultimately affirm their future decision in way of life; decision in the selection of housing type and construction (Green, 2008).

(Beneficiary) *"It is better to spend more money rather than all of my family has the same bad impact by the future earthquake. At this time my family still has trauma if any earthquake happened suddenly, moreover Pangalengan seems to be more vulnerable of shocking ground after the 2009 earthquake. Although there is only a little amount of money for the addition, but it more relaxed because our house has used column construction".*

On the other hand, engineer respondents also admitted that until now there has never been people who are totally really follow the implementation of earthquake-resistant housing technical guidance. Still according to the engineer, the amount of government assistant again becomes the main reason for that. Moreover, it is worsen by the cost enhancements of some building material at the local material shops as it has been estimated by Nazara and Resosudamo (2007) in Chang (2010). Some engineers in this case had at least give information regarding technical guidance of earthquake resistant houses to their probable clients. It is important in term of information and knowledge dissemination, although the final decision is still at the probable client with all of their financial limitation. In anticipation of this, beside actually local engineers still usually follow the technical guidance of earthquake-resistant housing. However to meet with the limited resources they have, they have to reduce the quantity or/and quality of some building material. Some examples of their strategies are:

- In making the column, the amount of iron used can be reduced or even replacing them with bamboo. The engineer also said that the most important thing is how to keep the essential of column use as a binding frame of house wall, followed by choice of material building type as the next priority.
- In making *footplat* or well stone foundation, the area of section support can be reduced. According to foundation function as the main cantilever for the house, so the reduction should not take too much.

Alternative choice of replacement material actually had ever been highlighted in the Aceh Tsunami reconstruction process in 2004 (Steinberg, 2007). At that time, the problem is just because the forest conservation consideration, which many recommended materials for the reconstruction are forest resources. In addition those all of the processes were still in the authority and responsibility of donors. Differently with West Java earthquake case, which people's financial condition becomes the main consideration of some material replacement. The authority and responsibility of this replacement also has been theirs, so generally everything is well implemented.

Based on their knowledge and experience of technical construction, the engineers really believe on that government given of technical guidance. They sure it can effectively reduce the impact that may be caused by a future potential earthquake. In the other hand they also believe on their strategies, which usually were applied in response the limitation of people ability.

(Engineer) *"People usually have known the Technical Guidance of Earthquake Resistant Construction, but still the final decision is in their own hands. Usually due to the limited amount of assistance or impossibility of their financial condition, no one has ever really followed the guidance. Overall therefore it can be handled by reduce the amount of iron used or even replace them to bamboo. It has same essential as a frame for the house wall, which further we only just can pray for the best".*

Figure **2 Reconstruction Process of Earthquake-Resistant Housing.** Picture Information (left to right): One of the housing reconstruction process in Panjalu District which has implemented the using of column (Source: Observations, 2010); House in the Pangalengan District which have applied one part of technical guides of earthquake resistant construction (Source: Observations, 2012).

Housing Location

Soon after the earthquake in 2009, there were some people in the study locations who wanted to relocate. In addition to the large scale of impact they had received, the people perception of potential hazards there is also the main reasons. As explained some in the previous finding, at this time people have felt that there is more intensity of earthquake strike in study locations (generally is interpreted as every earthquake events in West Java). For example people in Pangalengan, who have perception that some low land in northern Pangalengan such as Banjaran have less earthquake disaster potency. Actually it makes them want to migrate there someday even though they have known the potency of flood disaster in that area.

The impacts to their economic conditions become main factor for people to cancel their migration, although in field observations also found some houses that had been inhabited by the moving residents. The second factor is related to their livelihood, which largely work in the sector of agriculture, plantation, and also farm. Of course with their capacity and opportunities at this time, people become very hard to leave their place. Further there are almost no more options to move their housing location if they still survive in their each study locations. For that, people tend to re-build their houses in the same location or at least next to the remnant of their damaged old building which can’t be totally cleaned.

> (Beneficiary) *"Soon after the earthquake, there is a strong desire to move out from Pangalengan. It is caused by how such big impacts that we had received by the 2009 earthquake. But in line with the running time, that feeling disappear significantly because we finally realize with our limitation of financial and capacity-opportunity to get work."*

Different cases are only found in Sukamanah Village, Pangalengan. Until now even some refugees are still living in temporary relocation place there, at the plantation land owned by government (PTPN Walatra) as shown in Figure 3 below. In the other side, in 2011 government actually had provided a permanent relocation place not far from the current location, even though at this time there are some refugees who had been occupy (Figure 3). Some obtained information show that those people do not want to occupy the provided location because of the incompatibility reason. They assumed that the location is less access and steep in some area, so it has potency for landslide in the future. Researcher in the observation also tend to has quite similar assume for the land impropriety. This is even contrary with Usamah and Haynes (2011) who are very concerns in term of disaster risk reduction in their every relocation process. In the other side, the District Government stated that the choice of location is had been preceded by the study. This confusion, according to some informants is more because there are some decisions making were took in hurry condition and not involved targeted people. In some cases all of these confusions can be so difficult process or even rejected by the people (Diken, 2002)

(Pangalengan Sub-District Secretary) *"Actually, our land has been preceded through an initial review and study, even the provision of the settlement facilities and infrastructures has also been planned at that location. Indeed, in many times we had ever been recommended or even accused by some sides to immediately provide the permanent location."*

Figure 3 The Long Process of Relocation Activities. Picture Information (left to right): temporary relocation place of 2009 earthquake refugees in the government land (Source: Damayanti, 2010); A permanent relocation place provided by government has begun to be occupied, although still remaining refugees who remain in the temporary relocation place (Source: Observations, 2012)

Conclusion

Disasters disrupt human life and their effects extend over time. Contrary to popular belief, disaster management is not just simply instantaneous process in its every phase. It tends to be crucial and complex as well as having close links with issues on environmental, social, and economic. Referring to that, in the fact housing becomes one of prominent sectors in every disaster events. It is representated in recovery phase of housing sector which poses both challenges and even a window of opportunity for the better planning implementation in the future.

In accommodating the background, housing recovery activity generally is expected to be more sustainable. The learning process from previous relevant disasters event are necessary, considering this research focus is still rare to be founded. This study main purpose is to get some lesson learnt from housing sector recovery after disaster, which as shown as follow:

In several conditions, a partial scheme can enhance public participation, so of course it can optimize the process of post-disaster recovery in housing sector

particularly. In addition in the future it can also minimize the people's dependence on every kind of assistances given and even can increase the people capacity in faces future disaster through the role of social capital. The last important lesson is: all of those important findings will be run properly if the communication between stakeholders, especially government and communities, can smoothly proceed.
People perception of the disaster is one of the major factors in the consideration of housing construction. Sometimes even financial condition factor in many ways will systematically follow the perception, although it cannot totally happen. In the other hand, the role of engineer is quite vital, in this case as building expert, information agent, as well as executor in the field with its uncertainty.

In general, the most influence factor is the consideration of livelihood compatibility, availability of accessibility, perception of the disaster, as well as the opportunity to find economic activities. In the context of government programs relocation, the process of determining the location should involves the targeted community. If it runs as non government program / self-relocation, there will appear the financial condition factor, which tends to defeat the disaster perception factor.

Acknowledgement

The authors would like to thank all those who participated in this research, in particular Mr. Djoko Suroso and Ms. Rintakasari Vitri as the member of our research project. Our colleagues Ramanditya Wimbardana, Alpian Angga, Intania Rahmasani, Dodon, Fernando Situngkir, Dian Lutfiana, Anastasia Wijayanti for helping the field survey in Pangalengan, Bandung District. This paper is part of a research project entitled "Planning for Post Disaster Recovery. Case Study of: Earthquake Disaster in Pangalengan, Bandung District" funded by Osaka Gas Foundation while field work data in Pangandaran and Panjalu was provided through research project funded by Oxfam Great Britain and UK-Aid.

References

Antara. 2011. Pangalengan Daerah Paling Banyak Mendapat bantuan Gempa. Accessed from http://www.antarajawabarat.com/lihat/berita/33785/pangalengan-daerah-paling-banyak-mendapat-bantuan-gempa on 23 May 2012

Barakat, Sultan. 2003. *Housing Reconstruction after Conflict and Disaster.* Humanitarian Practice Network.

Carrillo, Gabriel et al. 2010. *Introduction To Disaster Management.* Virtual University for Small States of The Commonwealth (VUSSC). Commonwealth of Learning (COL).

Chang, Y., Wilkinson, S., Potangaroa, R., and Seville, E. 2010. *Resourcing challenges for post-disaster housing reconstruction: a comparative analysis.* Building Research and Information, 38(2), 247-264.

Chang Y., Wilkinson S., Brunsdon D., Seville E., Potangaroa R. 2011. *An Integrated Approach: Managing Resources for Post-Disaster Reconstruction.* Overseas Development Institute, 35(4), 739-765.

Coppola, Damon. 2008. *Introduction to International Disaster Management*. Elsevier.

Damayanti, P. 2010. Peran Stakeholder dalam Rehabilitasi dan Rekonstruksi Bencana Gempa Bumi di Pengalengan, Tugas Akhir, Perencanaan Wilayah dan Kota, ITB.

Dikmen, Nese. 2002. *Relocation Our Rebuilding In The Same Area: An Important Factor For Decision Making For Post Disaster Housing Projects.* Department of Architechture, Suleyman Demirel University, Ankara.

Flick, U. (2006:313). An Introduction to *Qualitative Research, Third Edition*. London. Sage.
Green, Rebekah A. 2008. Unauthorized development and seismic hazard vulnerability: a study of squatters and engineers in Istanbul, Turkey. *Disasters,* 2008, 32(3): 358−376. Blackwell Publishing.

Jha, Abhas K., Barenstein, J., Phelps, P., Pittet, D.,and Sena, S. 2010. *Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disaster.* World Bank

Olshansky, Robert B., Laurie A. Johnshon and Kenneth C. Topping. 2006. *Rebuilding Communities Following Disaster: Lessons from Kobe and Los Angeles*. Journal of Built Environment vol. 32 No. 4, 354-374.

Olshansky, Robert B., and Chang, Stephanie. 2009. Chapter 2. Planning for disaster recovery: emerging research needs and challenges. Shaken, shrinking, hot, impoverished and informal: Emerging research agendas in planning. Progress in Planning 72 (2009) 195–250. Elsevier.

Ozden, A. T. 2006. Developing A Model For Community Involvement in Post-Disaster Housing Programmes. *Inonu Bulvari* , 06531.

Sagala, S. 2010. Dealing with Disasters A Review of Disaster Risk Reduction Investments in West Java and West Sumatra, Indonesia, Oxfam Great Britain Research Report.

Steinberg, Florian. 2007. *Housing Reconstruction and Rehabilitation in Aceh and Nias, Indonesia – Rebuilding Lives.* Habitat International. pp 150-166.

Undang-Undang No. 24 of 2007 (Indonesian Law) about Disaster Management.

Usamah, M., & Haynes, K. 2011. An Examination of The Resettlemnet Program at Mayon Volcano: What Can We Learn for Sustainable Volcanic Risk Reduction? *Springer*.

PANEL 2

INTEGRATING FORMAL/INFORMAL URBAN SYSTEM

Alternative to Live: The Rented Vertical Flats in Yogyakarta

Maria Adriani

Department of Architecture, Islamic University of Indonesia

Email: mariaadriani_khan@yahoo.com

Abstract

This paper tries to observe globalization effects on social life, especially in kampung communities. It based on 2011 etnographic research on two areas with modern development inserted on the kampung: Cokrodirjan and Juminahan vertical flats, in the city of Yogyakarta[1]. Vertical flats represent global phenomenon from modern urban planning and management. Yogyakarta, a city famous with urban kampung is not immunne from global pressure. Taking question into further direction, in which way physical development affect social – kampung life, and by how the communities put strategies on it? At the end Changes of global world as well as different kampung's character has made different results.

KEYWORDS: Rusunawa, kampung, globalization, urban social.

This is a prelimenary study about the *Rusunawa* and *kampung* in Yogyakarta in global era. *Rusunawa (Rumah Susun Sederhana Sewa)* - Rented Vertical Flats (RVF) is a form of housing management for low-income people promote by the Indonesian government. Two area of RVF which have been studied were built on the riverbank and the slope of Code River - a river which flows across the inner areas of Yogyakarta.

Code river shaped the city structure and has a long history of settlement. Marginalized people built houses on it since pre-independence era, and develop kampungs as seen now. Those kampungs are high density areas, interms of population and houses. Most houses in Code riverbank also experienced a long "grey" history of ownership. Although ownership problem existed, houses are differently shaped, represent diversity of wealth, and lifestyle of the owner.

In late 80's, the World Bank came with housing program for the poor. With rigid modern paradigma in mind, the state went along with it and developed some projects. The first vertical flats built in 1980's in Jakarta. Yogyakarta follows approximatelly 20 years later.

Yogyakarta has different scheme from Jakarta. In Yogyakarta, the RV-flats project proposed by the city government to the State (*Kimpraswil* – Housing and Infrastructure Department). There are total 6 RVF in Yogyakarta, 4 of them manage by the province, and 2 of them managed by the city government. This paper focus on the study of RVF managed by the city; Cokrodirjan RVF and Juminahan RVF.

---

[1] The 2011 research is a pair project between Maria Adriani and Bridget Sikayena in a program held by Center for History and Political Ethics – Sanatha Dharma University and Haverford College. With consent given, this paper relies most information on the research.

Cokrodirjan Rented Vertical Flat

It is set on the flat side of *kampung Cokrodirjan*, near Malioboro district[2], just on the west side of Code. The building lay north-south orientation, blocking most of kampung view to the east. It was built on the land of neglected state elementary school and bamboo areas. Before, the elementary school was left due to flood in the area. The development started in 2005, initiated by "negotiations" between the city government and the kampung[3].

The Cokrodirjan RVF consists of two masses - four storeys building, and it has 74 units distributed above the groundfloor. The groundfloor is used for public space and some rented units. Semi-open meeting room for the kampung (*balai RW*) at the south, a playgroup and playground for children in the area, and motorcycle garage. Some units in the groundfloor areas are temporarily divided by wooden wall to be stalls, and foodcorner (*warungs*), while some units remain empty.

RVF's residents prefer to live above the groundfloor to avoid humidity. However, when Merapi erupted in 2010, they were affraid to live above and decided to stay at the ground level temporarily. Each rented unit has 3x5 square meters, with bathroom, kitchen, and sun-drying space inside. Each unit faces open air and sun, connected with small corridor (1 meter wide), which full of hanging clothes due to lack design of sun-drying space. Facility included personal electricity bill, and shared well water distributed to each units. The well had to dig deep down to occupy all resident. However, the water pump easily broke and pushed all residents to interact to kampung people and have water from the kampung public wells.

Most RVF's residents are merchant. They selling goods to the Malioboro or Beringharjo market nearby. For daily meal they count on *warung* at the groundfloor which owned by Cokrodirjan kampung residents. Playgroup also managed by the kampung people. Interactions among kampung people and RVF residents ussualy occurred on the groundfloor in the form of daily chats and deep conversations, as well as buying vegetables and meals at the warungs and sharing well for water. They are also interrelated when social events occured: ceremonies, independence day event. When 2010 volcanic flood took place, they worked together on to break the concrete bridge that blocked the flood.

Juminahan Rented Vertical Flat

The building is named RVF Juminahan because it faces Juminahan road[4]. However, most of the land is actually within the area of Jagalan, a kampung on

---

[2] Malioboro is the city center area, famous as tourism destination and commercial uses. Just near the area, set a 4 star hotel –Mediterranian architecture. The hotel became a landmark since it was built since it's scale compare to the surroundings. This hotel and the location cause a debate in two RVF studied.

[3] Negotiations indicated is remain unclear. It is said by most residents of the kampung, however the meeting for negotiations counted only once, before the construction started.

[4] Juminahan street built in1990's. Across the Code river connecting Lempuyangan train station area to Malioboro. At the end of the street is Melia Purosani hotel- a mediteranian style hotel discussed before. Juminahan RV-flats resemble the hotel in facade, by reason not to give a bad

the other side of the road. It is located in the east area of Code River, at the opposite dirrection to Cokrodirjan RVF. Before it was built, there are 10 families living in the area, a public building belongs to Jagalan *(balai RW),* a shared volleyball field between Jagalan and Juminahan, and garbage station. The construction started from 2007 to 2008, but it was unclear whether the development got people's consent.

RFV Juminahan consist of 5 storeys, from groundfloor to fourth level. It has 50 units of 3x4 meters, with bathroom, kitchen, and internal sun-drying space. Each unit connected to corridor, free from hanging clothes. There is a rule to the residents for not allowing them to hang their clothes in the corridor or being seen from the street. The rule mostly driven by the city goverment for aesthetic reason.

The overall look of the vertical flats are modern, and exclusive from the surrounding. The groundfloor is under the street level, with rarely used public meeting hall and badminton space. Public space in the ground-floor, belong to kampung Jagalan, and only used when events have to be performed. It has fence surround the site, and enclosed motorcycle garage. It takes approximatelly 5 years to built, however bad construction creating water drip all over corridors.

The ground-floor level occupied by 10 families lived in the area before. They are from a Approximately 1,5 meter below the level of the road, it minimize traffic buzling. Those who live in the groundfloor have more space to dry their clothes, park their motorcycle just infront oh their units, or to have small store or workshop.

The first floor is one meter above the road level. It consists of a common praying room, commercial spaces, and a management office. Except the management office, which is open from 10 am to 1 pm, all spaces are not functioned. All residents live on the second to the fifth floors. Their units are categorized by their original district. The 2nd floor is for Danurejan people, the 3rd is for Pakualaman people, and the rest are from surrounding district.

Residents of Juminahan RVF conduct "arisan" and meeting each month. Even so, they are more or less attached to the kampung they are set in. Residents from Jagalan rarely went to public meeting in their kampung.

Globalization Effects to Kampung

Observation on residents of RVF, RVF managements, and kampung people indicates that there have been tensions between the residents of RVF and the kampung people. The tension that occurred in Juminahan is more intensive than that of Cokrodirjan. The tension is about social obligations, water, and access. Economical gap represent by aesthethical appearance (building façade and fashion) is not the main problem. Statements about how RVF is representing modern middle-class life sometimes occured, but there were no further discussions about it. Both Juminahan and Cokrodirjan see RVF as a new ordinary "thing" coming into the kampung life. They value RVF residents as more individualistic, but they have neither complaints nor social conflicts with RVF residents. Kampung people understand that the life of RVF residents different with them. The RVF residents in both locations have slightly different discourse due to time they have already passed by living in the rusunawa. The residents

---

view. The bad view said by local people is Cokrodirjan RV-flat. Juminahan residents like to use "aesthethic" reason to underestimate Cokrodirjan's.

cannot stay apart from the kampung life (eg. water and safety) eventough privacy and social cost become the major issues.

RVF residents have busy activities. The management in both cases is the one who earned a “position” in the kampung and RVF. In Cokrodirjan RVF, which has longer operating, sometimes management faced hard situation when they have to mediate the two communities, although in most cases they could manage it. The management acts as a ‘connector’ between kampung and the residents, but instead of connecting people by heart, they connect them by obligations.

People’s detached from its site

The third party who live in the RVF but does not belong to the kampung administration, are the one who loose most. They loose social interaction of one or both communities and leads to loosing their income, however they can create new social relations with the RVF residents.

Both residents of Cokrodiran RVF and Juminahan RVF appear to be detached to the site, with diffrerent levels. Juminahan RVF which have rigid and “clean” design and rules expereince the most detached. Rigid space and rules have made the community falling appart.

People’s Strategies

Place need tobe created by making moments

In Cokrodirjan RVF the ground floor acts as a social space that create dynamic social relations especially among the rusunawa residents, and the kampung people. They did conversations, neighborhood watching, playing, and other things together, which eventually created trust among them, yet became the base of social capital. They are in the process of making moments needed to turn the space into place.

Frictions are needed, mediating space to be made

This makes frictions among subjects temporary. There were no further discussions about what happened before. Gossips and rumors were easily led to conflicts, even in the most sensitive cases such as the protest of Cokrodirjan RVF residents to the RVF management was negotiably solved.

References

Jellineck, L, 1995, “Seperti Roda Berputar – Perubahan Sosial Sebuah Kampung di Jakarta”, LP3S, Jakarta.

Guiness, P, 1986, “Harmony and hierarchy in Javanese kampong” , Oxford University press, Singapore.

Development of Housing Settlement: Basic Resource Development Strategy for Housing

Ahmad Saifudin Mutaqi

Department of Architecture, Universitas Islam Indonesia

ahmadsaifudin@uii.ac.id

Abstract

The issues of provision of healthy homes for the low-income communities and simple flats are still facing many obstacles. The most classic obstacle is the inability of low-income people to make purchases for their home. The factors that cause the inability motivated by many things, among others: loss of jobs in the formal and non formal sectors, as well as small business community is not growing. Another obstacle in the provision of housing for low-income communities is the availability of suitable land prices and the value of strategic location. The issue of land is the most sensitive issues for the community. It is seen from the rampant unrest execution of land that is usually motivated by the irregularity of the acquisition of land for housing benefit.

So far the government has been trying to make a breakthrough step in fulfilling the housing needs of low-income communities, such as: set the size of the house and the lot area so that prices become affordable, but the impact on the feasibility of living to be so inhumane; down payment assistance for Civil Servants (PNS) through non-bank institutions such as Jamsostek, Bapertarum and Pension Fund to subsidize interest rates for Home Ownership Loan (KPR) only effects people who worked to gain access to formal course. What about the Low-Income Communities in obtaining the right to live where? Should they be forced to meet the formal requirements as stipulated in Government Regulation?

Key words: *Self-help, land, cheap-source of funds*

Background

Government efforts to provide assistance to Low-Income Communities to obtain their rights have lived a decent place to have a different variation. Assistance can include Loan Interest Subsidy or the Home Ownership and Down Payment Assistance. Most government grants for the provision of new housing, especially for the Prosperous Home Footprint (not the Flats – Rumah Sejahtera Tapak) are a Liquidity Facility Financing Housing (Fasilitas Likuiditas Pembiayaan Perumahan | Permen. No. 15 Tahun 2010 tentang FLPP) . Distribution mechanism is done by the management in particular by the Task Force (Satker BLU) - Ministry of Housing Department (Kemenpera) in cooperation with the Executing Bank. Grants are a Home Loan (Kredit Pemilikan Rumah - KPR); Self-help Home Loan Improvements (Kredit Perbaikan Rumah Swadaya | Permen. No. 14 Tahun 2011 tentang Bantuan Stimulan Perumahan Swadaya) and Prosperous Home Construction Loans (Kredit Konstruksi Rumah Sejahtera - KKRS). Thus all forms of government assistance in the procurement of public housing always use a banking mechanism, this means all sorts of requirements for assistance must use the formal borrowing mechanism is governed by the Executing Bank. What impact, funding assistance is not effective until the destination because it is constrained by a rigid mechanism that not all communities are able to fulfill it. It is available from the preparation of the stimulant fund of 4.7 trillion rupiah absorbed only by 2.4 trillion rupiah only. Target of 240,000 units' Prosperous Home Footprint is not reached and only 180,000 units. Thus we can be sure if the mechanism is not reformed then it will only repeat the past failures that happened during those years. To respond to the above issues required resolution in strategic and fundamental issues, among others, regarding (A) of land for housing; (B) housing finance, and (C) institutional housing sector.

A. Land development strategy for housing development

Issues surrounding land should be seen in the context of urban governance, urban planning & infrastructure provision and economic & social empowerment. Effective planning of the land is necessary to facilitate the arrangement of land for housing development. Land is often seen as a commodity and not as an object with which its use should be regulated for the good of all citizens. Change of ownership will provide major implications for how public and private land use, and how its use by the government. Some ways to do by the government to regulate the issue of land for housing construction and development sectors (Undang-Undang No. 1 Tahun 2011 tentang Perumahan dan Permukiman), among others:

1. Effective planning

Development, growth, competition, and speculation into the cause of rising land prices. Actually, if at the time of establishing a new housing or community development projects, with good planning can reduce the selling price per unit, ensure basic services efficient and affordable.

2. Better land information

With the good land information system is one of the main prerequisites to effective housing development. If land data is not clear, it would be very open opportunity misuse of land. The lack of reliable data and has the status information and the latest land transaction, an obstacle to efforts to establish an effective land market and transparent. This will encourage the informal land market, where a large number of land transactions are not recorded, and the town was eventually lost. Good land information is required in the city's land in order to remain efficient and fair and brings benefit to all citizens. Effective information systems and useful for society, especially for the poor, the system must be accessible, transparent and affordable. Here is what must be in good land information system:

a. Land Information System
   Computer system that organizes information about land, including its location, extent, boundaries, ownership, and the history of its utilization. There are a wide range of land systems with different levels of accuracy, depending on the purpose, such as to plan the city, or for the benefit of the law or taxation.

b. Land data.
   Written information on specific pieces of land with the legal documents of ownership and use. These data provide information about the owner's right to the

land. Land registration procedures should be simple, and is the first step in good building information and management systems. This procedure can be improved time by time, to overcome the existing of technical barriers that and build institutional capacity and human resources in the city.

c. Land Cadastral System
Public records that include survey or map value, extent and ownership of land within a city. These data not only have information about landowners, but also the location of the land owned. The system must be constantly updated as changes in land use and land ownership has changed in the field, as well as related to land registration system and data concerning land rights.

d. Land Registration System
Information regarding land rights and the preservation of evidence legal ownership. To be effective for a variety of household, land information systems must be capable of capturing various forms of ownership.

3. Legality of land arrangement

a. Legality of the arrangement of land can be done by doing the following:
Transfer of ownership can be done in two ways:
   1) Transfer of ownership is not directly carried out by intermediary agencies handling
   2) Transfer of ownership is directly without going through intermediaries. Directly from land owners to program beneficiaries

b. Freehold land and direct sales with or without a mortgage
c. Land lease agreement
d. Ownership by the community in the form of cooperatives
e. Land ownership remains in the hands of landowners and communities program is only given permission to hire

4. A more rigorous system of taxation

The tax on land has become a major source of revenue for every city in the world to finance various public interests. However, taxation of land, especially the idle land, is also a powerful fiscal tool to inhibit land speculation and ensure the amount of land ready to build for various purposes. Adequate amount of land available will result in decreased overall land prices, and improving accessibility to housing the poor. Land tax can also be done in various ways, depending on the variety of tax systems: government regulation relating to taxation, especially taxing land values it is certain that its benefits are benefits of implementing a tax on land:

a. Gains tax, charged on land that has been sold, according to the provisions of that person benefits from the sale of land should be taxed, and views as a form of income.
b. Idle land tax, given to landowners who are not used to someone not take advantage of unused leave his land. Even the government regulates land use to be more productive by using the Law on Abandoned Land (*Undang-Undang No. 11 Tahun 2010 tentang Tanah Terlantar*).
c. Land tax, which in different countries, different tax on land and tax on building, so someone had to pay two types of taxes, or there are two different taxpayers for a land that is for those who own land, and those with the building. Some countries use the tax system to increase local revenues, to finance the provision of public facilities in city.

1. As a source of city revenue. Taxes do not distort the market mechanism or burden the local economy as other taxes. The numbers tend to be inexpensive and efficient because it does not require a lot of work to monitor land ownership and value, rather than individual income or monitor the sale and purchase agreement. Land tax evasion is also difficult because these assets cannot be hidden or covered in the electronic data system.
2. The tax is also increasing the amount of land available. Because the owners of idle land have to pay taxes so that expensive push to sell the land to the market. In many countries, local governments use progressive taxation to cope with land speculation and ensure maximum utilization of land.

5. Development of land consolidation

Land consolidation is the merger of several parcels of land (owned by different owners) and removing ownership restrictions to be a great site that can be used for project development activities. This scheme is usually performed in low-density neighborhoods in the city, and turns it into part of the city's high density, new, has a vast number of housing units with a smaller, more efficient designs, as well as public facilities and better infrastructure. If the project is a large scale project, it can also be built parks, school playgrounds or shopping area in the master plan. As is done in Taiwan, the notion of land consolidation by Hsieh (1986), as follow "*....urban land consolidation is a measure (legeslative enactment) which arranges all the irragularly shape or fragmented land for regular shape and adequates sizes through combination, separation, exchange or readjustment of land within city planning area in line with the development of public facilities such as road, park, plaza etc. so as to achieve better economic use of land to form new urban area in accordance with the plan. In the course of developing urban land consolidation project all expenses involved are borne bu land ownerss themselves....*".

This adjustment process consists of various stages. First, land values have seen a variety of plans and adjustments were made. Then, these options were discussed with the owners and residents who helped determine the form of a plan eventually. Then the land was allocated to the owner in accordance with the new plan, and is usually based on land values, rather than breadth. Land consolidation cannot generate thousands of housing units per year, but can be used to provide land and housing for the poor, especially where there are informal settlements in the area.

Due to the consolidation of land is a complicated process and takes decisions by consensus, it usually requires good facilitation and support of the sensitive design to people's aspirations.

a. The collection of land by the Government. There are several places where the government took the initiative and implement a land consolidation scheme in inner city areas by allocating areas for the poor. The government can ensure that there are some plot, or portion of land in the new scheme for low-income communities, as a form of cross-subsidies. The collection of land is land readjustment technique in which the entire process of rebuilding must be done by specialized government agencies and participates of land rights holder (owner or tenant) in the area. In some cases, redevelopment has resulted in an increase in land prices and drastically accelerated the process of gentrification, where the uncertainty in land ownership for the poor has also increased and resulted in them expelled from the settlement. When this occurs, then it must be addressed immediately.

b. Consolidation of land / re blocking in the slums. At the time of the illegal occupants to negotiate for land tenure security (through purchase or rental) and rebuild on the same land, they often choose a technical consolidation of land which entirely razed to the ground, and build from scratch a settlement that is more dense and efficient in space utilization, so that more households can stay organized and reduce the per unit compared with buying the land and build settlements from the beginning. There are some who may not be satisfied with an area smaller land holdings, but they get is a reciprocal guarantee of land ownership.

c. Consolidation of land settlement involving some consolidation of land in slums and informal settlements can also be done with large-scale, which some settlements (on land or on land around together) to join and build resettlement in a joint project. Such consolidation is possible to do in settlements that are too dense, to move some of its inhabitants to other settlements that still have room, so the plot of land per unit, the design density, facilities and infrastructure that uniform can still be done in several settlements.

Can be concluded that urban land consolidation is a form of urban management engineering to regulate all forms of parcel of land which was originally irregaular to be more regular (Yunus, Sabari, 2005, Manajemen Kota, Perspektif Spatial).

6. Farm Subsidy Scheme

Land subsidy scheme is a policy that requires developers to set aside a portion of the private sector formal project market-rate housing for low-income housing. The idea is simple if the developer later took a big profit by creating housing for wealthy clients, would not it be better if a small portion of those profits (or the sale of the unit) is set aside to subsidize housing for disadvantaged households who are unable to reach the housing market?. This policy can be implemented in various ways, but most stipulate that a certain amount of the total units built, or a certain percentage of the total land area designated for new development should be set aside for low-income housing. Usually the smallest unit size and maximum sale price or rental specified in the policy, to ensure that housing is truly affordable to the poor.

B. Housing development finance sector

Intervention in the housing sector financing is needed to achieve housing that is accessible or affordable to all levels of society. Increasingly important role of housing finance as it will open up opportunities or more choice for citizens to access the home according to their abilities. Strategies in development financing in the housing sector that is able to regulate the flow of financing mechanisms in the development of the housing sector, including:

1. Facilitate the formal system

Make adjustments or simplification of the formal financial sector mechanisms to informal financing sector, the system becomes more in line with the characteristics of the informal sector.

2. *Lending through savings group (social gathering) societies*

Community-based savings and loan schemes to make governments and lending institutions establish mechanisms that can be managed in the poor communities themselves to manage the disbursement of loan and return as a group, thereby reducing expenditures manager of financial institutions. A community savings group not only raise funds for housing finance, but the process of running a savings and loan process in poor financial shape management capabilities of individual and collective (joint) that will be needed by the poor in managing loans for homes and land in the future (Klaus W. Konig, in Kota dan Lingkungan, Takashi Inogichi, 2003).

3. *Using a mediator to bridge the financing institution of formal and informal*

One way to link poor households (in an organized society) with the formal financial sector is to establish an intermediary institution or the like, which can bridge the gap between them in various ways. Mediating institutions can:

a. Increase the comfort factor. Formal institutions can be helpful to feel more comfortable in a poor household lending by offering risk mitigation, collateral loans, bridge financing, or even non-economic security of a credible mediator.
b. Open up new markets. Formal financial institutions will help to reach the market which has not been affordable.
c. Promote large loans. Can take the whole of the loan financing and lending institutions in ways that loosely to a variety of public housing, land and improvement projects - all with the amount of the loan, repayment terms and interest rates.
d. Form a revolving fund. It can use a comprehensive long-term loan from financial institutions to complete a variety of short-term loans to poor households for various purposes-not only for housing. This can provide flexibility in using the funding to support community development process is more thorough and comprehensive.
e. Introducing subsidies. Subsidies can be introduced to make loans more accessible to poor households. These subsidies can take the form of interest subsidies financed by the government or donors, such as for example, the commercial interest rate cut will be lower for loans to households.

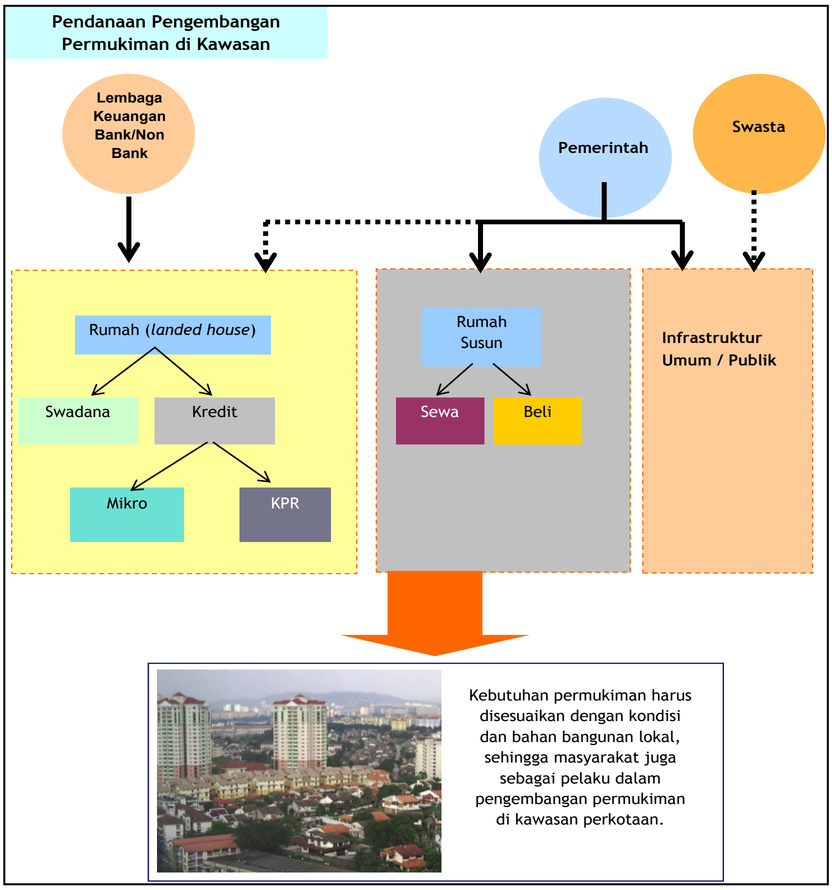
4. *Develop internal cross-subsidy mechanism*

Another strategy that can be used by governments, developers and communities to finance housing for low-income community with a minimum loan is a subsidy for housing is through the profits from the sale of residential units at market price on the same development.

Another alternative approach to the procurement of housing is self-help. Mechanisms of self-help housing construction that require special attention are housing organizations for Middle-Income Communities and Low-Income Communities. Attention that is needed is related to the issue of funding, given to build a home uninhabitable, requiring no small amount of funds, and generally difficult to be provided directly by the Middle-Income Communities / Low-Income Communities.

Some programs from the central government have done to support the facilitation of funding by way micro-credit financing including banking services at locations around the housing residents. The system is made in terms of self-help housing so that the government should seek access to funding availability in new home building and repairing homes uninhabitable. This funding also includes support for infrastructure improvements around the neighborhood. In addition, the provision of rental housing is also very necessary as a facility for low-income residents and do not have a fixed income.

Low citizens expected funding can be anticipated with the use of technology, standards and building materials. Housing standards should refer to local conditions, so that residents still feel the true meaning of home.
For that much needed a special management of the remaining budget to fund housing budget and the economic empowerment of citizens. The existence of a special program about the housing should be a goal in the development of the city, in addition to improving the city's economic growth. Diagram of funding the development of settlements in urban areas is below:



Figue 1. Housing Development Financial Scheme. Reference: Report of RP4D Province DIY, 2009-2014

C. Institutional sector housing development

The purpose of the housing development plan has been prepared is to provide guidance to governments, the private sector in order to quantitatively and qualitatively, the houses are built in accordance with the requirements and then are an asset to the city that have high added value. For it as described in the previous section, important aspects contained in a housing development plan are:
(1) Referral number (quantity); (2) Referral proportion of house types; (3) Referral Landing site; (4) Referral order site (site), including its relation to the structure of the space, the space open the public, and other residential

infrastructure; (5) Referral forms the building unit.

The plan is expected to be easily implemented and adopted by the perpetrators or development. Outside the government itself, in general there are two classes of development actors housing, the private developers and individuals. Therefore, the application guide and control is also distinguished from these two actors.

It is important for developers in general are regulated:

1) List the location of the land utilization through permits,
2) Site Plan, which is associated with the availability of open space for social activities, open space, watershed, and open green spaces for the breathing (respiration)
3) Completion of infrastructure and facilities
4) The proportion of the types that would ensure fairness of distribution of ownership.
5) Standards of construction to ensure consumer safety
6) Types associated with the themes of the development plan pursuant to the RT RW

In general, for the city plans developer, housing development guidelines should be more widely adopted as a standard rule. While for most individuals will be effective when applied as a call and guidance. For individual players, the important thing that needs to be informed and to be guided are:

1) Glossary of forms suitable for the particular site (hills, beaches, roadsides, etc., as described in the previous section)
2) Guidelines for the use of construction technology that can be used (appropriate)
3) The actions of the construction and building forms that can be detrimental neighbors and who in turn benefit
4) The patterns of compromise and cooperation with neighbors or community

Approach to 'neighborhood pattern' can serve as a solution to social problems in communities that are currently filled. The existence of the interdependence between people cultivates a spirit of mutual help that has been long lost for urban communities. On the other side to build an understanding of the rules also need to experience with the community. So that they build in their own homes remain on the corridor regulations, including the issuance of Construction Permits Letter. Suitability of land guarded by the local government regulations, such as: Building and Land Use Plan Environmental and Land Use Plan. Schematically, the application of rules / guidance for the development and construction of individual housing can be described as follows:

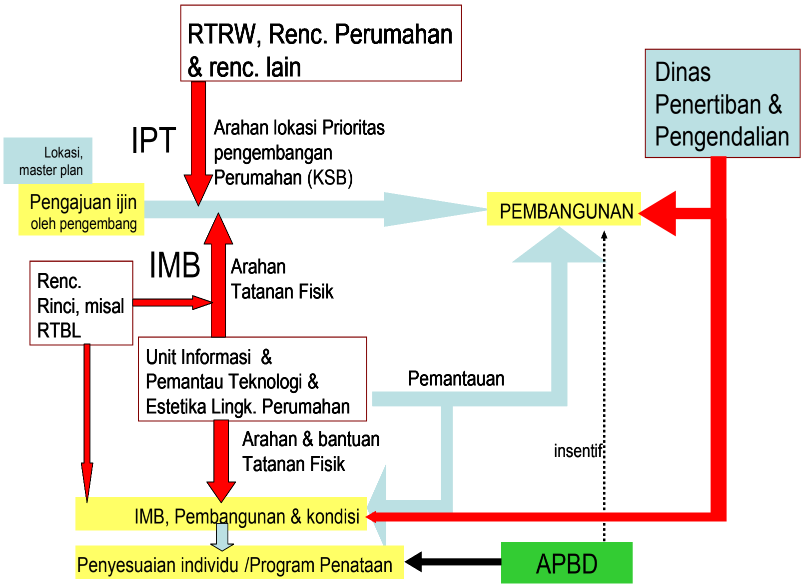


Figure 2. Housing Development Refereal Scheme. Reference: Report of RP4D Province DIY, 2009-2014.

The starting point of efforts to implement the utilization of space is permitting. Licensing mechanism is the application of the principle of prevention (preventive). Various permits and requirements pertaining to the utilization of space has been set up, both at central and regional levels, eg the principle of consent / land use permits, site permits, business licenses, premises licenses, building permits, permit interference, Environmental Impact Assessment (EIA), site plan, certification, RT RW, IPPT (drying), consolidation of land, permit the public interest, and others. Having no set plan, space utilization needs to be monitored and controlled when there are deviations, or prevent the occurrence of irregularities.

a. Control, a business or activity to maintain compliance with the spatial function spaces defined in the spatial plan that takes the form:
   1) Reporting, business or activity providing objective information about both the appropriate use of space and not in accordance with the spatial planning;
   2) Monitoring, or activity to observe, supervise and examine closely the changes of spatial and environmental quality are not in accordance with the spatial planning;
   3) Evaluation, business or activity to assess the progress of the overall space utilization after first reporting and monitoring activities performed to achieve the spatial plan.

b. Control, business or activity to take action so that the planned use of space can be realized. Imposition of sanctions with regard to policing are:
   1) Administrative sanctions may include revocation action and revocation of licenses,
   2) Civil penalties, the imposition of measures may include the imposition of fines or restitution,
   3) Criminal sanctions, actions may include detention or confinement.

Conclusion

From the above study it can be concluded that the important and fundamental for the realization of the principle of 'house for all', as follows:

1. Approach to land development strategy to ensure the need to reform housing development in the area of land. Directed towards the improvement of legal certainty for Low-Income Communities to obtain a settled place
2. Approach encourages the development of more funding for Low-Income Communities empowered to be able to meet the primary intent would be their home. This is done not by giving aid, but merely set up a fair mechanism to be capable of Low-Income Communities.
3. Institutional development approach to deregulate the housing sector with government regulations that provide opportunities for Low-Income Communities to easily follow the licensing mechanism for the development of their own homes.

References

Hadi, Sabari Yunus, Manajemen Kota, Perspektif Spasial, Pusataka Pelajar, Yogyakarta, 2005.

Hsieh, P.C.R. (1986) A Study on the Urban Land Consolidation. Taoyuan: Landreform Training Institute.

Inoguchi, Takashi, Kota dan Lingkungan, Pendekatan Baru Masyarakat Berwawasan Ekologi, Pustaka LP3ES Indonesia, Jakarta, 2003.

Undang-Undang No. 4 Tahun 1992 tentang Perumahan dan Permukiman

Undang-Undang No. 26 Tahun 2007 tentang Tata Ruang

Undang-Undang No. 11 Tahun 2010 tentang Tanah Terlantar

Undang-Undang No. 1 Tahun 2011 tentang Perumahan dan Permukiman

Peraturan Menteri Negara Perumahan Rakyat, Nomor: 03/PERMEN/M/2007 tentang Pengadaan Perumahan dan Permukiman dengan dukungan Fasilitas Subsidi Perumahan melalui KPR Bersubsidi.

Peraturan Menteri Negara Perumahan Rakyat No. 7 Tahun 2007 tentang Rumah Susun Bersubsidi
Peraturan Menteri Negara Perumahan Rakyat No. 15 Tahun 2010 tentang Fasilitas Likuiditas Pembiayaan Perumahan.

Peraturan Menteri Negara Perumahan Rakyat, Nomor: 09 Tahun 2011, tentang Petunjuk Pelaksanaan Pengadaan Perumahan melalui Kredit Konstruksi Rumah Sejahtera Tapak dengan dukungan Fasilitas Likuiditas Pembiayaan Perumahan.

Peraturan Menteri Negara Perumahan Rakyat No. 14 Tahun 2011 tentang Bantuan Stimulan Perumahan Swadaya.

Rencana Pembangunan & Pengembangan Perumahan & Permukiman Di Daerah (RP4D) Daerah Istimewa Yogyakarta tahun 2004-2014, Dinas PU Perumahan & ESDM Provinsi DIY.

Coping Noise Efforts Through Territorial Concept: Learning From Kampong Kauman Yogyakarta Indonesia

Sativa
Department of Civil Engineering and Planning Education,
Faculty of Engineering, State University of Yogyakarta
E-mail: sativa@uny.ac.id

Abstract

The more increasing density of urban environment has brought an impact on the increase of social, cultural, physical, and traffic density problem. Air pollution and noise are those, for example, impacted by the dense traffic. Urban village, commonly named as kampong, as the main basis of settlement in urban areas has also been mainly affected by traffic congestion in the vicinity. It is therefore necessary to find an alternative solution, including through a study of a certain kampong considered to have a potential in a physical and social order to be adopted by other kampongs. In Yogyakarta one of the potential kampongs is Kauman, a unique kampong particularly on its cultural and social aspects, embodied in its physical structure. A territorial system in this kampong is very specific, mainly through the prohibition either for motorized vehicles to enter the village in the engine running or for the singing beggars. The aim of this paper in turn is to explore the positive impact of the territorial concept of Kampong Kauman Yogyakarta particularly related to the aspects of noise in the settlement. This study uses a comparative evaluation method in which the data is obtained by measuring the level of noise in the village and a village surrounding Kauman using a sound level meter and compared with residential and settlement noise standards. It is also supported by secondary data from the respondents. It is found from the study that the territorial concept of Kampong Kauman Yogyakarta strongly supports the achievement of a comfortable settlement situation of noise disturbance with the average noise level of 49db. This is consistent with the residential noise standards 45db-55db. On the other hand, most of the other kampongs surrounding have average noise over 55db. The concept of territory therefore is possible to be adopted by other solid kampongs, in particular to have a comfortable environment of noise disturbance to local communities.

Keywords: dense urban kampong, Kauman Yogyakarta, coping noise

Introduction

Most of major cities in Indonesia currently have been experiencing a rapid growth in industry, transportation, or expansion of residential areas. At the same time, the growth also impacts on the number of settlements and the infrastructures of the daily human activities, which is adjacent to noise sources such as industrial area, the area of nearby highways, airports, or railroads. Along with this increasing development, several negative impacts on human life emerge, one of which is noise. Noise comes to be an issue directly impacting on and interfering with everyday human activities, even threatening human health. In this regard, to maintain comfort and environmental sustainability, several efforts in controlling noise are necessary to reduce the negative impact potentially emerging. In the urban settlements, for the sake of a comfortable settlement a study is deemed to be essential to find out an alternative in controlling the noise, mainly derived from voice traffic in the vicinity.

In the center of Yogyakarta Indonesia, a dense kampong, related to aspects of noise control in the settlement, for some reasons is interesting to be studied. It is kampong Kauman, which has a highly distinctive character, especially for its historical features of the Islamic Javanese kampong. Similar to the former cities of the Islamic Mataram Kingdom in Central Java, Kampong Kauman in Yogyakarta is also located in the area behind or around Masjid Agung (the great mosque). Kampong Kauman in Yogyakarta along with its development, however, has a typicality compared to other Kaumans in other cities.

In 1912, led by KHA Dahlan, Muhammadiyah Islamic reform movement was born in Kauman Yogyakarta (Darban, 2000). This movement attempted to obtain the purification of Islamic teachings from a syncretistic Islamic tradition assimilated by Hindu, Buddhist, and animistic culture to Islamic reform based on *Qur'an* and *Sunnah* (Darban, 2000). Darban also says that there is no change for the social values in Yogyakarta Kauman. Islamic values adopted by society still remains to be a life cornerstone. This can be seen from *Masjid Agung* (the great mosque) used as the center of religious activities and orientation of the primary environment.

Today, Kauman Yogyakarta with an approximate area of 192,000 m2 has become a dense kampong located in the city center. Occupancy rate with 80 % of the building coverage ratio (BCR) has led the open space to be very rare. An existing road coming to be a typicality of Kampong Street is called as *Gang*, a narrow street or pathway formed from a row of buildings that form a straightaway then impressing a corridor. Nonetheless, compared to other solid kampongs, this has created a typical atmosphere now that no motorized vehicles are allowed to pass through with the engine running, though the road space is adequate to do so.

From the previous research, the authors found that the most distinctive physical character of the environment in Kauman Yogyakarta is the existence of a very strong territorial control, with a spirit to create a silent atmosphere in doing the religious activities. The territorial control of the kampong is divided into a private room (a residential area that is not facing the main road and bordered by ahead of the pathway with the sign of warning to turn the engine off and prohibiting the coming of the singing beggars), semi-public area (area in the courtyard of the Great Mosque allowing the cars to park and motorcycles to pass through, but still with the ethical propriety), and public area (area directly adjacent to a highway of kampong border in which the rules in kampong are no longer applicable).. This research is a continuation of previous authors studies, related to the impact of the concept of kampong territory towards the condition of noise in the kampong.

Research Purposes

The purpose of this study is to determine the level of noise in Kampong Kauman Yogyakarta compared with residential noise standards, and to find out the noise levels compared with other dense kampongs surrounding. This research is expected to appear some local findings that allow to be transferred to another location that has a sort of kampong Kauman conditions. The results of this study is expected to enrich the vocabulary of science residential architecture that is able to inspire other built environment, particularly with regard to the convenience of settlements in dense urban neighborhoods.

Theories

Settlements and noise

Housing or settlement is a basic human need and the determinants of public health. Hence, the provision of housing comes to be a complex fundamental purpose. The availability of housing standards in addition refers to an important issue in public health. In order to make the residents stay healthy, a habitable housing must meet several health requirements. At this point, a healthy settlement can not be separated from the availability of infrastructure and related facilities such as water supply, sanitation, waste disposal, transportation, and availability of social services (Krieger and Higgins, 2002).

The house is a physical structure made up of the room, courtyard and surrounding areas used as a residence and a means of family formation (Law No. 4 of 1992). According to WHO (World Health Organization) the house is a physical structure or building for shelter, where the environment at this point is useful for physical and spiritual health and good social conditions for individual and family health (WHO Commission Regarding the Health and Environment, 2001). Thus, it can be interpreted that building a healthy home is a refuge and resting as well as a means of family formation that fosters a healthy life physically, mentally and socially - thus enabling the entire family to be able to productively work. The existence of a healthy, safe, harmonious, orderly house as a result is very essential to make the function and use of the house well-fulfilled. Housing is a group of houses that serves as a residence or residential environment equipped with a basic environmental infrastructure, namely the facilities of the physical environment such as water supply, waste disposal, electricity, telephone, roads, allowing neighborhoods to properly function; and the environment refers to facilities to support the implementation and development of the economic, social and cultural rights such as playground facilities, sports, education, shopping, transportation facilities, security and other public facilities.

Meanwhile, according to Law No. 4 of 1992, the settlement is part of the environment outside the protected areas, as both urban and rural areas that serve as the neighborhood or residential environment and the activities that support the life and livelihood. Neighborhood unit is a residential area in a variety of shapes and sizes with the arrangement of land and space, infrastructure and facilities in a structured environment. Environmental infrastructure is the basis of completeness of the physical environment that allows neighborhoods to properly function. Environment is a means of supporting facilities, which serve to organize and develop the economic, social and cultural rights. Public utilities meanwhile are supporting facilities for environmental services.

Table. 1. Noise Zone Standard

Zone	Area	Ideal (dB)	Maximum (db)
A	Hospital, research area	35	45
B	Settlements, educational place, recreation area;	45	55
C	office, bank, shop, market area	50	60
D	Industrial areas etc	60	70

(Source: The Decree of Health Ministry of Indonesia (Kepmenkes) No. 829/Menkes/SK/VII/1999)

In addition, based on the health standards of housing and settlement environment of the Decree of Health Ministry (Kepmenkes) No. 829/Menkes/SK/VII/1999, the recommended noise level in a settlement is 45 db, and 55db in maximum.

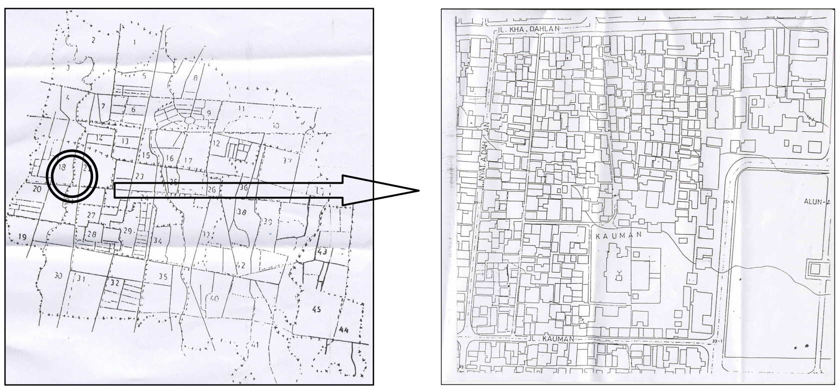
Kampong Kauman Yogyakarta

The concept of territory as one of the attributes of the environment in Kampong Kauman Yogyakarta is very distinctive and associated with the concept of privacy in their home-scale (micro level). In some previous studies the authors have found that the concept of privacy Kauman Yogyakarta is influenced by Islamic Javanese values adopted by the locals (Sativa, 2004). This concept specifically is to regulate relationship among human and to support the transcendent interaction with God (Allah). As a manifestation of the concept of privacy in the residence of Yogyakarta Kauman, territory is divided into three -- public area (a hallway in front of the house and living room), semi-public area (living room or family room) and private sphere (interior spaces besides living room).

The concept of privacy on a micro scale of residential is proved to be extremely territorial coloring concept on meso scale (residential area). The author also has found that the concept of privacy in the residence of Kauman is very influential on the order of kampong (Sativa, 2012). At the kampong scale, there are also three levels of territory; namely private area (covering the interior areas of kampong bounded by ahead of pathway to the kampong), semi-public area (the courtyard of the Masjid Agung (Great Mosque)) and public areas (the roads surrounding the kampong).

Methodology

This study is a comparative evaluation by measuring the rate of noise in Kampung Kauman Yogyakarta and compared it with the noise standards for settlements that have been regulated by the government. To strengthen the research results, levels of noise in addition were also compared with other populous kampongs surrounding kampong Kauman Yogyakarta. Those kampongs were: Rotowijayan, Ngupasan, Suronatan, Prawirodirjan and Keparakan Lor. Method in obtaining data was through measurements using a noise meter sound level meter. This study to support the discussion then was accompanied by field survey and interviews with some respondents.



Yogyakarta city Kampong Kauman

Picture 1. Kampong Kauman Position in the center of Yogyakarta city (source: Bapeda Yogyakarta, in Sativa, 2012)

Results and Discussion

The physical signposts for the territorial borders of private areas in Kampong Kauman Yogyakarta can be clearly seen in ahead of pathways (*gang*). There have been 17 pathways ranging from 0, 75 meter to 4 meter in width . In a word, it can be said that there have been some pathways sufficiently suitable for motorcycles to pass through; even for facing each other. Uniquely, there always has been a signpost in the form of pasteboards to prohibit the motorcycles to enter the pathway in a running engine. Meanwhile, in a main pathway with 4 meter in width (principally sufficient for a car), there is a signpost to forbid a rider to ride on motorcycle as well as a small gate with a trap. This thus indicates a message that the vehicles could not pass through the pathways freely. In other pathways with above 3 meter wide, ornamental illuminations are installed in the middle of each pathway making the pathway to be narrower. Physically, this strengthens the territorial system in Kampong Kauman Yogyakarta.

Picture 2. Territorial signage of kampong kauman Yogyakarta, use signpost in the form of pasteboards and physical signage such as narrow gate and trap toward kampong (source: author's survey, 2012)

Picture 3. Ornamental illuminations are installed in the middle of each pathway making the pathway to be narrower, to strengthens the territorial system in Kampong Kauman Yogyakarta. (source: author's survey, 2012)

The respondents who are also the inhabitants of Kauman feel comfortable with such condition – not being disturbed by the noise of vehicles. Since this has been a habit, the inhabitants are willing to guide the motorcycle into the kampong. In common, the motorcycles of the inhabitants are parked in the kampong and, the motorcycles are parked in front of the houses at day and are in the house at night. Furthermore, in Kauman it is only few of inhabitants that have car in which most of them park their own car on the side of the main road and some entrust their car to their relatives living nearby such as Notoprajan (western Kauman, the most inhabitants of which are the relatives of Kauman inhabitants).

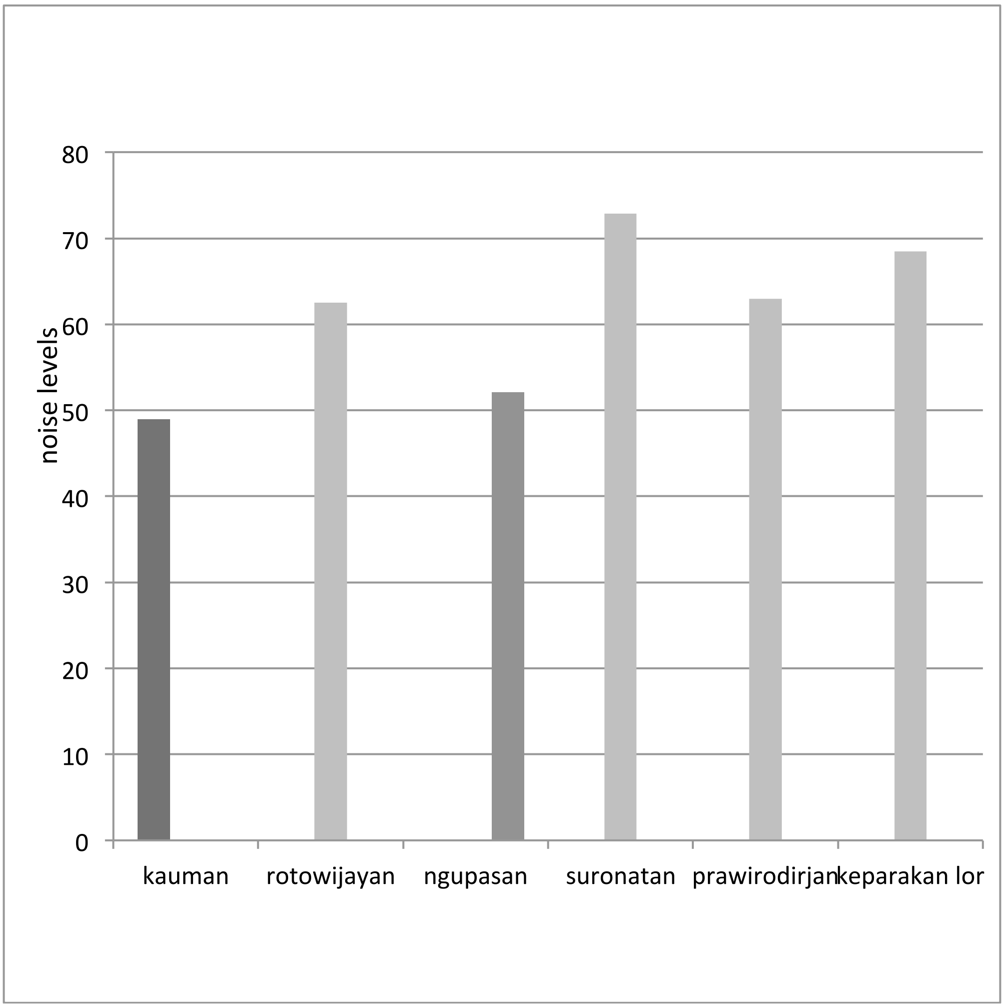
Based on the result of noise measurement in Kampong Kauman and other kampongs surrounding, some data of noise level are obtained as presented in the following table.

Table 1. Noise average in Kampong Kauman and other surrounding kampongs

Name of Kampong	Noise Average (db)	Noise Standards in Settlement		Remark of Sufficiency and being exceeding
		Suggested	Max	
1. Kauman	**49**	**45**	**55**	**sufficient**
2. Rotowijayan	62,5	45	55	exceeding
3. Suronatan	72,9	45	55	exceeding
4. Ngupasan	52,1	45	55	sufficient
5. Prawirodirjan	63	45	55	exceeding
6. Keparakan Lor	68,5	45	55	exceeding

(source: author’s survey, 2012)

From the measurement above, it can be clearly seen that the noise level in Kampong Kauman Yogyakarta is the closest one to the recommended noise level in accordance with the standard of settlement noise regulated by the Minister of Health of Indonesia (the Decree of Health Minister (Kepmenkes) No. 829/Menkes/SK/VII/1999). Kampong Ngupasan that has some rules corresponding to that of Kampong Kauman Yogyakarta similarly has the noise level under the standard but higher than Kauman; namely 52,1 db (near the maximal threshold of 55db). This is due to the prohibition of motorcycles to pass through the kampong of Ngupasan for having the relatively narrow streets (1 meter on average). Conversely, other 4 kampongs have the noise level at the distance of health threshold. Most of those kampongs do not have regulation to prohibit motorcycles even cars to passthrough their kampongs, except f the width of alleys are not available. The graphic of noise level of 6 kampongs is presented in the figure below.



Picture 4. The graphic of noise level of Kampong kauman Yogyakarta and surrounding kampongs (source: author's analysis, 2012)

Conclusion

Several following conclusions are drawn from this study:

1. The noise in the area of Kampung Kauman is in accordance with the noise standard regulated by government; that is 49 db, near the recommended level (45 db) and under the maximal threshold of 55 db.
2. Compared to the other kampongs surrounding, the noise level in Kauman Yogyakarta is the lowest one. It is only in Kampong Ngupasan Yogyakarta that has the noise level under the threshold; namely 52, 1; yet it still is higher than Kauman. Other 4 studied kampongs have the average of noise level ranging from 62,5db to 72, 9 db, thus going beyond the maximal noise threshold for the area of settlement.
3. It can be concluded in this study that the territorial system in kampong Kauman Yogyakarta significantly very supports the level of convenience from the noise level leading it to be more potential to be adopted by other similar dense urban kampongs.

Suggestion

There is a need to do a research deeper in Kauman Yogyakarta to more significantly show the significance of territorial control related to the aspect of air pollution as well as in the level of crime in the kampong compared to the kampongs nearby. The parking system in the area of Kauman and surroundings is essential to be well planned as well.

References

Darban, Adaby, 2000, Sejarah Kauman, Penerbit Tarawang, Yogyakarta

Keman, Sudjajadi, 2005, Jurnal Kesehatan Lingkungan Vol 2 No 1, hal 29-42

Rapoport, Amos, 1969, House Form and Culture, Prentice Hall, London

Sativa, 2004, Konsep Privasi Rumah Tinggal di Kampung Kauman Yogyakarta, Tesis, UGM

Sativa, 2012, Konsep Teritori Kampung Kauman Yogyakarta, Makalah untuk Seminar Nasional Arsitektur Islam 2, Universitas Muhammadiyah Surakarta

The Decree of Health Ministry of Indonesia (Kepmenkes) No. 829/Menkes/SK/VII/1999

PANEL 3

URBAN FOOD SECURITY AND AGRICULTURE

Environmental Economic Valuation of PAMSIMAS Program

A. Widodo Brontowiyono

Dept of Environmental Engineering FTSP; Center for Climate Change and Disaster Study (C3DS-PuSPIK), Universitas Islam Indonesia (UII)

Email: widodo.bronto@gmail.com

B. Ribut Lupiyanto

Center for Environmental Study (PSL) and Center for Climate Change and Disaster Study (C3DS-PuSPIK), UII

C. Yudha Heston and Dimas H. Nugraha

Ministry of Public Work, Republic of Indonesia

Abstract

One of the aspects that need to be examined of PAMSIMAS (Community Based Drinking Water and Sanitation Development) is the considerable amount of cost contribution, which used and benefit value. Environmental economic valuation was conducted to find the level of PAMSIMAS implementation. Analysis was done through sampling process in three villages of Kupang Regency. Economic valuation analysis was conducted for the period of 20 years, which is assumed as the mean-age of PAMSIMAS with discount rate level of 16%. Another assumption is the service ability of PAMSIMAS that reaches 100% from the target of family's total number to serve. Analysis result shows that PAMSIMAS is worth to be developed in the research areas. It is caused by the high benefit of those 3 areas which have water efficiency compared to that of buying privately. Valuation result in Kupang is a little lower because water source becomes a problem for PAMSIMAS development.

Keywords: Economic valuation, PAMSIMAS, drinking water, sanitation

INTRODUCTION

Water is the primary need for humans and other living things. For that reason, water availability becomes one of indicators for the development progress of a certain area. Indonesia has more than 32,000 undeveloped villages, which need the development of suprastructures and infrastructures of drinking water (Public Works Ministry, 2010). Besides that, there are many urban areas, which have problems of water deficit.

Area with water crisis becomes the priority to be immediately and sustainably handled so that the present solution can solve the next problems, which may emerge. Water crisis can be caused by natural factors or the ones did by humans. One of the government programs related to the providing of clean water and sanitation for the community is PAMSIMAS (Community-Based Water Drinking and Sanitation) program. PAMSIMAS has been started in 2008 with the target area covering 3960 villages or "kalurahan" located on 110 regencies/cities within 15 provinces.

PAMSIMAS activity involves all community by using the approach of *"demand responsive program"*. They made written statement about their interest in the letter called as Statement Letter of Interest to Join in PAMSIMAS. This program is to achieve MDGs target in 2015 that is to decrease a half number of the total community who have not got the access to get drinking water and sanitation in 2015. It covers around 70 million people for the coverage of sanitation services and 36 million people for the coverage of drinking water services at suburban areas. The target of this program is the group of poor people at suburban area and peri-urban area that have high disease prevalence related to water and they have not got access to drinking water service and sanitation.

PAMSIMAS program has not completely fulfilled the expected target. One aspect, which should be examined is the contribution level of cost spent and the advantage value that people get, so that the potential users will positively respond which then it will influence the target and achievement. Valuation of environmental socio-economy can be conducted to find the validity level of PAMSIMAS implementation. This paper describes PAMSIMAS program in Kupang, NTT Province, which are in Naikolan, Liliba and Nunbaun Sabu villages.

ANALYSIS METHOD

Economy validity analysis is analyzed using the analysis of cost benefit by the criteria of *Cost-Benefit Ratio (CBR)* and *Pay Back Period* and analysis of *Ability To Pay*. The economy validity reflected with the CBR number which is more than 1. Cash value is resulted through conducting discount rate. The level of discount rate interest is a certain coefficient which will determine how low or high the level of social opportunity cost (Gray, 1997). The interest level that used is how high the advantage level can be resulted if the needed sources are not used for the project, but it is used for other investment opportunities. On the projects of development which used private funding usually use social discount rate interest level, that is interest level which change into zero of the present value until infinite level. This social discount rate interest level calculates the items of tax-risk and inflation rate. In practice, there are not any social interest levels determined by BAPENAS, however the numbers used usually covers around 10-15% (Gray, 1997). In order to get a distinctive result, this research used the maximum discount rate interest level that generally used, 15%.

CBR is analysis to find the comparison between benefit and cost in PAMSIMAS implementation. The formula used to get the number of CBR is:

$$NetB/CRatio = \frac{\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t - B_t}{(1+i)^t}}$$

with,
- B_t : Bruto social benefit of the project on year of -t.
- C_t : Bruto social cost of the project on year of -t.
- n : Economy period of the project.
- i : Social opportunity on capital stated by social discount rate level.

Category of the second analysis is called as Pay Back Period. It is the time needed so that the project benefit has been balance with the total cost previously spent (Tarigan, 2005). In order to get the real time value, the cost and benefit values used are also the real ones (with the discount rate). This criterion has similar concept with Break Event Point. It is the time when input value is the same with output value or at the advantage position is 0. The validity with this category may be achieved if the value of *Pay Back Period* is smaller than the predicted project validity period.

PAMSIMAS implementation will run optimally if the pattern used involves the community participation. This participation pattern implies on the source of funding that mostly come from private funding or self-help. Then, descriptions of benefit and cost have not sufficient for conducting validity study. Economic validity, at other side, also needs to consider the doer ability, in this case is the community. This research conducted a comprehensive economic study by doing the analysis of Ability To Pay. This is an analysis in order to find how high the community is able to spend cost for implementing PAMSIMAS through survey research by using technique of open questions. Open question, or also called as unstructured question, is a question without the availability of answer options, consequently the respondents should stated their own answers (Faisal, 1995). This technique was chosen because it does not have value limitation in determining the level of Ability To Pay. Value of Ability To Pay generally resulted from the mean of value from the respondents' answers (Kadariah, 1999). If respondents are able to spend the same or higher cost than it is predicted, thus it means PAMSIMAS is valid to be developed.

Analysis of social validity is conducted to find the levels of acceptance and willingness from the community to participate, which analyzed from the data of survey result. Survey research is a research that takes sample from one population and uses questionnaire as a means of primary data collection (Singarimbun and Effendi, 1995). This method was chosen because according to Singarimbun et al (1995) one of its goals is to be conducted for evaluative research, and so is this research. Surveys were conducted to collect data of community socio-economy which influence the validity of PAMSIMAS implementation based on the analysis unit of family. Family was chosen as the analysis unit based on the consideration that family becomes subject and also as the main object in PAMSIMAS implementation. Sample taking was done by applying *quota sampling* technique. This technique was conducted by determining samples with certain amount and according to Faisal (1995); it is suitable for data collecting about general opinions, such as the goal of this study. It is to find perception and willingness of the community towards PAMSIMAS implementation. Respondents of each analysis area were determined based on the existing needs, which had been determined by health sample. As stated by Singarimbun and Effendi (1995), a very minimum requirement can be taken from 20 family samples, which based on the minimum requirement that to analyze frequency table, there should be 20 samples. Thus, this research can use that analysis to get socio-economy consideration of PAMSIMAS development. This analysis is based on family unit by considering the difference among area characteristics.

Economy validity reasonably influences the level of social validity because economy factor, specifically expense cost still becomes the most influencing factor for the determining of community decision. In this research, social validity is focused on how far the people's willingness is to implement PAMSIMAS by giving the economic description of the previous analysis result. Social validity is analyzed using the method of Willingness To Pay through the survey research. According to Tamim (1999), Willingness To Pay is the willingness of the users to pay rewards for services they get. Therefore, in this research, Willingness To Pay means that the people's willingness to use PAMSIMAS with a certain alternative model they want based on the consideration of benefit value, which they can get. In order to find the respondents' Willingness To Pay towards an alternative model, it is possible to do through distributing questionnaires using question forms that based on the method of stated preference (Setiawan, 2000). Some methods of stated preference, for example, are: Contingent Valuation (CV) Methods, Conjoint Analysis, and Choice Modelling (CM). Contingent Valuation (CV) Method is a technique which gets value prediction from units of several alternative scenarios. This consists of Open Ended CV method that gives several alternatives with more focused on environment factor and also Referendum CV Method which gives options for respondents to choose one between two alternatives. Conjoint Analysis consists of Conjoint Rating, Conjoint Ranking and Paired Comparison. Conjoint Rating is a method which gives opportunity to respondents to give assessment towards the offered alternatives using rating scale. Conjoint Ranking is almost the same with conjoint rating, but the assessment is enough to give by determining a list of chosen alternatives. Paired Comparison is a method that provides two alternatives for respondents to be chosen one of them, in which one alternative describes the existing condition at the present time and the other describes the existing of a change. Whereas, Choice Modeling chooses among more than two alternatives by seeing some attributes which are described to be considered.

The analysis of Willingness To Pay in this research was chosen using the method of Referendum Contingent Valuation (CV) and Choice Modelling. The whole levels of willingness towards PAMSIMAS were determined with Referendum Contingent Valuation (CV) because it is more effective since it is suitable with the purpose of the research. It is easier to get an exact answer between "yes" and "no" from the community towards PAMSIMAS implementation. In social research, such alternative options follow the model of Guttman scale, which also has purpose to get a confirmed answer (Faisal, 1995).

RESULT AND DISCUSSION

Economic valuation in this research is evaluative since PAMSIMAS program has been started. Analyses were conducted with sampling technique in Kupang, NTT Province (Naikolan village, Liliba village, and Nunbaun Sabu village). PAMSIMAS as a national program has standard parameters, so that the patterns were almost the same at most places. There was only a small creation to be suitable with local condition. In the matter of cost, at the beginning it was maximally arranged to be Rp. 275,000,000.00 which gained through sharing among the central Government, province, regency/city and the community. The difference among places/locations will be seen from the community contribution on the next years for the operation and maintenance of PAMSIMAS. Analysis of economic valuation was done for the period of 20 years, which was predicted as the mean validity period of PAMSIMAS with discount rate level of 16%. Another assumption is PAMSIMAS service level reaches 100% from the planning about the numbers of family that can be served.

PAMSIMAS cost consists of construction cost for drinking water facility and or sanitation, cost for "LKM" (community institution) operation, cost for "PHBS" (clean and healthy habit improvement) implementation, and also cost of operation and maintenance of PAMSIMAS facility. The capital of PAMSIMAS was predicted as shown on Table 1.

Table 1. Capital of PAMSIMAS Development

Component	Naikolan Village	Liliba Village	Nunbaunsabu Village
Construction Cost	Rp. 188,973,000	Rp. 214,516,700	Rp. 195,126,219
LKM Cost	Rp. 14,272,000	Rp. 35,000,000	Rp. 40,000,000
PHBS Cost	Rp. 24,517,500	Rp. 25,000,000	Rp. 39,500,000
Total	Rp. 227,762,500	Rp. 274,516,700	Rp. 274,626,219

Source: "RKM" (community work plan) (2009) and interview (2010)

All costs above were spent in the first year. The next step spent the cost for operational and maintenance (OP) of PAMSIMAS facility. These costs were fully afforded by people used PAMSIMAS. The amount of cost for each family was determined based on the water usage and economic level. The payment conducted each month by calculating the operational and maintenance demands needed which compared with the total existing families. These costs were routinely spent each year. OP cost for each village shown on Table 2.

Table 2. Costs of PAMSIMAS facility Operation and Maintenance per Year

Component	Naikolan Village	Liliba Village	Nunbaunsabu Village
OP Cost	Rp. 162,000,000	Rp. 122,040,000	Rp. 43,200,000

Source: "RKM" (community work plan) (2009) and interview (2010)

The next evaluation is for benefit. Direct benefit of PAMSIMAS development, for instance, are people cost efficiency for water consumption and cost efficiency of sickness decrease/the increase of environmental health. Another benefit is actually the increase of community economy, however, it cannot be valuated since its prediction coverage is wide and there is not description from the community about how they directly use water for their economic business. Other benefit variables are difficult to predict economically because the area coverage and the water economic value are based on the mean standard of water tank price. Target area of PAMSIMAS is area with water crisis and most villages are difficult to get PDAM facility. Thus, water price assumption used is water tank that people should buy before PAMSIMAS existed. Average price of 1 water tank was Rp 50,000 with the capacity of 5,000 liters or 1 liter 10. The people average need of water, based on questionnaires, was 80 liters per day per capita. Every family at the research area generally has 4 people. Consequently, the cost each family must spend before PAMSIMAS was 80 liters x Rp. 10/litre x 4 persons x 30 days = Rp. 96,000. Cost efficiency was resulted from the cost, subtracted by the cost spent for the present PAMSIMAS. Table 3 shows the total efficiency gained by the community which resulted from the water cost per year.

Table 3. Total of Efficiency of Consumption Cost for Water Per Year

Village	Family number served	Contribution Per Month	Total of Eficiency
Naikolan	900	Rp. 15,000	Rp. 874,800,000
Liliba	678	Rp. 15,000	Rp. 659,016,000
Nunbaunsabu	240	Rp.15,000	Rp. 233,280,000

Source: "RKM" (community work plan) (2009) and interview (2010)

The next benefit is efficiency caused by the decrease of sickness from environment coming from water and sanitation. In this matter, it is predicted that the efficiency of each family is Rp. 50,000 per year and previously it was used for curative (Table 4). Another benefit can directly follow if it keeps continuously developed at other sectors, such as for economic business. For that reason, it requires a synergy of the program among stakeholders for the next implementation of PAMSIMAS.

Table 4. Total of Health Cost Efficiency Per Year

Village	Family number served	Total of Eficiency
Naikolan	900	Rp. 45,000,000
Liliba	678	Rp. 33,900,000
Nunbaunsabu	240	Rp. 12,000,000

Source: "RKM" (community work plan) (2009) and interview (2010)

Based on the cost and benefit above, we can valuate the economic validity of PAMSIMAS by using assumption that the program validity period is 20 years and the discount rate interest level is 15%. Table 5 shows that the *net benefit* is gained more earlier that the net cost. The deviation between the two values are the net benefit value based on the present value (NPV). NPV at all villages are positive, which means that the *cost-benefit ratio* will be more than 1 (it can be seen on Table 5). Based on this value/number, it can be concluded that economically PAMSIMAS is worth to be continuously developed at the research area.

Table 5. Analysis result of *cost-benefit ratio* PAMSIMAS

Parameter	**Naikolan Village**	**Liliba Village**	**Nunbaunsabu Village**
Net Cost (15%)	Rp. 1,238,460,100	Rp. 1,037,742,020	Rp. 549,595,419
Net Benefit (15%)	Rp. 6,616,121,400	Rp. 4,984,144,788	Rp.1,764,299,040
Net Present Value	Rp. 5,377,661,300	Rp. 3,946,402,768	Rp.1,214,703,621
Cost-Benefit Ratio	5.34	4.80	3.21

PAMSIMAS development in Kupang is quietly hampered by problem of water source if it is compared with other areas. The problem happened on the limited availability of groundwater. PAMSIMAS validity will increase if the water supply is sufficient. The water source that has high potency to be developed is by making use of rain water (rain water harvesting- RWH). Rain water usage can be conducted by applying technique of family scale harvesting or communal.

Based on the research result conducted by the writer previously about the potency of rain water-based water providing program development in Kartamantul, it shows that the community was ready to participate or accept and also stated as able to afford the cost. The community's ability determined using ATP (ability to pay) analysis, while the people willingness using WTP (willingness to pay) analysis. Both analyses resulted from the survey data at the research area, which was anthropogenic crisis area ("DKAn") and naturally-in-crisis ("DKAl"). The following is the description of the analysis result.

The providing of RWH (rainwater harvesting) facility, besides it is influenced by physical environment factor as what has been analyzed previously, surely also influenced by economic level especially the ability to establish it. Economic condition of respondents at research area is generally almost the same although with various level. The easiest way to find the economic level is by using poorness indicator. One way to determine the poorness level, according to Sayogyo (1971, in Muta'ali, 2000), is based on the family's cost level which is equivalent with rice, from which the minimum limit is the same as 320 Kg/capita/year (BPS/statistics bureau standard). Based on the macroeconomic condition at the three research areas which are almost the same, then took the mean value of poorness limit which was equivalent with the rice price of Rp.4,000/Kg, so that it will result the value of poorness limit based on the family cost which reaches Rp.1,280,000/capita/year. The mean value of family at the research area is the same, it consists of 4 people, so that the poorness limit of the family cost is Rp. 5,120,000/year or around Rp. 427,000/month. At the research area, the mean value of economy is good, showed by the all positions which are above the poorness line/limit (Table 6). A worse condition happened at naturally-in-crisis area in which 45% respondents are poor because this area is not fertile enough and dominated by agricultural activities.

Table 6. Respondents' Economic Condition

Expense/month	DKAn		DKAl		Poorness category	DKAn		DKAl	
	F	%	F	%		F	%	F	%
≤ Rp. 427,000	3	15	9	45	Poor	4	20	9	45
Rp. 427,001-Rp.800,000	4	20	7	35	Not poor	16	80	11	55
Rp.800,001-Rp.1,200,000	10	50	3	15					
≥ Rp.1,200,001	3	15	1	5					

Condition such as above has generally been able to indicate that respondents have ability to establish RWH facility. It is because most of RWH facility cost needed is only for the earlier development. Table 7 shows qualitative number of respondents' ability to establish RWH facility. The highest respondent's ability is Rp 1,250,000, which is at anthropogenic crisis area. This is because best level of respondents' economy in this area and the demand of need. Based on the value/number, RWH facility that can be immediately established by considering the cost needed is absorption well, conservation pond, or open land. At the middle condition there is naturally-in-crisis area, which reaches Rp 965,000. Its need demand is similar with that of anthropogenic crisis area, but its economy condition is lower. RWH facilities which may be established are conservation pond and or open land. However, those suprastructures are not recommended regarding that the lack of physical condition to take advantage of them. The respondents are unable to reach rain water collecting (PAH) as the most possible facility to be established in this area, so that the more effective effort is on how the people are able to conduct it. Efforts related to economy are needed to conduct, such as the possibility of stimulus help, credit system management, or others which can ease and optimize the establishment of RWH facilities immediately.

Table 7. Respondents' Ability To Pay for RWH facility

Area	Ability To Pay (Rupiah)	RWH that may be immediately established	Primary cost needed	
			Type	Rupiah
Anthropogenic Crisis Area	1,250,000	Absorption well, Conservation pond or open land/space	Absorption well	1,170,000
Naturally-in-crisis Area	965,000	Conservation pond or open land/space	PAH	3,020,000
			Conservation pond	300,000

Besides the ATP analysis result above, in order to strengthen the validity analysis, it is also socially supported by the result of WTP analysis. WTP analysis is conducted to find the perception of RWH implementation in the form of respondent willingness level. WTP shows positive condition for RWH establishment (Table 8). The willingness level from the highest in sequence is naturally in crisis (90%) and anthropogenic crisis area (75%).

Table 8. Respondent Willingness to participate in RWH Facility Establishment

Willingness	DKAn		DKAl	
	F	%	F	%
Agree to participate	15	75	18	90
Disagree to participate	5	25	2	10

Facility which is most possible and urgent to conduct in Kupang is PAMSIMAS with the system of rain water collecting (PAH). Observing the research result at Kartamantul (Yogyakarta – Sleman – Bantul), PAH needs high cost that is beyond the people ability to pay although its availability is also high (Widodo, 2008). This fact will be suitable if it is developed with PAMSIMAS program, in which there is collaboration between the government help and community participation.

CONCLUSIONS

1. Economically, PAMSIMAS in Kupang is worth to be developed.
2. For the sake of PAMSIMAS sustainability in Kupang, the effort which needs to be conducted is applying the system of rain water usage (RWH)
3. PAMSIMAS development with the system of rain water usage (RWH) needs to conducted with the collaboration between the government help and the community participation.

REFERENCES

Faisal, S., 1999, *Format-format Penelitian Sosial: Dasar-dasar dan Aplikasi* (Social Research: Basicand Application) , Rajawali Press, Jakarta

Gray, C., 1997, *Pengantar Evaluasi Proyek* (Introductory for Project Evaluation), second Edition, PT.Gramedia, Jakarta

Kadariah, 1999, *Evaluasi Proyek Analisa Ekonomi* (Project Evaluation of Economic Analysis), First Edition, LPFE-UI, Jakarta

Public Work Ministry, 2010, *Kajian Sosial Ekonomi Pengelolaan PAMSIMAS* (Social Economic Study of PAMSIMAS), Final Report, Research and Development Center for Social Economy and Environment, Jakarta

Setiawan, R., 2000, *Studi Kelayakan Pembangunan Gedung Parkir dan Analisis Willingness To Pay: Studi Kasus di Universitas Kristen Petra Surabaya* (Feasibility Study for Parking Cosntruction and ATP/WTP: A case of petra University Surabaya), UKP,Surabaya

Singarimbun, M., and Effendi, S., (Editor), 1995, *Metode Penelitian Survai* (Survey Research Method), LP3ES, Jakarta

Tamim, O., 1999, *Evaluasi Tarif Angkutan Umum dan Analisis Ability To Pay dan Wilingness To Pay di DKI* (Public Transportation Evaluation for ATP and WTP in Jakarta) , Journal of Transportasi-ITB, Vol. 1 No.2, December 1999, Bandung

Tarigan, R., 2005, *Perencanaan Pembangunan Wilayah* (Regional Develeopment Plan), Bumi Aksara, Jakarta.

Widodo B, 2008, Sustainable Water Resources Development with special reference to RWH: A Case of Kartamantul, Indonesia, University of Karlsruhe

The Effect of Rainwater Harvesting to The Groundwater Quality in Faculty of Engineering University of Indonesia

Meydam Gusnisar. Gabriel Andari Kristanto. Irma Gusniani

Environmental Engineering Study Program, Civil Engineering Department, University of Indonesia

E-mail: meydamgusnisar@yahoo.com**.** gakristanto@gmail.com**.** gusniani@yahoo.com 2

Abstract

Water scarcity is a major problem in many developing country. Despite the degradation of surface water as raw water, people still used it for drinking water supply. The present, the existences of fresh water in Jakarta, Indonesia, is very apprehensive. The quality of groundwater is being decline and requiring treatment before usage. The present study on groundwater was conducted in the building structure of faculty of engineering University of Indonesia where rainwater-harvesting system were installed and where rainwater-harvesting system were not installed. The objective of the study is to show the difference of water quality which is located near and far from rainwater harvesting. In this study, the groundwater quality was assessed by determining the physic-chemical parameters. The physic-chemical parameters which were observed are Fe, Mn, pH, turbidity, color, Cl-, and TDS. The preliminary study showed that some parameters (Fe, pH, turbidity and color) decreasing by the time. The findings from this study provide evidence that rainwater harvesting in faculty of engineering influence the groundwater quality. Hence, providing sustainability of drinking water supply. This technology can applied in city that has high density population.

Keyword rainwater harvesting, water quality, groundwater, artificial recharge

Introduction

Indonesia is one of developing countries which participated in Millennium Development Goals. National Labor Force Survey, conducted by the Central Bureau of Statistics, shows the improving of drinking water access from 37.73 % in 1993 to 47.71 % in 2009. But in order to obtain the target as much as 68.87% in 2015, an improvement is needed. [(BAPPENAS), 2010]. Jakarta as the capital of Indonesia is having a problem related to drinking water access. Currently Compared to all province in Indonesia, Jakarta is the 4th lowest in order to drinking water access to the resident. In some parts of Jakarta, sea water intrusion affects the quality of ground water and makes its not suitable for consumption. On the other hand, the dependence of industry in ground water has caused the scarcity in ground water. This is caused by clean water supplied by government only 1% of total industry necessity [DELINOM, 2008]. In order to acquire the needs, they tend to use ground water. The impact of this action is decreasing the water table causing land subsidence, sea water intrusion and transport pollutions.

In order to achieve a sustainable clean water access, a method like rainwater harvesting (RWH) can be used. In President Regulation Republic of Indonesia No 54 of 2008, Depok is one of regions where play role as an area for water and soil conservation, assuring the availability of ground and surface water, flood prevention, and economic development for welfare society. Shallow groundwater in Depok is one of groundwater basin for Jakarta, in 1950 to 1995 has decreased reaching 20 m even at different places [Hutasoit Prindratno, 1997]. This impact in one side shows the shrinkage in catchment area caused by the change of land use for the need of residential, industry, store, etc. the increasing of land used changes will be equal to the amount of runoff will occur. It will reduce the quantity of water infiltration and depletion groundwater basin in Depok. Rainwater harvesting is a method that will solve this problem. Instead of that, rainwater harvesting can improve the quality of ground water around the area [Stiefel, Melesse, McClain, Price, Anderson, Chauhan, 2009].

Study Area

University of Indonesia (UI) reside in Depok city located in latitude of 06o19 – 06o28 and longitude of 106o43 – 106o55, at about 33 km south of Jakarta (Figure. 1). Depok is a low lands with elevation 50-140 m above sea level and slope less than 15 %. As the youngest city in West Java, Depok has a total area about 200,29 km2. Depok city is a low land (50-140 meters above sea level) and slope is less than 15%. Turkandi and Sidarto (1992) differentiated Depok lithology into some formation as follow:

- Bojongmanik formation consists of interbedded of sandstone and clay stone, with intercalated limestone.
- Serpong Formation consists of interbedded of conglomerate, sandstone, marl, pumice conglomerate, and tuffaceous pumice.
- Alluvial stone formation consist of soft laminar tuff, interbedded of conglomerate tuff and intercalated limestone tuff
- Alluvial material consists of clay, stone and gravel.

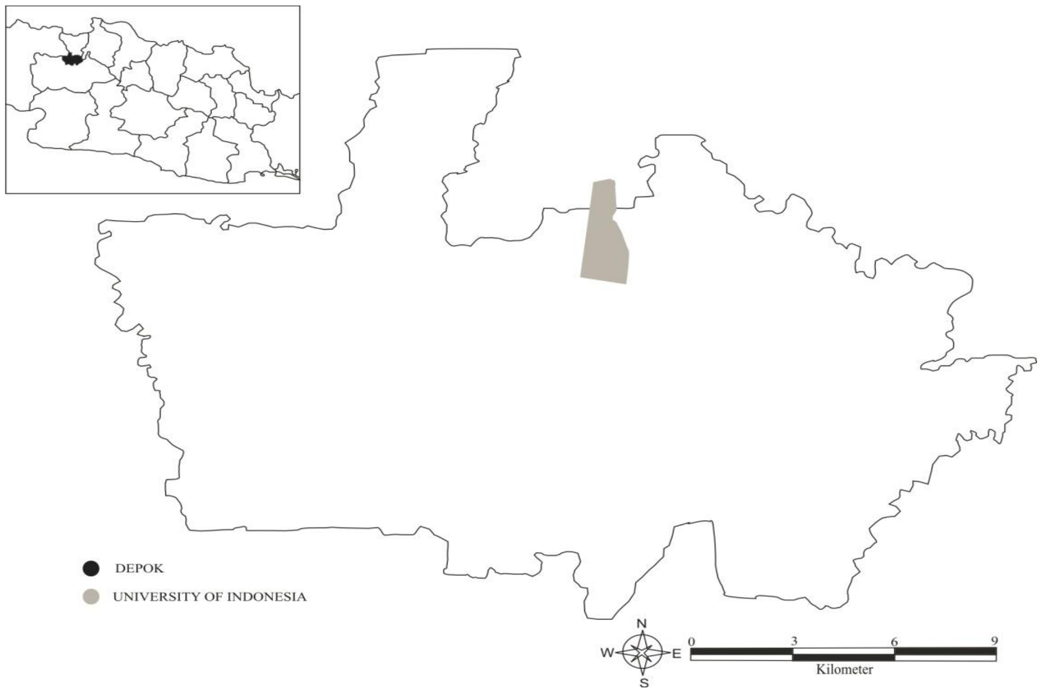


Figure. 1 Location of study area in University of Indonesia

Shallow aquifer in Depok is less than 20 m from the surface (unconfined aquifer). The ground water flow is to the north following the drainage system. Drinking water demand in Depok reach 75.976502 m3/years with government supplies about 15.301.267 m3/year its means that government service ratio has reached 22.1% [Wibowo, Harsono, Fajar, 2010]. According to this data, 77.9 % resident water demand comes from ground water. If this condition happen much longer its will affect the existence of ground water in Depok. As already said that UI located in Depok, Depok can be a buffer zone because UI has a forest with an area of 10 ha and a water ecosystem with an area of 30 ha. It is an important role in water catchment area. In order to increase infiltration capability, Faculty of Engineering in University of Indonesia has made rainwater harvesting as many as 23 units. Rainwater harvesting can be an alternative to increase groundwater quantity and this method can be used in big cities like Jakarta which most of its resident is still using ground water to fulfil clean water necessity.

Method

Rainwater Harvesting Method

Faculty of Engineering University of Indonesia has 23 rainwater harvesting. These rainwater harvesting has encircled 2 main building that is Common Building Lecture K and Dekanat Building. In Common Building Lecture K there are 19 unit and 4 unit in Dekanat Building (Figure. 2). The 19 units of rainwater harvesting has encircled Common Building Lecture K while the other rainwater harvesting is placed around Dekanat Building (Figure 2). These buildings are chosen as a rainwater harvesting construction because it have rainwater controlling basin that encircle these buildings. These rainwater controlling basins is used for rainwater harvesting so that instead of functioning in runoff controller, it can be used as rainwater infiltration.

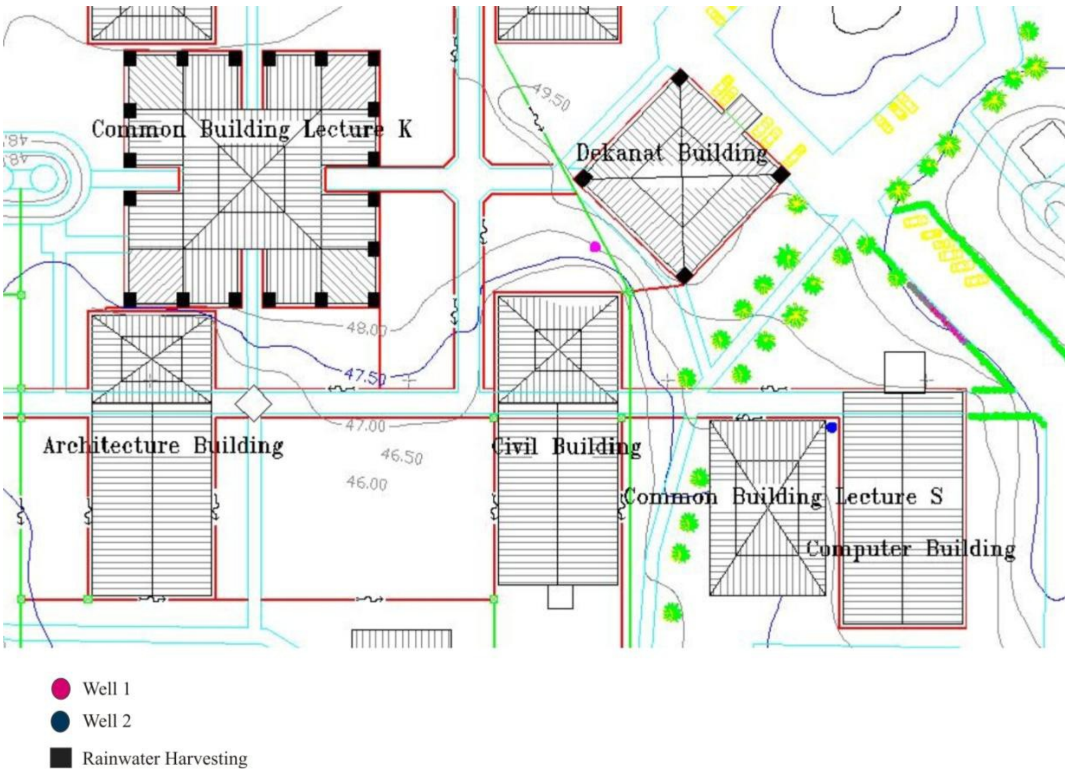


Figure. 2 Location of Rainwater Harvesting, University of Indonesia

The advantage of choosing these buildings is the area of roof large enough as a rainwater catchment area (1607 m2 for Common Building Lecture K and 367 m2 for Dekanat Building. The rainwater harvesting has a dimension as big as 84 x 86 x 110 cm with the main source of water coming from rain water. Rainwater harvesting construction is conducted in 21st March 2011. Rain water harvesting construction has used demolition building as materials to fill in rainwater harvesting because at the same time there is building construction in Faculty of Engineering University of Indonesia. These construction waste mostly consist of demolition building is used as material to fill in the rainwater harvesting. But in 2 August 2011 there is a change in material to fill in rainwater harvesting. This changes is still using demolition building as the main material added with gravel and palm fiber (Figure 3).

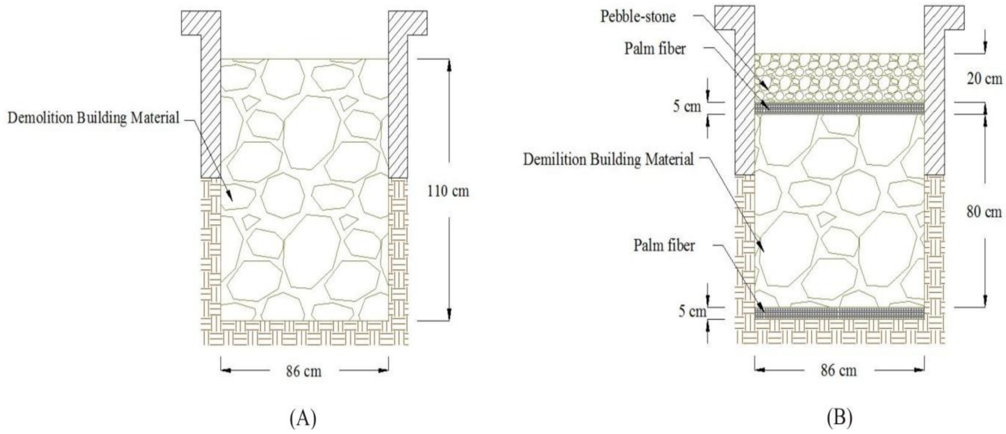


Figure. 3 Cross section of Rainwater Harvesting. (A) Rainwater Harvesting on 21 March 2011. (B) Rainwater Harvesting on 2 August 2011

Water Sampling Method

According to an experiment done by Stiefel et al (2009), a well that is located near rainwater harvesting has better quality than those located far from rainwater harvesting. Rain water that is infiltrated into rainwater harvesting will contact with material that fills rainwater harvesting so that chemical, physic and biological process will improve water quality. After that water will be infiltrated by soil layer and will fuse with ground water located under rainwater harvesting [Lehr Keeley, 2005].

Table 1 Methods use for the analysis of quality paramters

Parameters	Method	Unit
Fe	Spectrofotometry	mg/l
Mn	Spectrofotometry	mg/l
pH	Potensiometry	
Turbidity	Spectrofotometry	NTU
Color	Spectrofotometry	PtCo
Cl	Spectrofotometry	mg/l
TDS	Multiparametry	mg/l

Based on this study, in Figure 2 shown that the location of well 1 is nearer to rainwater harvesting than well 2 (located + 25 m from well1). Therefore the quality of groundwater that will be tested is coming from well 1 compared with well 2. The depth of well 1 is 30 meters under the ground surface while well 2 is 25 meters underground surface. Water table of well 1 is located at 11 meter underground surface while well 2 is located 10 meter underground surface. Ground layer that lie in both well is shown in Figure 4 with hydraulic conductivity of 0.0305 m/d. Ground water sampling from well 1 were conducted from 11 April 2011, 31 Mei 2011, 12 July 2011, 7 October 2011, 9 November 2011 and 20 March 2012 while well 2 sampling were conducted from 12 July 2011, 7 October 2011, 9 November 2011 and 20 March 2012. Water sample is taken by high-density polyethylene (HDPE) bottle which is sterilized so that it will not affect water sample quality. After the sample is acquired, sample is tested in Sanitation & Environmental Laboratory Faculty of Engineering University of Indonesia. Water parameters and methods used in water testing can be seen in Table 1

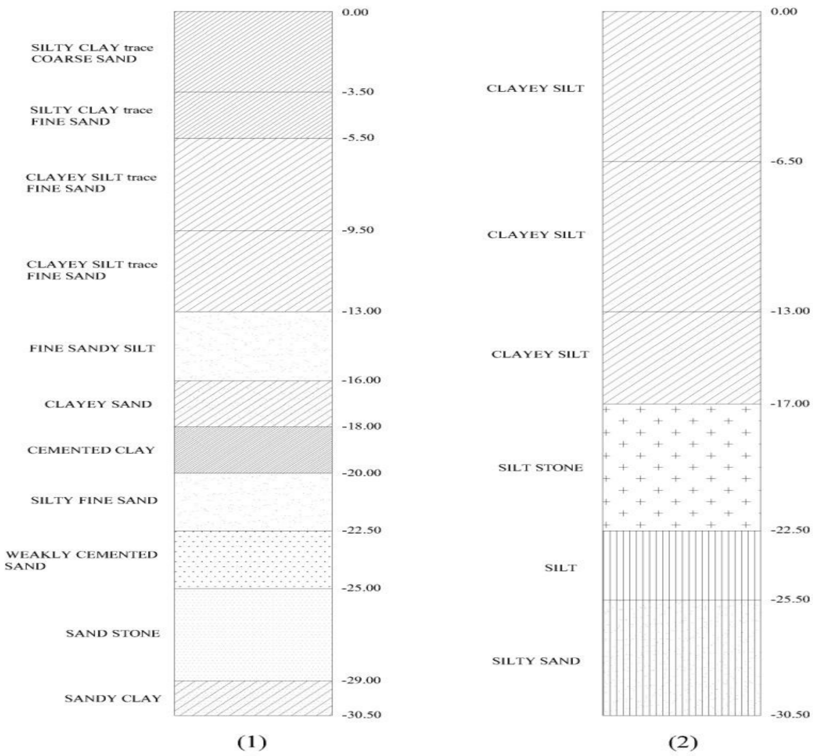


Figure. 4 Soil later in University of Indonesia. (1) Soil layer in well 2. (2) Soil layer in well 2

Result and Discussion

Rainwater Quality

The main source of water infiltrating into rainwater harvesting is rain water. When it is raining, raindrop falling to the roof of Common Building Lecture K and Dekanat Building is transferred with gutter. Water will enter rainwater harvesting and infiltrated into the soil. When the soil surface is saturated, rainwater harvesting cannot infiltrate water and its will be transferred so sewerage system. Rain water quality which is infiltrated into the rainwater harvesting can be seen in Table 2. According to Government Regulation No 82 of 2001, for class I water used as raw drinking water, rain water entering into rainwater harvesting had a good quality and it can be used as raw drinking water. The location of UI which is far away from industry area is one of benefit to use rainwater as the main source of water for rainwater harvesting. When a region locate near industry area, rain water will have pH ranging from 3-4 and containing sulphur substance from industry emission contained in atmosphere [Freeze Cherry, 1979].

Table 2 Rainwater quality in Faculty of Engineering University of Indonesia

Parameters	Unit	Rainwater Value	Government Regulation No 82 of 2001 (water class 1)
pH		5,78	6-9
Fe	mg/l	0,04	0,3
Mn	mg/l	0,1	0,1
Turbidity	NTU	2,04	-
Color	PtCo	19	-
Cl	mg/l	0,3	-
TDS	mg/l	9,2	1000
Nitrat	mg/l	14,9	10
Conductivity		21,4	-
Sulfat	mg/l	2	400

Similar study has been conducted by Sudinda et al (2009) at The Agency For the Assessment and Application Technology building by examining the water quality before entering the rainwater harvesting. The tested water comes from sewage water, condensed water from air conditioner, and wudu's water. The result was the water from sewage did not meet the raw quality standard regulated in Government Regulation No 82 of 2001. The condensed and wudu's water meet the standard requirements thus decent enough to fill the rainwater harvesting. The sewage water need to be treated before streamed into the rainwater harvesting to reduce the quality and comply with the standard. Another study conducted by Sang-Ho Moon et all (2011) at Jeju Island, Korea. This study use rain water as the water source for the rainwater harvesting. The rain water quality was mostly composed by Na and Cl from the sea water and SO4 from air pollution caused by industrial and agricultural activities.

The pH Value

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. It is a way of expressing the hydrogen-ion concentration, or more precisely, the hydrogen-ion activity. [Sawyer, McCarty, Parkin, 2003]. Mean pH value for well 1 and well 2 obtained from this study are 5.45 and 6.13.

On 12th July 2011 the pH in well 1 was decreased to 5 (Figure 5). The decrease in value was possible since during the construction of the RWH, the filler material stability was not reached thus resulted a decrease in pH value. This condition generates incomplete aerobic and anaerobic reaction that produced low CO2 content. Another possibility is that the CO2 product from the reaction was released through cavity among filler materials into the air.

As stated by Freeze & Cherry (1979), the degree of CO2 content in soil affects the acidity levels of groundwater. CO2 that undergo contact with water will generate H2CO3 which will lead to the increased in groundwater acid levels, as shown by this reaction:

$$CO2\ (g) + H2O \leftrightarrow CO2\ (aq) + H2O$$

$$CO2\ (g) + H2O \leftrightarrow H2CO3\ (aq)$$

H2CO3 is an acid commonly found both in natural and the contaminated groundwater. Stability will occurred when the filler material changed as shown in Fig 3(B). The RWH materials begin to dense thus decreasing the probability of CO2 released into the atmosphere and affect the water acidity. Similar study was conducted by Dzwairo et al (2006) in Zimbabwe. This study shows an increasing at the beginning, and was followed by a decreasing in pH value. The increase was occurred due to ammonium nitrogen, which can cause the environment to be alkaline resulting increased in pH. The decrease was occurred when the nitrogen content decreased.

Another study in Rajastan, India, by Stiefel et al (2009) was conducted to examine infiltration well effect to the groundwater quality. The study shows an increasing in pH, possibly occurred due to several factors such as the increase of alkalinity levels, carbon dioxide presence, dissolution of mineral carbonate, the existence of boron compound, silica, H2S, and organic acid. The increase in pH was caused by organic acid. This was occurred as a result of the sediment generated from accumulated soil erosion which was brought by rain water into the infiltration well. According on Ministry of Public Health Regulation No 492 of 2010, pH value allowed in drinking water is 6.5-8.5. pH value in well 1 did not fulfill the standard thus the water cannot be consumed directly whereas the water in well 2 was decent enough to be used as drinking water.

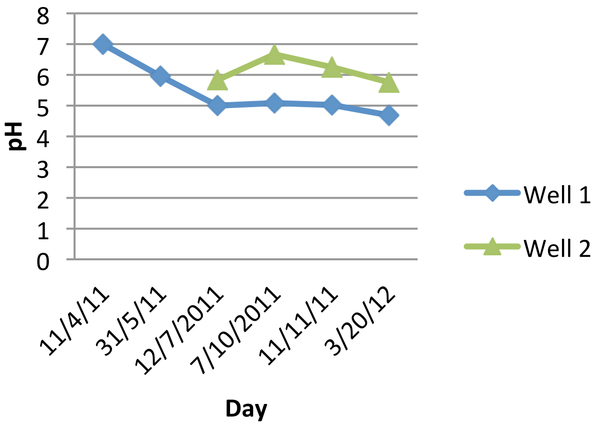


Figure. 5 Variation of pH due to time series

The Fe and Mn Value

Iron exists in soils and minerals mainly as insoluble ferric oxides and iron sulfide (pyrite). It occurs in some areas also as ferrous carbonate (siderite), which is very slightly soluble. Groundwater which contains carbon dioxide from bacterial organic oxidation and experienced contact with water will trapped the carbon dioxide, thus it will not freed in to the atmosphere. Since carbon dioxide is a product of aerobic and anaerobic bacteria oxidation, the concentration will depend on the dissolved oxygen content. Since ground waters usually contain significant amounts of carbon dioxide, appreciable amounts of ferrous carbonate may be dissolved by the reaction

$$FeCO3\ (s) + CO2 + H2O \rightarrow Fe2+ + 2HCO3-$$

in the same manner that calcium and magnesium carbonates are dissolved. However, iron problems are prevalent where it is present in the soil as insoluble ferric compounds. Dissolution of measureable amounts of iron from such solids does not occur, even in the presence of appreciable amounts of carbon dioxide, as long as dissolved oxygen is present. Under reducing (anaerobic) conditions, however, the ferric iron is reduced to ferrous iron, and solution occurs without difficulty [Sawyer, McCarty, Parkin, 2003]. According to Stumm & Morgan (1996), the oxidation reaction of Fe(II), by dissolved oxygen, in mildly acidic to neur-neutral waters described by the stoichiometry

$$4Fe2+ + O2 + 10H2O \leftrightarrow 4Fe(OH)(s) + 8H+$$

Thus the degree of dissolved oxygen in soil will affect the generation of Fe(OH)(s). According on Ministry of Public Health Regulation No 492 of 2010, Fe concentration standard for drinking water is 0.3 mg/l. In this study the mean Fe concentration obtained from well 1 is 0.4 mg/L with maximum concentration measured on 12th July 2012 as high as 1,15 mg/L. . In well 2 the mean Fe concentration is 0.06 mg/L. The increase occurred due to aerobic or anaerobic reaction in the RWH. The reaction occurred is as shown in previous equation in which Fe2+.is formed. If the Fe2+ generated was not compensated by oxidation reaction, the amount of Fe(OH)(s) produced will decreased, thus it will raise the Fe2+ content. The shift of RWH material will lead to stability in the RWH, so at stretches of time, the Fe2+ concentration will decreased by oxidation reaction occurred in the RWH and the soil.

When oxygen-bearing water is injected into the ground for recharge of the groundwater aquifer, it is sometimes noted that the soluble iron content of the water increases. The explanation is that oxygen is consumed through the oxidation of insoluble pyrite (FeS2), leading to anaerobic conditions and the formation of soluble iron sulphate [Sawyer, McCarty, Parkin, 2003].

$$2FeS2 + 7O2 + 2H2O \rightarrow 2\ Fe2+ + 4SO42- + 4H+$$

Study concerning this matter was done by Miotliriski et al (2012) in Europe. This study shows an increase in sulphate and iron concentration due to flood that locally occurred. The flood resulted from exploitation of groundwater and declining of groundwater surface level. Pyrite oxidized as the oxygen reduced and sulphur and iron oxidized

$$FeS2 + 15/4O2 + 7/2H2O \rightarrow Fe(OH)3 + 2SO42- + 4H+$$

When the electron receptors present are not enough, the reaction occurred was only oxidizing of sulphur

$$FeS2 + 7/2O2 + H2O \rightarrow Fe2+ + 2SO42- + 2H+\ 12$$

The products of the reaction are Fe and SO4. Study concerning the iron concentration decrease was conducted by Appelo et al (1999). The study was done by putting water containing oxygen into a well with large Fe concentration. The oxidizing process taking place was a reaction between Fe(II) and oxygen produced insoluble ferric ion and it will be precipitated forming oxyhydroxide. The precipitation can absorbs Fe2+ thus reducing Fe2+ concentration in ground water.

Manganese (Mn) exists in the soil principally as manganese dioxide, which is very insoluble in water containing carbon dioxide. Under reducing (anaerobic) conditions, the manganese in dioxide form is reduced from oxidation state o IV to II, and solution occurs, as with ferric oxides [Sawyer, McCarty, Parkin, 2003]. The mean Mn concentrations obtained from this study are 0.18 mg/L for well 1 and 0.15 mg/L for well 2. The range of concentration value from both wells is between 0.1-0.2 mg/L (Figure. 7).). The standard of maximum concentration of manganese is regulated in Ministry of Public Health Regulation No 492 of 2010 is 0,4 mg/l. Mn concentration was more stable compared to Fe concentration since the amount of dissolved iron can be found easily in aquifer [McBride, 1994]. The stability can be seen from Fig. 7 where Mn concentration from both wells does not changed significantly. As stated by McBride (1994), water containing oxygen that penetrated through the ground tends to reacted more with Fe than with Mn. Figure 6 and 7 shows Fe concentration more prone to change than Mn.

Study on alteration of Mn concentration was done by Chae et al (2008) in Seoul, Korea. This study is modeling geochemical reaction on Mn and Fe. The substances concentration does not increase in their oxidized form. However, the presence of organic compound brought by water stream will triggered the reaction. But Vandenbohede et al study (2009) shows an opposite result. The increasing of oxidizing of Fe will lead to an increase of oxidizing of Mn, thus will raise the Mn concentration.

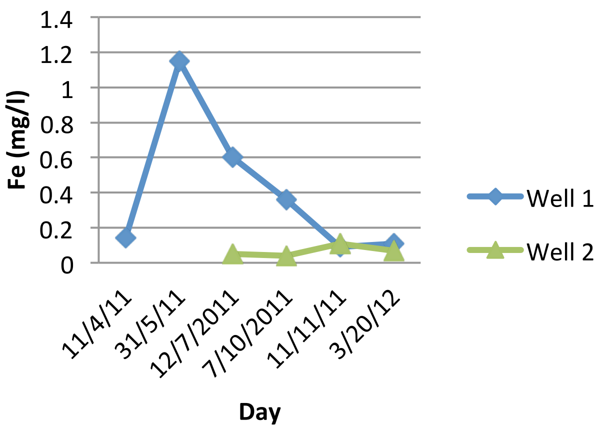


Figure. 6 Variation of Fe due to time series

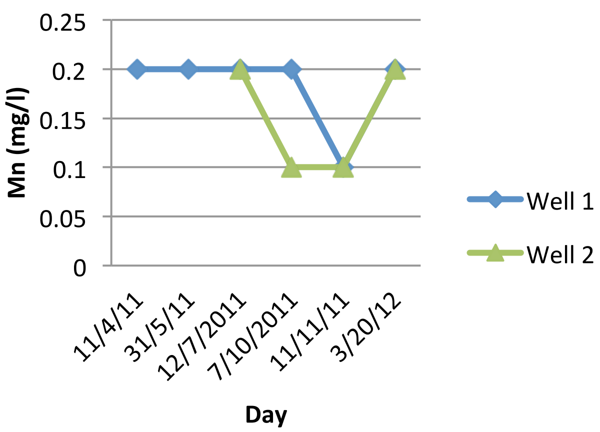


Figure. 7 Variation of Mn due to time series

The Total Dissolved Solid (TDS) Value

Total Dissolved Solids (TDS) are materials in the water that will pass through an filter with a 2.0 μm or smaller nominal average pore size. [Sawyer, McCarty, Parkin, 2003]. The mean TDS concentration in well 1 is 33 mg/l and in well 2 is

70 mg/l. Fig. 8 shows TDS content in well 1 was smaller compared to well 2. TDS value in well 2 was twice than the TDS value in well 1. A study conducted by Alhumoud et al (2010) shows that TDS value has a reverse connection with bicarbonate (HCO3) value. TDS concentration will increase as the HCO3 decrease and likewise. The water that entered the ground will react with CO2 therefore increase bicarbonate concentration in soils.

A study conducted by Vandenbohede (2009) concerning infiltration well effects to the groundwater quality in West Belgium shows that TDS value of 0 extracted water from the infiltration well gradual decrease. The TDS value of water from deep well was less then water from shallow well. Increasing of TDS value can be caused by low recharge rate. And also as the result of minerals evaporation and dissolution occurred along the groundwater flow [Currell, Cartwright, Bradley, Han, 2010]. The maximum standard concentration of TDS in Ministry of Public Health Regulation No 492 of 2010 is 500 mg/l.

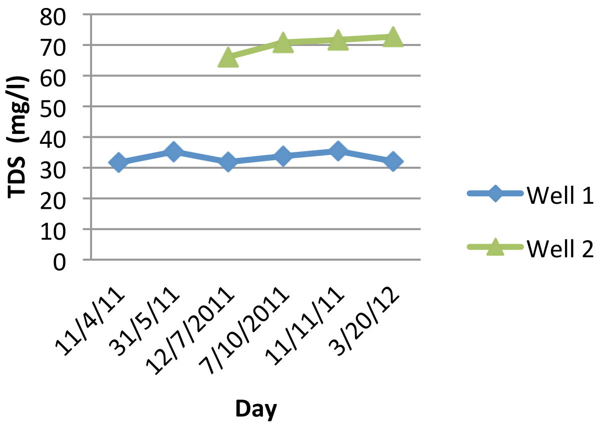


Figure. 8 Variation of TDS due to time series

The Turbidity and Color Value

Turbidity is a value used to addressed the amount of suspended matter contained in water that interferes with the passage of light through the water or in which visual depth is restricted [Sawyer, McCarty, Parkin, 2003]. Turbidity is closely related to color in water since turbidity may contribute to color value. This study will show how turbidity related with color. Well 1 has mean turbidity value is 1.63 NTU whereas well 2 has mean value 0.62 NTU. On 12th July 2011 the turbidity value was increased and peak as much as 4.42 NTU and was followed by an increasing of color value as much as 35 PtCo. This was caused by instability of the RWH filler material hence a huge amount of solids was generated and streamed into the RWH. Additionally, soil particles that were removed from the surface soil near the RWH will contribute to the increase of turbidity and color. Another cause would be a road work occurred at the site where the RWH was located. Similar study was conducted by Dzwario et al (2006) in Marondera, Zimbabwe. In this study, the high turbidity value was due to excavated land near the well. Other factor would be due to solid particles movement in groundwater extraction process. The particles flowing from the well will settled at the bottom of the tank, and then if there was another flow entering the tank, the settled particle will dispersed in the tank and another span of time will be needed for the particles to settle. Another case of high turbidity was found in Al-Khaatib and Arafets (2009) study which indicates that it was caused by the sampling that were done at the time when settling of the solid was not fully completed.

On 10th October 2011 there was a decreasing of turbidity and color value. The decreasing may be a result of the substituting of RWH filler material done on 2nd August 2011. The substitution significantly affects turbidity and color value as shown in Figure 3(B). This was possible since the arrangement of filler material was more dense thus supporting the RWH stability. Furthermore, the use of palm fiber and gravel was effective to reduce the turbidity and color. Based on Ministry of Public Health Regulation No 492 of 2010 the maximum value of turbidity and color allowed in drinking water is 5 NTU and 15 PtCo.

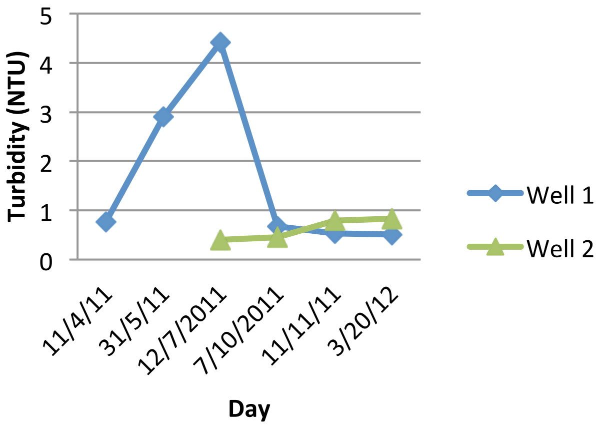


Figure. 9 Variation of turbidity due to time series

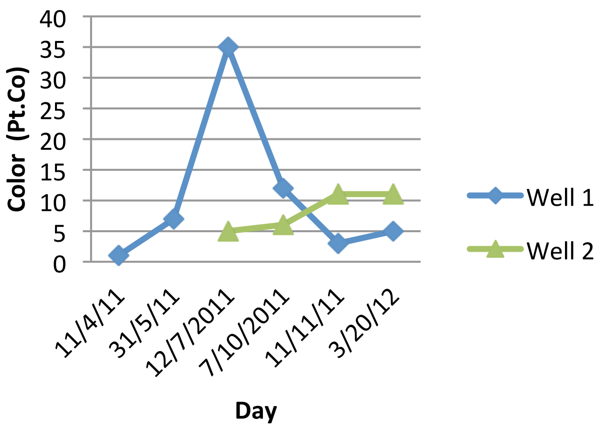


Figure. 10 Variation of color due to time series

The Cl Value

According to Ministry of Public Health Regulation No 492 of 2010 the maximum concentration of Cl is 250 mg/l. In This study the mean concentration of chloride obtained in well 1 and 2 are 5 mg/L and 5,8 mg/L. Since the beginning of the study on 11th April 2011 the Cl concentration was increasing. This was caused by the depth of the well which is as deep as 30 meters from the ground surface. This depth was located at the siltysand layer that contributes to the increase in Cl concentration. The depth of well 2 is 25 meters located at sandstone layer which will not affect Cl concentration (Fig 4). The increase of Cl concentration was discovered at first until third measurements which used layer shown in Fig 3 (A). H+ ions from H2O will tend to react with anions such as HCO3 and SO42- thus decreasing the portion of H+ to react with anion Cl- therefore it will be left in its ion form or Cl-. However, after the changing of RWH filler material, H+ normally reacts with anion Cl-. Similar study concerning the same problem was done Vandenbohede et al (2009). This study shows that the Cl concentration of deep well was higher than shallow well. As stated by Freeze & Cheryl (1979), deep well contained large amounts of minerals since there is no refilling of water thus the groundwater quality was rich in Cl and TDS content.

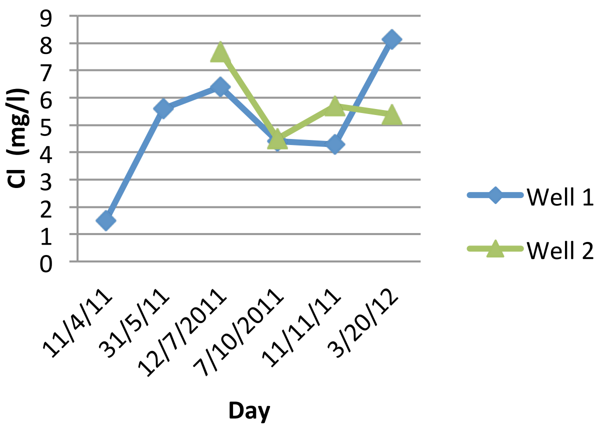


Figure. 11 Variation of Cl due to time series

Conclusion and Recommendation

It can be concluded from this study that the use of RWH will affect the groundwater quality. Some parameters vary for the time series. The use of RWH will reduce the turbidity and color, which were closely related, and also reduce the Fe concentration of the groundwater. The materials used to fill the RWH, which were demolition building, have significant effect to change some parameter. However the decrease of a few parameters occurred. Stability of the filler material would not take place in short time, thus at the beginning of the study the quality of groundwater did not immediately refined, but it occurred gradually until the desired quality of the groundwater can be reached.

References

(BAPPENAS), M. o. (2010). *REPORT ON THE ACHIEVEMENT OF THE MILLENNIUM DEVELOPMENT GOALS INDONESIA 2010.* Idonesia: Ministry of National Development Palnning / National Development Planning Agency (BAPPENAS).

Alhumoud, J. M., Al-Ruwaih, F. M., & Al-Dhafeeri, Z. M. (2010). Groundwater quality analysis of limestone aquifer of Al-Sulaibiya field, Kuwait. *ELSEVIER* , 58-67.

Al-Khatib, I. A., & Arafat, H. A. (2010). Chemistry and microbiological quality of desalinated water, groundwater and rain-fed cisterns in the Gaza strip, Palestine. *ELSEVIER* , 1165-1170.

Appelo, C. A., Drijver, B., Hekkenberg, R., & de Jong, M. (1999). Modeling In Situ Removal from Groundwater. 811-817.

Currell, M. J., Cartwright, I., Bradley, D. C., & Han, D. (2010). Recharge history and control on groundwater quality in the Yuncheng Basin north China. *ELSEVIER* , 216-229.

DELINOM, R. M. (2008). Groundwater management issues in the Greater Jakarta area, Indonesia. *Proceeding International Workshop on Integrated Watershed Management for Sustainable Water Uses in a Humid Tropical Regions* (pp. 40-54). Indonesia: JSPS-DGHE Joint Research Project.

Dzwairo, B., Zvikomborero, H., Love, D., & Guzha, E. (2006). Assessment of the impacts of pit latrines on groundwater quality in rural areas: A case study from Marondera district, Zimbabwe. *ELSEVIER* , 779-788.

Freeze, R. a., & Cherry, J. A. (1979). *GROUNDWATER.* New Jersey: Pretice-Hall, Inc.

Gi Tak, C., Seong-Taek, Y., Byoung-Young, C., Soon-Young, Y., Ho-Young, J., Mayer, B., et al. (2008). Hydrochemistry of urban groundwater, Seoul, Korea: The impact of subway tunnels on groundwater qality. *ELSEVIER* , 42-52.

Hutasoit, L. M., & Prindratno, M. H. (1997). Groundwater salinity and its Management in Jakarta. *in Coastral and Nearshore Geological/ Oceanographical assessment of Jakarta Bay : a Basis for Coantral Zone* (pp. 103-114). Jakarta: CCOP & LIPI.

Lehr, J. H., & Keeley, J. (2005). *Water Encyclopedia Ground Water.* New Jersey: John Wiley & Sons, Inc.

McBride, M. B. (1994). *ENVIRONMENTAL CHEMISTRY OF SOIL.* New York: Oxford University Press, Inc.

Miotlinski, K., Postma, D., & Kowalczyk, A. (2012). Valiable infiltration and river flooding resulting in changing groundwater quality- A case study from Central Europe. *ELSEVIER* , 211-219.
Sang-Ho, M., Jin-Yong, L., Bong-Joo, L., Ki-Hwa, P., & Yun-Jo, J. (2011). Quality of harvested rainwater in artificial recharge site on Jeju volcanic Island, Korea. *Journal of Hydrology.*

Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry of Environmental Engineering and Science.* New York: McGraw-Hill Education.

Stiefel, J. M., Melesse, A. M., McClain, M. E., Price, r. M., Anderson, E. P., & Chauhan, N. K. (2009). Effect of rainwater-harvesting-induced artificial recharge on the groundwater of wells in Rajashan, India. *Hydrogeology Journal* , 2061-2073.

Stumm, W., & Morgan, J. J. (1996). *AQUATIC CHEMISTRY.* New York: John Wiley & Sons, Inc.

Sudinda, T. W., Naryanto, H. S., Nugroho, S. P., Samsuhadi, Tjokrokusumo, S. W., Riyadi, A., et al. (2009). Study and Application of Artificial Recharge to overcome Flood and Dryness. *Proceedings of Artificial Recharge Technology to overcome Flood and Dryness*, (pp. 8-53). Jakarta.

Turkandi, T., & Sidarto. (1992). *Geologic of Jakarta and Kepulauan Seribu.* Java: Geological Research and Development Centre.

Vandenbohede, A., Van Houtte, E., & Lebbe, L. (2009). Water quality changes in the dunes of the western Belgian coastral plain due to artificial recharge of tertiary treated wastewater. *ELSEVIER* , 370-382. 19

Wibowo, H., Harsono, E., & Fajar, S. (2010). Evaluation of Avalaibility Rawwater for Cleanwater in JABODETABEK. *Proceeding of National Limnologi Conference*, (pp. 469-478). Jakarta.

Remediation of nitrate (NO_3^-) ions in groundwater by photo catalytic reduction over bimetal loaded semiconductor photo-catalysts.

Awaluddin Nurmiyanto [1], Hirofumi Kondo, Yuichi Kamiya [2]

1. Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

2. Research Faculty of Environmental Science, Hokkaido University, Japan

Email: awaluddin@uii.ac.id

Abstract

Groundwater serves as an important water resource for drinking in the world. However, groundwater is highly vulnerable to damage by contamination related with human activity. One example is the pollution with nitrate (NO_3^-). In this study, investigations of photocatalytic reduction of NO_3^- in water over bimetal semiconductor were conducted. Several type of catalyst (TiO_2 (anatase), TiO_2 (rutile), ZnO, ZrO, $SrTiO_3$, and WO_3) was loaded over Cu-Pd. The reaction was systemically investigated in the presence of light and no light. It is shown, that TiO_2 supported by Cu-Pd more suited for efficient NO_3^- reduction compared to other. Thus, it is expected that the efficiency of bimetal loaded TiO_2 can be used to reduced high amount of NO_3^- (wastewater). However in very high NO_3^- concentration, the reduction were not efficient .The catalytic reduction of NO_3^- was efficiently performed with H_2 or H_2 + HCOOH as the reductant, but was poorly efficient in the presence of HCOOH alone. In the photocatalytic experiments, UV irradiation significantly improved the reaction provided that both H_2 + HCOOH were present.

Keywords: Bimetal catalyst, Photo-catalyst, Nitrate, Remediation, Groundwater

Introduction

The pollution of groundwater with NO_3^- can be caused by over fertilization with nitrogen to famland, animal waste, domestic and industrial waste. Until now groundwater still used as major source in drinking water, thus contaminated groundwater with nitrate is suspected to cause serious health risks (blue baby syndrome, cancer). In order to ensure an adequate supply of safe drinking water in the future, we have to develop the technique for remediation of the polluted groundwater immediately. Thus far several techniques including biological, physicochemical, and (photo) catalytic treatments have been studied [i]. Among them, photocatalyticreduction (or decomposition) of NO_3^- into harmless nitrogen gas over semiconductor photo-catalysts is expected to be a promising technique, because of easy handling, and non-necessity of any chemicals in principle.

Many researchers are extensively studying this technique now including Prüsse et al [ii], who described new selective nitrate-reducing bimetallics (Pd–Sn, Pd–In). Wenliang et al [iii] conducted liquid phase catalytic reduction of nitrate ions using bimetallic semiconductor (Cu-Pd). Some modification on bimetal semiconductor have done by Sakamoto et al [iv] by adding activated carbon on Cu-Pd bimetal cluster, it can increase NO_3^- removal from water.

This work was a preliminary research, and has objectives to (1) show the possibility using several types of catalysts loaded into bimetal semiconductor to remove NO_3^- concentration from ground water. (2) To find the optimum performance of bimetal semiconductor photo-catalyst in NO_3^- removal. The optimum performance of catalyst thus was applied to remove in NO_3^- real groundwater and high concentration of NO_3^- in artificial polluted water. The effect of the presence of light in NO_3^- removal also covered in this research

Experimental

Catalysts preparation

Several types of bimetallic semiconductor catalysts were prepared by impregnation method [v]. The material used for the synthesis of the catalyst were: TiO2 anatase (P25); TiO2 (rutile); ZrO2; ZnO; SrTiO3 and WO3. Firstly 0,5 g weight of catalysts added to 50 ml beaker glass, furthermore the metal solution required for the loading was added (PdCl2 , Pd:0,0075 g/ml) to the required weight of catalyst in such way it wets and completely mixed with catalyst. The slurry was dried over night in oven at 100ºC, after that the powder was burned on the furnace at 300ºC for 1 hour.

Next step was to add the second metal solution (CuCl2, Cu:0,05 g/ml) according to the specified weight of the catalysts, afterwards the slurry dried over night in oven at 100ºC, after that the powder was burned on the furnace at 300ºC for 1 hour, just like were applied like on the first step. The selected Cu-Pd composition was (Cu/Pd=2) and the metal loading amount were 0% wt; 0,5% wt; 1% wt and 2% wt, the difference of those loading amount were obtained by adjusting the amount of PdCl2 and CuCl2 in the solution. Finally the obtained catalysts were labeled according to the variation of material and the metal loading amount.

NO_3^- solution and groundwater solution

Three kinds of aqueous NO_3^- solutions were employed as a reaction solution. Two artificial NO_3^- was made from distilled water in which sodium NO_3^- (Wako Pure Chem. Co.) was dissolved. The NO_3^- concentration on artificial NO_3^- solution was 1mmol/L and 100mmol/L respectively. Thus the 100mmol/L NO_3^- solution referred as artificial wastewater. The other NO_3^- was actual groundwater obtained from a well in Kitami, Hokkaido, Japan in which sodium NO_3^- was dissolved. The NO_3^- concentration on actual groundwater was adjusted to 1.06 mmol/L.

NO3- reduction test

Before the reactions were carried out, it required to wash the catalyst with sodium borohydride. Previous research suggests that washing with such metal reductant like $NaBH_4$ can overcome the shortage of effective surface area because in catalyst preparation, catalysts have to suffer the high temperature; an aggregation of active metal component and a reasonable decrease of effective surface area [v]. 0,15 g of bimetal catalysts suspended in 20ml of water and added NaBH4 with the proportion about ($NaBH_4$/(Cu+Pd) =10) and stirred for 30 minutes. Thereafter washed the catalyst with water and filtered using 0,2 um filter paper. Next step, filtrate Bimetal semiconductor catalyst were suspended on 10 ml NO_3^- (10mmol/l), added 38,5 µl of Formic acid (1 mmol) as sacrificial agent.

The reactions were performed in Pyrex glass tube reactor (Figure 1) equipped with 200W Xenon lamp (maximum wavelength 340nm) as light source. During the reaction, the tube reactor was set in water bath at room temperature to avoid thermal reaction. The reactor also equipped with magnetic stirrer in order to make catalyst maintain in suspension. After the irradiation period, the solution was centrifuged for 5 minutes at 10.000 rpm.

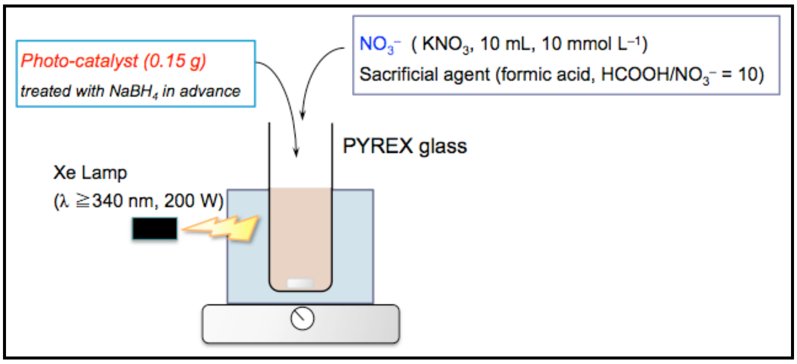


Figure 1 Reactor scheme

Groundwater remediation

NO3- reduction test on groundwater were carried out on the same reactor and procedure. Cu-Pd/TiO2 (anatase) 2% wt suspended on 10ml NO3- (10.6 mmol/l) in the presence of Formic Acid as sacrificial agent. The photocatalytic experiment were carried out by irradiating with 200 W Xenon lamp (maximum wavelength 340nm) while non photocatalytic experiment carried in dark condition.

The concentration of nitrate, nitrite and ammonium were determined by Ion Chromatographic instrument (TOSOH IC-2001) equipped with a TSKgel Super IC-Anion column. Ion chromatography offers the possibility of simultaneous determination of a few ions in a short time, good reproducibility of results, high sensitivity, the possibility of simultaneous determinations of anions and cations (including organic and inorganic ions), small volume samples and the possibility of using different detectors (from the most popular conductometric one, UV, to mass spectrometry) [vi].

Results And Discussion

Standard time reaction of NO_3^- reduction.

Cu-Pd/TiO2 (1 wt%) were used to find out the optimum time reaction, it refer to the previous report that TiO2 photocatalysts have been tested for NO3- reduction with different type of bimetal including (Ni–Cu) [viii, ix] and (Pd–Cu) [x] in the presence of organic hole scavengers (oxalic acid, formic acid) and previous research [xi] also found the highest activity on TiO2 supported with Cu-Pd Metal.

Selected reaction times were 0 min; 15min; 30min and 60min. Figure 3 shows that the yielding amounts of reacted NO3- and produced NH4+ increased proportionally to the irradiation time, all NO3- successfully removed after 60 minutes.

At 15min the reliable number of NO3- removal percentage about 40% was found, it expected to see the reduction of NO3- even in optimum variation of metal loading amount. Thus 15min time reaction was proposed as standard for photo-catalyst reduction of NO3-. There was no detection of NO_2^- on all different time variation. The possible explanation of this phenomenon was due to rapid transformation of NO_2^- into NO_3^-.

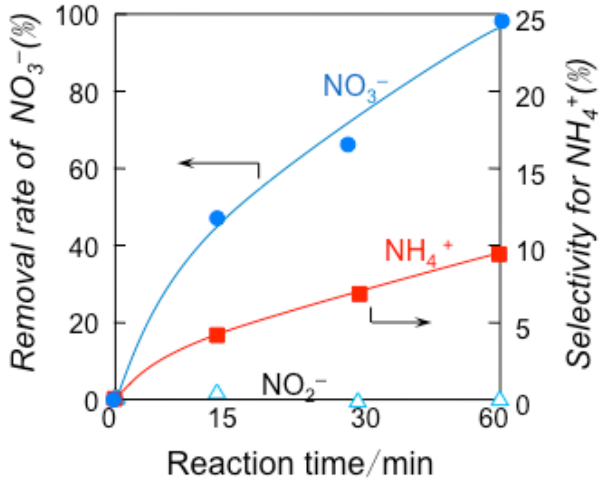


Figure 2 Time dependence of removal rate and selectivity.

NO_3^- reduction over different types metal loaded semiconductor.

Various bimetal catalysts were tested for the reduction of NO_3^- to N_2 and the corresponding results are shown in Figure 3. It can be seen that under the given conditions, Cu-Pd/TiO_2 bimetal semiconductor catalysts have highest average percentage (more than 50%) on NO_3^- reduction otherwise and the lowest one were occupied by WO_3/Cu-Pd. Other semi conductor materials like; ZnO;

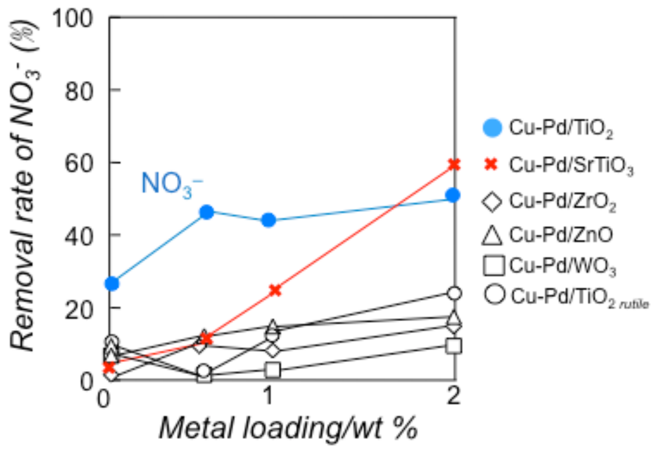


Figure 3 Time dependence of removal rate and selectivity

ZrO; WO_3; and TiO_2 (rutile) deliver nitrate removal percentage under 30%. The nitrate removal percentage tends to increase herewith the escalation of metal loading amount.

Among these catalysts, Cu-Pd/TiO_2 (anatase) showed the maximum average photocatalytic activity and thereby was selected as model catalyst in this study. Even Cu-Pd/$SrTiO_3$ 2 wt % was the most high percentage in NO_3^- removal rate. Cu-Pd/$SrTiO_3$ showed inconsistence result, it may because of uneven distribution of metal solution in catalyst preparation. Thus it interfere the the process, other possibility was proton reaction in surface of metal with the Atmospheric hydrogen then it will convert $NO_3^- \rightarrow NO_2^-$.

Effect of light

The effect of the presence of light in NO_3^- removal was conducted in two experiments. First experiment (Figure 4) to be carried out was using Cu-Pd/TiO_2 since it was the most optimum performance of bimetal semiconductor catalyst. The other experiment was using Cu-Pd/WO_3 as the lowest performance (Figure 5). The result (Figure 4) showed that presence of light has strong influence on the removal rate of NO_3^-. Removal rate of NO_3^- using light was higher (above 40%) compared to without light (under 40%). Thus author make an hypothesis if the removal activity on Cu-Pd/TiO_2 were involved by two types of reaction. Photocatalytic activity with light and catalytic activity without light.

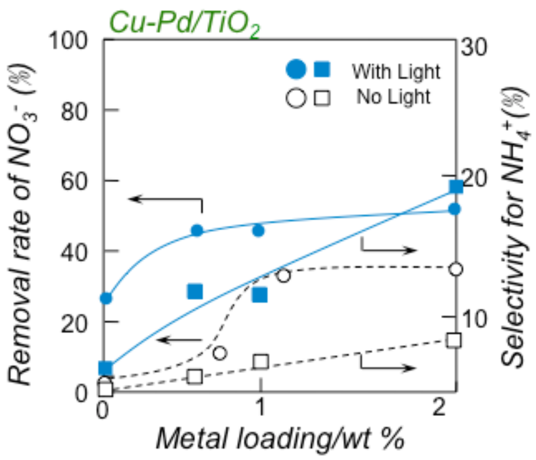


Figure 4 Effect of light in NO_3^- removal using Cu-Pd/TiO_2

Photocatalytic activity reaction as originally evidenced by Bard in the presence of various carboxylic acids. The photocatalytic effect in the presence of formic acid can be attributed to the photo-Kolbe reaction [xi]. The catalytic reduction of NO_3^- was involved by the chemical activities. Formic acid takes a place as reductant in this process. Previous research by Prüsse et al [ii] showed if formic acid has been proposed as an efficient reductant for nitrates instead of hydrogen. Figure 5 ensure if presence of light enhance removal rate

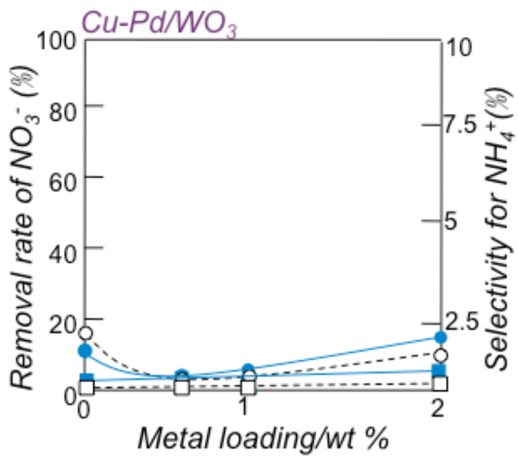


Figure 5 Effect of light in NO_3^- removal using Cu-Pd/WO_3

of NO_3^- even on low performance or inactive bimetal semiconductor catalyst.

Groundwater remediation

Removal rate of NO_3^- in actual groundwater has satisfied result. Log removal of NO_3^- occurred in the first 5min and reach the peak on 15min. 15min was the optimum reaction time since the removal rate of NO_3^- tend to be stable even the reaction continued until 30min. Figure 6 also shown if ammonium forms as soon as the conversion of nitrates begins, its concentration increasing regularly with nitrate conversion. Y. Wang [xii] found that Cl^- and organic compound affect in reaction thus force the production of ammonium. The excess of ammonium on remediated water was a problem since drinking water can not be tollerated, which is a problem to be solved.

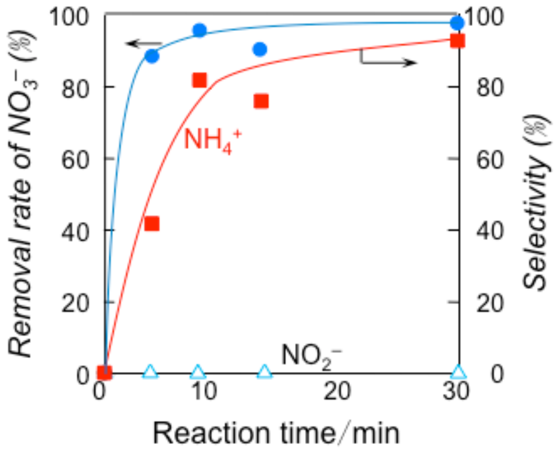


Figure 6 Removal rate and selectivity on Groundwater remediation

Wastewater remediation

Other possibility application of bimetal semiconductor photocatalyst was wastewater remediation. High concentration of NO_3^- was treated using Cu-Pd/TiO_2 (Figure 7). The result showed in initial 2 h the reaction proceeded rapidly, but afterwards the reaction tends to stop. This research cannot give scientific explanation regarding to this phenomenon since so many parameter influences the reaction, but author strongly recommended if the low efficiency of waste water removal if due to accumulation of impurities compound on the surface of catalyst. Further improvements were needed to treat such wastewater.

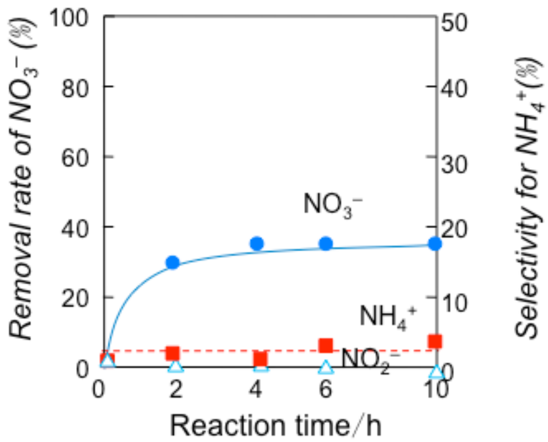


Figure 7 Removal rate and selectivity on artificial wastewater remediation

Conclusion

After all the research activities undertaken, it can be drawn a conclusion as follows:

- Cu-Pd/TiO_2 (2 wt %) was the most active photo-catalyst;

- NO_3^- removal mechanism occurred in combination of catalytic and photocatalytic process
- Nitrate in actual groundwater could be removed by using Cu-Pd/TiO_2 (2 wt %) but amount of formed ammonia was still large;
- Nitrate in wastewater can be removed only in initial 2 hours.

Acknowledgments

This work was a part of JENESYS 2010 Program on Graduated School of Environmental Science, Hokkaido University. I acknowledge gratefully the research assistance Mr. Hirofumi Kondo and the research supervisor Mr. Yuichi Kamiya for full support to conduct this research.

References

[i] A. Kapoor, T.J. Viraraghavan, J. Environ. Eng. 123 (1997) 371.

[ii] U. Prüsse, S. Hörold, K.-D. Vorlop, Chem. Ing. Tech. 69 (1997) 93.

[iii] W. Gao et al. / Applied Catalysis B: Environmental 46 (2003) 341–351.

[iv] Y. Sakamoto, K. Nakamura, R. Kushibiki, Y. Kamiya, T. Okuhara, Chem. Lett. 34 (2005) 1510–1511.

[v] O.S. Biackmond and E.I. Ko, Appl. catal., 13 (1984) 49.

[vi] G.A. Somorjai, Catal. Rev. Sci. Eng. 18 (1978) 173.

[vii] Buchberger W. W. Detection Techniques in Ion Chromatography of Inorganic Ions. Trend. Anal. Chem. 20, 296.

[viii] W. Gao, R. Jin, J. Chen, X. Guan, H. Zheng, F. Zhang, N. Guan, Catal. Today 90 (2004) 331.

[ix] J. Sa´ , C. Alcaraz Agu¨ era, S. Gross, J.A. Anderson, Appl. Catal. B: Environ. (2008).

[x] H. Kominami, T. Nakaseko, Y. Shimada, A. Furusho, H. Inoue, S. Murakami, Y. Kera, B. Ohtani, Chem. Commun. (2005) 2933.

[xi] Najah Wehbe, Mira Jaafar, Chantal Guillard, Jean-Marie Herrmann, Sylvain Miachon 1, Eric Puzenat, Nolven Guilhaume. Appl. catal.A Gen, 368 (2009) 1–8.

[xii] Y. Wang, Y. Sakamoto, Y. Kamiya, Appl. Catal. A; General, 361 (2009) 123-129.

PANEL 4

ENGINEERING THE PUBLIC ATTITUDES IN DEVELOPMENT

The Application of *Tri Hita Karana* Concept in the Environment of Urban Settlement in *PERUMNAS* Monang Maning, Denpasar, Bali - Based on Its Cultural Components

Priyo Akuntomo

Graduate Program of Environmental Sciences, Postgraduate School,

Universitas Gadjah Mada,

Suratman Woro Suprodjo, Sri Rum Giyarsih

Geography and Environmental Sciences, Faculty of Geography,

Universitas Gadjah Mada,

E-mail: rum_ugm@yahoo.co.uk

Abstract

This research is conducted in the *Perumnas* (Public Housing) Monang Maning in Denpasar City in order to analyze the application of *Tri Hita Karana* concept in the settlement environment based on its cultural component. Survey method is used in this research. Data was collected by field observation and in-depth interview to several informants. This research was analyzed by qualitative descriptive method.

The result of this research shows that the forms of the application of *Tri Hita Karana* concept in *Perumnas* Monang Maning is able to be found in each *parahyangan*, *pawongan*, and *palemahan* elements with any shifts or changes in the application itself and without any presence of distinct border. Based on the findings in this research, it can be suggested that in the beginning of building a settlement area, the concept of *Tri Hita Karana* as the base becomes necessary in order to provide spatial utilization of *Tri Hita Karana* as well as to obtain the planning model with *Tri Hita Karana* as its base.

Keywords: Tri Hita Karana, Perumnas, cultural, environment

Introduction

Tri Hita Karana is a fundamental philosophy foundation underlying the socio-cultural life and environment of the Balinese (Boehmar and Wichkham 198, in Mitchell and Martopo 1995). *Tri Hita Karana* is a manifestation of local wisdom which is based on the concept of harmonious relationships between men with God (moral and mental), between human beings (devotion) and between men and nature with its environment (concerns). The concept of *Tri Hita Karana* in space utilization implies the meaning of harmony in placing worship in the main zone (*parhyangan*), settlement in intermediate zone (*pawongan*), and rice fields, dry fields, grave in the "insult" zone (*palemahan*).

According to Wesnama (2009), as a form of wisdom, *Tri Hita Karana* is shown by the characteristics: (1) able to withstand the pressure of foreign cultures, able to accommodate, unite, provide guidance and direction of cultural development, and (2) has the function of conservation, preservation, resource development, knowledge development, and provides policy values. Having combined with the modern management and integrated application in community, this concept may represent a moral society, full devotion and concern for the challenges.

However, the constraint experienced is the beginning of the local wisdom's values decrease in along with the impact of globalization and era development. Nowadays, Bali Province has experienced many changes, especially from the views of culture, character, and life comfort.

The concept of *Tri Hita Karana* as a foundation of development is only a government's political jargon without fully implemented in the development itself ranging from provincial to village level. This triggers the emergence of *ajeg* (steady) movement in Bali as a reaction to the issue of Balinese culture degradation by immigrants (Suryawan 2004). To bear the *ajeg* condition in Bali means to maintain Balinese traditions and values which now begin to wear off in Bali. Denpasar, as a center of government and main activities in Bali Province, also bases its development on the philosophy of *Tri Hita Karana*.

Denpasar, as the center of activities, bears the attraction for immigrants to make a living, both from Bali and other islands. This leads to high level of heterogeneity in urban population such as ethnic, race, religion and origin.

This condition can be found in modern settlements that have emerged in Denpasar City. The challenge arose is how to maintain the local culture as the foundation of development in order to achieve harmony and sustainability in the midst of plurality. Based on this background, therefore, this research is conducted under the aim of analyzing the application of *Tri Hita Karana* concept based on the cultural component of the environment in a housing i.e. *Perumnas* Monang Maning Denpasar City.

Research Methods

This research was conducted in *Perumnas* Monang Maning Denpasar City considering: (a) this housing as one of the densest housings in Denpasar City; (b) has the service of *banjar* in each residential block; (c) is a region with highest environmental health risks and classified as poor in Denpasar City. The method used in this study is the survey one. Data was collected by in-depth interviews of several informants. Besides, in order to gain a comprehensive picture of the environment in *Perumnas* Monang Maning, this study is also equipped with field observations. Data processing and analysis were conducted by qualitative descriptive method.

Result and Discussion

Balinese traditional space utilization is ideally based on *Tri Hita Karana* within the scope of village including: *parahyangan* element in the form of *khayangan tiga* which takes place in *utama mandala* whose function is as a holy place, (2) *pawongan* element in the form of settlement, village market, *wantilan*, and *bale banjar* which takes place in *madya* (intermediate) position. *Pawongan* functions as the media for indigenous people to socialize and gather in a traditional event such as *sangkepan*, including the media to express the cultural values, and (3) *palemahan* in the form of gardens, fields, and *bengang* as an open green space which takes place in *nista mandala* position. The application of *Tri Hita Karana* in environment's cultural component involves *parahyangan*, *pawongan*, and *palemahan*.

There are important social institutions in Balinese village called *subak*, *banjar*, and *sekaa*. They have several activities including economic, social, and religious systems but their identity are still related to the living space of each activity's concentration. *Subak* is the unity of rice farmers who receive irrigation water from a given dam with the activity concentration in agricultural economic sector and also religious activity which related to ceremonies in *Pura* (temple) *Subak*.

Banjar is a social unity on the basis of regional bond according to its function. Traditional *banjar* has a function in the field of customs and religion and is structurally a part of traditional village, while the *banjar* service with its main function in administration sector structurally becomes a part of the village service. *Sekaa* is a social gathering that has specific objectives. The base of its membership is voluntary. Its bond is established by common goals and rules which are established and agreed together.

The Application of Tri Hita Karana in Parhyangan

Socio-cultural activity, which is related to *parahyangan* element, is not separated from religious ceremonies. The ritual is always performed by the presence of forces beyond human beings that need attention in order not to bring negative impact to the community.

The foreseeable effort to improve the quality of the ritual activity is to form groups that are engaged in religion, the existence of an organization that moves in religious sector such as *sekaa teruna teruni*, *sekaa pesantian*, and *sekaa gong* not only helps the implementation of various religious activities but also functions as the media to strengthen the relationship between the community members.

The existence of these groups contains each *banjar* in the environment of *Perumnas* Monang Maning, as expressed by one of the informants who is a public figure there:

> *"There are all pesantian (in banjar) but not all of them are active. But, there are lots of them in merajannya. The exercises during the full moon are usually attended by at least 4 people. Whenever the odalan becomes plenty, there's no need to bring tukang kidung from outside"*

One of the social activities associated with *parahyangan* is *ngoyah bakti* which is related to *piodalan* (religious ceremony). It generally takes place from the level of *banjar* to the village where all villagers under the environment of *banjar*/village will take part, either as fund sponsor or personnel one. The series including the preparatory process to the event implementation involves all villagers.

Piodalan at *Pura Banjar* is one of the efforts to grow the unity among the members of *banjar*. The existence of *piodalan* leads to all forms of participation between villagers with different background and the improvement of family's bond. Table 1 below presents the application of the concept of *Tri Hita Karana* in *Parahyangan* conducted by residents of *Perumnas* Monang Maning.

Table 1The Application of *Tri Hita Karana* (THK) Concept in *Parhyangan* by the Residents of *Perumnas* Monang Maning

THK Concept	Factual Condition	Change
Community's social activities which are related to religious activities	The series of religious ceremonies are still performed by mutual work (*ngayah*)	Mutual work is relatively voluntary due to the absence of *awig-awig* that rules and is implemented according to the villagers' daily acitivities.

Source: Primary Data Analysis Result in 2011

In order to understand more about the application of the concept of *Tri Hita Karana* in *Parhyangan* by the residents of *Perumnas* Monang Maning, Figure. 1 is presented as follows to show the relationship between the community groups and activities and the activities related to *parahyangan* element.

Figure. 1. The Relationship between the Community Groups and Activities and Activities Related to *Parahyangan*

It can be observed from Figure. 1 that the groups/communities are voluntary and has the function as a supporting element of religious activities such as *piodalan* and *yadnya* human. Meanwhile, the community activities are performed to support the religious ceremonies which are still be able to be found in *ngayah*, but it is voluntary.

The Application of Tri Hita Karana in Pawongan

Social institutions in rural communities become more heterogeneous. In *Perumnas* Monang Maning, the traditional institutions such as *banjar* and *sekaa* still exist, while the other institutions such as LPM, PLL (family welfare education), and Karang Taruna (Youth Gathering) are developing. *Bale banjar* becomes the center of acitivities from various organizations and community institutions. The existence of public spaces utilized by all villagers provides room for these institutions in performing their activities. The following Figure. 2 shows the sport activities utilizing *bale banjar*.

Figure. 2. One of Sport Organization's Activities in Utilizing *Bale Banjar* as Exercise Room

One of the community institutions and organizations adopting the concept of traditional organizations which can still be found in *Perumnas* Monang Maning is *Sekaa Teruna Teruni*. It exists in each *banjar* that has the function as an organizing media for the youth. According to the Coordinating Board of Socialization of Youths Education and Development (BAKOR PPGM 1993:6), the functions of *Sekaa Teruna Teruni* are as follows:

1. Implementing the obligations of *banjar* in keeping the security in the environment.
2. Implementing the government programs in education, sport, PKK, KB (family planning), health, cleanliness, and art sectors.
3. Assisting *banjar* and its villages in building sector especially the one concerning on human resource supply.
4. Assisting *banjar* and the Balinese villages in implementing their religious obligations.
5. Being a potential media related to the preservations of traditions, cultural art, and traditional values as well as local wisdom.

Various activities carried out include the activities related to religious ceremonies such as the celebration of *Nyepi*, fundraising bazaar for community activities, taking part as the committee of the celebration of national holidays such as the Independence Day celebration, and also assisting in government activities such as becoming the committee in elections. The preparatory activity of *Nyepi* becomes the part of a large-scale activity of *Sekaa Teruna Teruni*, as seen in Figure.3. In addition, the *Sekaa Teruna Teruni* activity also concerns on its members activities which dominantly are still studying at schools, as expressed by the Head of Panca Kertha Hamlet, Gede Arya, as follows:

> *"Well, the activity seems relative, on certain days only, such as Nyepi, when they are excited. I don't want to bother their school activities whenever some socialization is presented, for example, one given by the police."*

Figure. 3. The Activity of *Sekaa Teruna Teruni* in Preparing the *Ogoh-ogoh* for *Nyepi* Celebration

In traditional villages, the relationship between their members is ruled by *awig-awig*. It is the standard behavior, both is written and unwritten, made by the indigenous community in Bali based on the sense of fairness and propriety in living in a community (Astiti 2005). It can be used also as a social control including the behavior regulatory in socializing in a community.

In fact, *awig-awig* is not found in *Perumnas* Monang Maning. Most of its residents are immigrants who have attachment to *awig-awig* in their own/native villages. However, as an effort to achieve the development goals, it becomes necessary to go along with a set of behavior towards the planned society where there always is a rule. These rules are adopted by mutual agreement of *awig-awig* in the traditional villages. Common rules on *piodalan*, funerals found in *Perumnas* Monang Maning are the form of the population consciousness in order to bear an orderly environment. The sanctions are generally in the form of fines, there is no social sanction as well as violation of *awig-awig* in traditional villages. The following Table 2 shows the application of *Tri Hita Karana* concept in *pawongan* by the residents of *Perumnas* Monang Maning.

Table 2. The Application of *Tri Hita Karana* Concept in *Pawongan* by the Residents of *Perumnas* Monang Maning

THK Concept	Factual Condition	Change
Community's social activities which are related to between-member activities	The activity of mutual work in family activities such as wedding ceremony and teeth cutting are rare, but the community institution/group that moves in community activities such as *sekaa* is still developing	Mutual work *ngupoin* in preparing large-scale family events are rare and more oriented in economy i.e. human resource are occupied

Source: Primary Data Analysis Result 2011

From Table 2, it can be observed that mutual work/*ngupoin* related to family event becomes rare. It's different with the activities in traditional villages, *ngupoin* concerning on family events such as wedding in *Perumnas* Monang Maning starts shifting into using occupied human resource who are paid based on their skills. Besides, the large-scale family events such as teeth cutting as well as wedding tend to be performed in each native village.

The Application of Tri Hita Karana in Palemahan

Social life in Bali knows *nguopin* (mutual work) which covers a wide range of activities such as farming and gardening (planting, seeding, harvesting) and activities in environmental conservation. In the social life of the *Perumnas* Monang Maning, community service activities concerns more on cleaning up the surrounding environment. Each *banjar* has a schedule of each community service, as expressed by Dena Arsana, a community leader in the *Perumnas* Monang Maning, as follows:

> *"The community service is routine and well-implemented, it happens in all banjar, not only in banjar bhuana sari. It is monthly. It involves palemahan banjar as well as pesucian and palemahan. They're also well-implemented."*

Table 3 presents the application of *Tri Hita Karana* in *palemahan* by the residents of *Perumnas* Monang Maning.

Table 3. The Application of *Tri Hita Karana* Concept in *Palemahan* by the Residents of *Perumnas* Monang Maning

THK Concept	Factual Condition	Change
Community's social activities which are related to environment conservation activities	The mutual work activities related to environment conservation are still implemented, and there are community groups that concern on waste management	The mutual work activities concern more on cleanliness and replanting.

Source: Primary Data Analysis Result 2011

It can be observed from Table 3 that except community service in *banjar* and village related to the environment hygiene, there are also some community groups that concern on the environment conservation. They are modern institutions formed as the answer of the existing environmental issues. They are KUB (joint business group) which concerns on waste management and KPL (care-about-environment family) which becomes a public forum that initiates the household waste management. These groups aim to create a clean settlement environment so that the life harmony is born.

Conclusion and Suggestion

Based in the previous analysis and discussion, it can be concluded that the forms of the application of *Tri Hita Karana* concept in *Perumnas* Monang Maning still exist either on *parahyangan*, *pawongan*, or *palemahan*. However, there is a shift or change in its application as well as the absence of the real distinct border. The narrow land condition and the presence of economic factor influence the change of the implementation of *Tri Hita Karana* elements. As an urban settlement inhabited by immigrants, there are no rules/*awig-awig* binding the villagers to apply the *Tri Hita Karana*. Therefore, it is based more on the awareness of culture preservation.

Based on the analysis and discussion result as well as the previous conclusion, there's a need to suggest that in the beginning of developing a settlement, the application of *Tri Hita Karana* becomes necessary so that the special room for each element of *Tri Hita Karana* is built by basing on the model under the its concept. Its application must be started in the beginning of the planning specifically to provide an open space that may give the balance in preserving the environment in the settlement.

References

Astiti TIP (2005) Pemberdayaan Awig Awig Menuju Ajeg Bali. Lembaga Dokumentasi dan Publikasi Fakultas Hukum Uiversitas Udayana, Denpasar

Badan Lingkungan Hidup Daerah Kota Denpasar (2008) Status Lingkungan Hidup Kota Denpasar, Denpasar

BAKOR PPPGM (1993) Pola Dasar dan Pengembangan Sekaa Teruna. Forum Komunikasi Sekaa Teruna Provinsi Bali, Denpasar

Dalem RAA, Suarna IW, Wardi IN, Andyana IWS et al (2007) Kearifan Lokal dalam Pengelolaan Lingkungan Hidup. UPT Penerbit Udayana, Denpasar

Kurnianingsih A (2008) Simulacara Bali, Ambiguitas Tradisionalisasi Orang Bali. Insistpress, Yogyakarta

Mitchell B, Martopo S (1995) Bali, Balancing Economy, Environment and Culture. Departement of Geography University of Waterloo,Waterloo

Sulistyawati et al (1985) Preservasi Lingkungan Perumahan Perdesaan dan Rumah Tradisional Bali di Desa Bantas, Kabupaten Tabanan. P3M Universitas Udayana, Denpasar

Suryawan IN (2004) "Ajeg Bali' dan Lahirnya Jago-Jago Kebudayaan. Kompas , 7 Januari 2004.

Virpiyanti U (2008) Banjar Adat and Local Wisdom: Community Management for Public Space Sustainability in Bali Province presented in IASC 2008 12th Biennale Conference, 14018 July 2008

Wesnawa IGA (2009) Perubahan Penerapan Konsep Tri Hita Karana dalam Lingkungan Permukiman-Perdesaan (Kasus Kabupaten Badug, Propinsi Bali). Dissertation, Universitas Gadjah Mada, Yogyakarta

Yunus HS (1996) Permukiman Murah di Daerah Perkotaan Negara Berkembang: Suatu Tinjauan Kebijakan. Media Geografi No 10, Maret.

A Framework for clean power station projects based on Public-Private Partnerships in Asia developing economies

Gigih U Atmo, Collin F Duffield, and Lihai Zhang

Dept. Infrastructure Engineering, The University of Melbourne, VIC, Australia 3010

Email: gig@student.unimelb.edu.au

Abstract

Governments in developing countries desire the benefits that can be achieved through the use of public-private partnerships, however, lessons learnt from numerous private power projects across different jurisdictions in Asia post the 1997 economic crisis demonstrate the difficulties of maintaining sustainable long term partnerships between the public and private sector. Three generations of power station projects from Indonesia (1 - PPP projects in the 1990s; 2 - 2004 to 2008; and 3 – 2011) were studied.The underlying principles leading to the success or failure of private power projects are developed by a detailed investigation. The contextual investigation considers: analysis of project concession contracts, reflection on published government reports, interviews with key public decision makers, and a review of the current legal and regulatory framework for enabling PPP projects. The research considers sources of project financing and the merits of different risk mitigation strategies. The findings indicate that the potential for favourable outcomes is enhanced: where clear legal and regulatory frameworks exist, there is strong support from both government and from international development agencies, and where systematic risks (e.g. political risk and currency exchange risk) are overtly managed and mitigated. It is concluded that sustainable PPP projects can be achieved if potential sources of systematic risks are mitigated through adoption of clear and strong legal and regulatory framework, strong project governance and leadership, and support from international finance organisations.

Keywords: Public-private partnerships, infrastructure development, power generation, environment

Introduction

Sustainable public infrastructure system is the foundation for the development of liveable cities. Infrastructure such as transport, clean water, and electricity are required to underpin economic development and support amodern living standard. However, it is identified that the processes for delivering such infrastructure services often create adverse environmental impacts. Of particular concern, gas emissions from coal-fired power plants can cause serious health and environmental problems. However, under current energy policies the global use of coal for energy sources is forecasted to increase by 65% in 2035 (International Energy Agency, 2011), particularly by developing countries (Massachusetts Institute of Technology, 2007). Therefore, while the use of coal remains high worldwide, deployment of new clean coal technologies becomes a critical factor to mitigate gas emissions from coal-fired power plants.

Development of clean coal technologies (CCT) is aimed to achieve the balance between mitigation of negative externalities from coal-power plants and requirement for affordable power supplies (Chikkatur et al., 2011). CCT such as supercritical/ultra-supercritical pulverized-coal can increase plant efficiency (42 – 47% for supercritical and 47-50% for ultra-supercritical) compared with conventional coal-power plant (thermal efficiency ≤ 40%) (Koh et al., 2011). The increased level of thermal efficiency reduces significantly the carbon emission level from coal-fired power plants. However, deployment of CCT also introduces technological risks that need to be considered. For example, supercritical/ultra-supercritical technology operates at significantly high operating temperatures and pressures which require specific design boiler material and a high level of construction and operation techniques. Furthermore standardisation of CCT is difficult to achieve as coal specification is widely varied (Franco and Diaz, 2009). All of those factors cause dimensional change of technological risk from the development of a coal-fired power project in developing countries.

The power generation sector is an area where Asian's developing countries frequently engage with the private sector. Since the 1990s, 137 transactions of private power projects amounting of US$65 billion in total value were recorded (Albouy and Bousba, 1998). However, after the 1997 Asia financial crisis, the scale of private power transaction has reduced significantly and actually is only now begin to recovered. Many studies (Woodhouse, 2006, Wu and Sulistiyanto, 2006, Chowdhury and Charoenngam, 2009, Eberhard and Gratwick, 2011) suggest that political risk and currency exchange risk becomes two major risk factors causing under performance of private power projects in developing countries. Nonetheless, the existing studies have not addressed the impacts from the 2008 global financial crisis and stringent environmental regulations leading to the increased project financing and technological risk.

Project Financing Of Privately Funded Power Projects In Developing Economies

Public-private partnerships (PPPs) as an alternative procurement strategy from traditional approaches has been widely implemented in many countries, both developed as well as developing. However, the driver for using PPP for procuring public infrastructure is different between the two groups of countries. While developed economies with extensive PPP experiences such as the UK and Australia focus on achieving better value for money (VfM) (Esther et al., 2009), primary motivation for developing countries engaging with private sector through PPP mechanism is to gain access to private capital for delivering public infrastructure (Deloitte Touche Tohmatsu Emerging Markets, 2004, Jiang and Wamuziri, 2008). This different motivation and background for adopting PPP mechanism will largely determine the ultimate performance of infrastructure projects delivered through this scheme.

Context Of Private Power Projects: A Single Buyer Electricity Market

Participation by the private sector, foreign investors and domestic investors, are required to support the development of economic infrastructure in the developing economies. In the electricity sector, Private participation has been intensively occurring since the early 1990s when a deregulated electricity market was introduced. In most OECD member countries, electricity market deregulation has led to electricity market liberalization allowing electricity tariffs to be determined by the market mechanism (Al-Sunaidy and Green, 2006). However, the extent of electricity reform in the majority of developing countries is limited to power generation sub-sector. Governments grant licenses to private power producers, commonly known as the independent power producers (IPPs), to produce electricity under the Build-Operate-Transfer (BOT) or Build-Own-Operate (BOO) (Jamasb, 2006, Nagayama, 2009). As the retail electricity tariff is controlled by the governments and often set below marginal cost of electricity production (Wu and Sulistiyanto, 2006), the state electricity company assumes commercial risks arising from the provision of electricity by private power producers or IPPs. Consequently, creditworthiness of the public sector is a key consideration to determine bankability of private power projects (Gratwick and Eberhard, 2008).

Project support from the international finance organizations

Developing countries in general have low quality of sovereign credit rating with level below investment grade (Chowdhury and Charoenngam, 2009). This introduces risk of default payment by the public sector and has been perceived as a high investment risk by the private sector. Consequently, private investors become risk adverse for making investment decision and charge for a high premium for investing capital in private power projects. The international capital market post the 2008 global financial crisis increases challenges for securing funds for private power projects in the developing countries. This recent financial crisis has reduce liquidity of capital markets and increase risk adverse from private investors to commit for a long term investment such as infrastructure projects (Regan et al., 2011).The perceive high investment risk causes a higher borrowing cost (Wang and Tiong, 2000) and reduce the scope of international project financing to mainly groups of developing countries with sound quality of sovereign credit rating.

Support from the international finance institutions such as the World Bank improves creditworthiness of private power projects in the developing economies. The multilateral development agencies (MDAs) such as the World Bank and export credit agencies (ECAs) can have roles as project lenders, insurers/guarantors, and professional advisers (Jiang and Wamuziri, 2008). Chowdhury et al. (2009) described that equity contribution from these international finance institutions improves bankability of renewable energy projects. They found that the eight largest MDBs such as the Asian Development Bank and International Finance Corporation allocate 5% - 30% of their investment portfolio to private equity funds.

Nevertheless, the MDAs and ECAs have different investment motivation which could influence the ultimate performance from such a private power project. The former aims to promote development through infrastructure projects while for the later, the ultimate objective is to support export of goods or services from the country's creditor (Inadomi, 2009). This different motivation could affect due diligence process required to ensure robustness of economic and financial checking from such an infrastructure project. Consequently, the internal process of project initiation and business case development within the public sector's organisation is required to ensure that such an infrastructure project worth proceeding from the dimension of financial and socioeconomic perspectives.

Domestic source of project finance

There is an increasing trend of domestic finance availability to support private infrastructure projects in developing countries especially those from emerging economies. In the event of constrained international capital market, domestic capital markets and local commercial banks can provide alternative sources of project financing. Project financing in local currency also provides a sophisticated form of currency risk mitigation strategy (Deloitte Touche Tohmatsu Emerging Markets, 2004). However, the capacity of domestic financial sources in developing countries is limited (Jiang and Wamuziri, 2008). Hence, participation from foreign investors remains one of key determining factor for infrastructure PPP-type projects in developing countries.

The structure of project finance for private power projects in developing countries is determined by the availability of funds either from local and international sources. In the event of capital contribution from international markets is expected, participation from MDAs or ECAs is required to make a project bankable.In general, foreign investors require guarantee coverage from the MDAs/ECAs to reduce the risk level from power projects in the developing economies. Although such support enhances creditworthiness of power projects in developing countries, the host government often has to provide a counter-guarantee, thus introducing a significant contingent liability to the public sector budget.

Government guarantee

Availability of government guarantee becomes essential element for PPP project success in developing countries where the private sector perceives a high level of investment risk. The availability of guarantee improves creditworthiness of PPP infrastructure projects (Chowdhury and Charoenngam, 2009) and become key one of private sector's key investment criteria (Yongjian et al., 2009). In the current situation of financial market post the 2008 global financial crisis, provision of debt guarantee could reduce the cost of capital and enhance project value for money (Regan et al., 2011).

Guarantee facility from the host governments is often required when the private sector perceives a high investment risk. The provision of government support changes the structure of risk allocation between the public and private sector. Therefore, the change in risk allocation resulting from the provision of government support needs to be incorporated into project value for money assessment (Fitzgerald and Duffield, 2009). However, many cases of PPP projects from developing countries show that governments often offer excessive guarantee to secure infrastructure investment from the private sector (Tillmann et al., 2007). Consequently the project could experience default payment or contract breach by governments when project risks covered by the guarantee eventuate (Wibowo, 2004, Chowdhury and Charoenngam, 2009). Provision of government guarantee requires robust diligence process by the public sector. Moreover, it should be incorporated into government annual budget so that transparency and accountability of such guarantee can be assured.

To sum up, the performance of private power projects in the developing countries is significantly influenced by the availability and commercial conditions of project financing sources. Extensive studies on the 1990s' private power projects found significant factors such as political and macroeconomic stability factors, which could determine the ultimate project outcomes. However, the current and future private power projects encounter new challenges associated with the project financing and environmental sustainability. These two key dynamic issues substantially change the overall risk profile from the delivery of private power projects in developing countries. This paper discus project risks arising from the delivery of clean coal power projects in the developing countries under current international context post the 2008 global financial crisis. Risk mitigation strategies are proposed as a result from the analysis of coal-power projects in Indonesia. It builds on these case study projects to develop a framework for corresponding future investment.

Methodology

The methodology for this paper was based on extensive theoretical analysis and literature reviews, and then proceeding with case study analysis. Three Indonesian private power projects were selected for the analysis, namely Paiton I coal-fired power project (CFPP), Cirebon CFPP, and Central Java CFPP. The projects selected represent the application of risk management strategies under the different context of project financing environment, namely a surge in foreign private investment in the 1990s (Paiton I CFPP), risk adverse environment post the 2008 global financial crisis (Cirebon CFPP), and local favourable investment climate (Central Java CFPP).

Research procedure

The data for the analysis was acquired from the project companies and financiers' websites participated in the private power projects, published project information from the governments' agencies, and secondary sources of data from journals and a book. Reports from newspapers were used only when other sources of data were not available. A comparative study was undertaken to draw lessons learned from the experiences of different risk management strategies. Matters considered for the project risk analysis include: project financing structure, government support, and deployment of clean coal technology. The advantages and disadvantages of the key strategic factors were analyzed in argumentative styles. Finally, the findings from the case comparison were used to establish a framework for mitigating risks from private clean coal power projects.

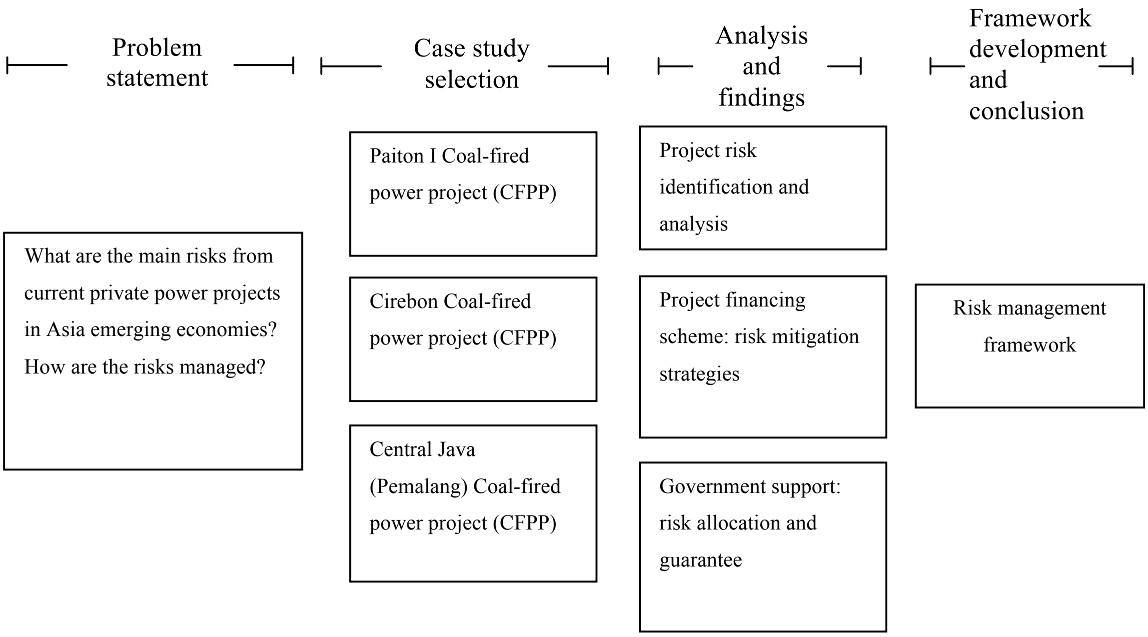


Figure 1 Research procedure.

Context of Indonesia's case study

Indonesia economic development has been progressing well since it recovers from the 1997 Asia financial crisis. To date, Indonesia, with Gross Domestic Products (GDP) above US$800b, has become the largest economy in the South East Asia. The country also received an upgraded sovereign credit rating to the level of investment grade by Fitch in 2011 and followed by Moody's in 2012. This is believed to further enhance the economic development in the country. Despite the positive outlook of Indonesia economy, the country is urgently required to upgrade its economic infrastructure. Of particular importance, constrained electricity supplies and poor public transport networks have been identified as a major investment bottleneck (Asian Development Bank (ADB) et al., 2010). However, the allocated government budget for the infrastructure development is inadequate to fulfil a massive scale of infrastructure investment.(Roesly, 2012)outlined the requirement of infrastructure fund in the amount of US$ 214 billion for the period between 2010–2012. Out of this figure, private sector participation is expected to reach 34% or US$ 74 billion.

In the area of electricity, the Indonesian government has invited private sector participation in the power generation sector since the early 1990s. Three different model of private power development program have been introduced consisting of the first, second, and third generation of private power projects (IPPs), respectively. The three Indonesian power projects were selected on the basis of project financing complexity, different government support mechanism, and clean coal power technology selection. Description of the three projects is summarised in Table 1.

Table 1. Summary of the three Indonesian case study coal power projects

Project time frame	1st generation PPP Power project (1990s)	2nd generation PPP power project (2005 – 2008)	3rd generation PPP power project (2010 – present)
External context	• Financial market was buoyant where project finance transactions were very high in Asia • Indonesia's sovereign credit rating (investment grade BBB-)	• Financial market was constrained due to the 2008 GFC. • Indonesia was not in investment grade position (BB+)	• Global financial market is still experiencing contraction as the uncertainty from the 2008 GFC continues • Indonesia is in investment grade position (BBB-)
PPP Scheme	Private power projects (Build-Finance-Own-Operate)	Private power projects (Build-Operate-Transfer)	Private power projects (Build-Operate-Transfer)
Project Size, Value, and technology	2 x 650 MW US$ 2.48 billion Conventional coal technology (Subcritical technology)	1 x 650 MW US$ 850 million Clean coal technology (Super critical technology)	2 x 1000 MW US$3.5 billion Advanced clean coal tech. (Ultra-super critical tech.)
Guarantee provider	• Ministry of Finance (Comfort letter) • Export credit agencies (JEXIM, US EXIM, and OPIC)	• Ministry of Finance under an Umbrella Note (a bilateral agreement between the Government of Indonesia and government of Japan) • Export credit agency (JBIC/ NEXI)	• Indonesia Infrastructure Guarantee Fund (state Indonesia guarantee company, backed by the Government of Indonesia) • Export credit agency (forecasted)
Risk coverage	Blanket guarantee (Project Equity and Project Debt)	Project debt (all debt portion both bilateral loans and commercial loans)	Project equity and debt (capped at specified level of downside risk and definite timeframe)
Transparency	Less transparent from	The Ministry of	Transparent and

and accountability	the public perspective	Finance establishes a risk management unit to assess the public sector financial risk. However, the terms of guarantee is from the ECA	accountable process. The private sector was charged with the premium which reflects the magnitude of risk covered by the government of Indonesia.

Notes: the data sources to construct the case study mainly comes from Wells and Ahmed(2007), Roesly(2012), and Chowdhury and Charoenngam(2009).

Results and Findings

The three cases of Indonesian coal power projects were analysis from the dimension of project financing structure, government support mechanism, and clean coal power technology. These three key assessment criteria enable the identification of critical strategic drivers for mitigating risks from clean coal power projects in the developing countries.

Project financial structure

Project financial structure of the Paiton I CFPP (representing first generation IPP projects), Cirebon CFPP (second generation IPPs), and Central Java CFPP (the third generation IPPs) are presented in Figure 2. The bar chart shows that foreign investors continue dominating large scale investments of IPP projects in Indonesia over the different time period. While it represents attractiveness of the sector to the international investors, the public sector continues to experience exposure to currency exchange risk. This is because the source of project finance is from hard foreign currencies while project revenues are in local currency. Studies of IPP projects across different jurisdictions from Asia, Latin America, and the Middle East (Woodhouse, 2006, Wu and Sulistiyanto, 2006) confirmed that foreign currency risk is one of the highest source of risks from IPP projects in developing countries. Nevertheless, effective measures still require further investigation.

Conventional currency risk mitigation such as commercial hedging currency is not available because the immaturity of local financial markets in developing countries (Deloitte Touche Tohmatsu Emerging Markets, 2004). Alternatively, Malgas et al. (2007) proposed to use basket currency (denominated local currency into several foreign currencies) as it has been demonstrated from Rades II project in Tunisia. Although theoretically systematic risk can be managed through diversification, during the 1997 Asia financial crisis, Indonesian currency lost its value against major global currencies. As a result, basket currency could be ineffective when the fundamental country’s macroeconomic situation is deteriorating.

Structuring project financing to incorporate local currency becomes effective measures against currency exchange risk. For example, financial impact from the 1997 Asia financial crisis is less severe for IPP projects in Malaysia as the project loans were secured from the local capital market (Woo, 2005). The inclusion of local sponsors as equity provide could also reduce the magnitude of currency exchange risk.

Strategic local project sponsors

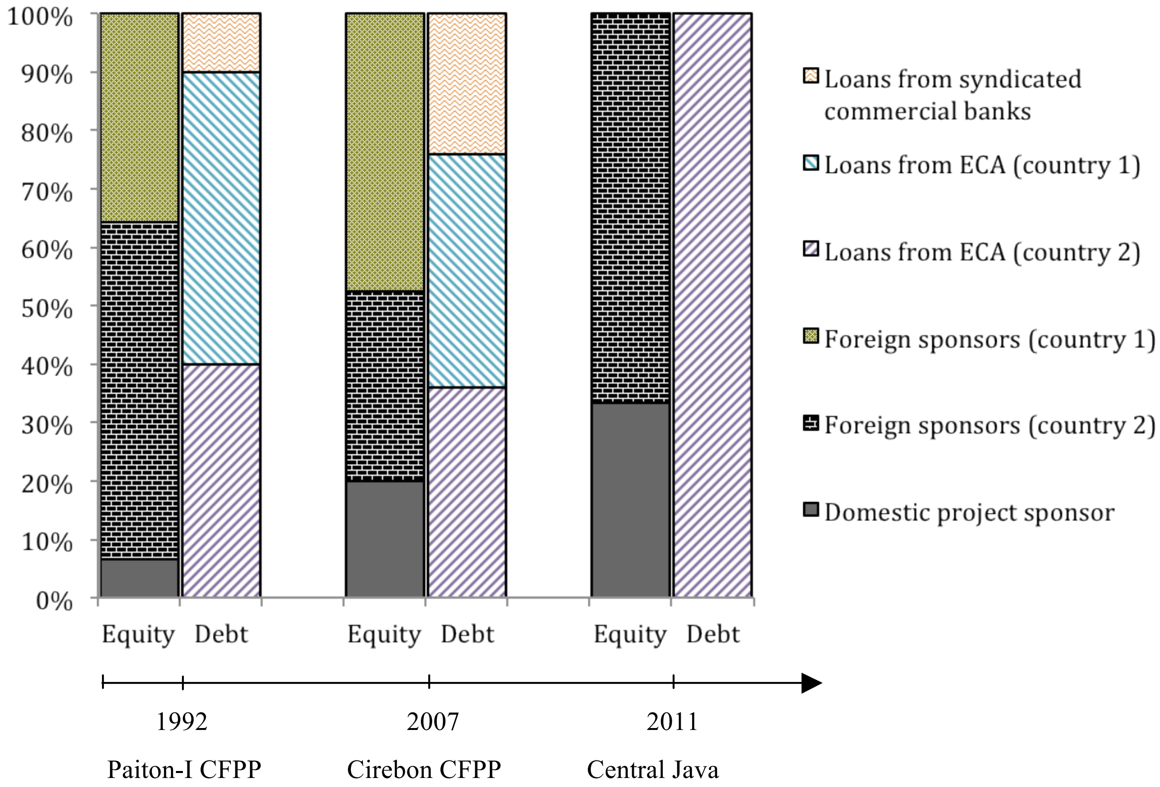


Figure 2. Project Financial structure of Indonesian private power projects

Notes:
1. The graph was developed based on the data from Wells and Ahmed (2007) (Paiton I CFPP), official project company websites and parent company websites (Cirebon CFPP),newspaper and company's websites (Central Java CFPP).
2. The proportion of commercial loans in Cirebon CFPP was an estimation based on the benchmark from Paiton-3 CFPP project. The two projects received a quite similar loan packages (direct capital and political risk guarantee) from JBIC.
3. The financial structure of Central Java project was an assumption on the basis of information from a reputable business newspaperin Indonesia, The Indonesia Today (2011).

It can also be seen from figure 2 that over the different time period, participation of local sponsors have increased significantly from just about 7% in Paiton I project to more than 30% in the recent Central Java project. The Indonesia case study shows a significant present of strategic local partners whose parent business interest is coal fuel suppliers. This is a crucial factor as coal component constitutes for more than 30% of total project whole-of-life cost (David and John, 1998). Two power projects namely, Meizhouwan coal power project in China (Woo, 2005) and Rades II gas power project (Malgas et al.,

2007) experience contract renegotiation because security of fuel supply could not be guaranteed. Therefore, the inclusion of coal suppliers into project consortium provides an effective mitigation strategy for managing the cost and availability of coal supply. Whilst, study of IPP projects in Africa concluded that local partners were not a key determining success factors in the projects Eberhard and Gratwick (2011), Indonesian's case study shows that the involvement of local business partners improves the performance of IPP projects. This can be achieved through alignment between project sponsors' long term business interests in the project.

Support from the foreign export credit agencies

Apart from the equity structure, project debt is largely dominated by foreign lending with majority of loan contribution from export credit agencies (ECAs). Figure 2 shows a relatively constant contribution from ECAs in the project debt structure (90% for Paiton I power project and 76% for Cirebon power project). Based on the current published information, Central Java project is expected to have main debt contribution from Japan Bank for International Cooperation (JBIC), the Japanese ECA.

It can be argued that Indonesia's IPP projects are still perceived as risky projects such that foreign commercial lenders have minimum capital contribution in the project debt structure. Nevertheless, Figure 2 shows an increased percentage of loan contribution from syndicated commercial banks of 10% (Paiton I power project) to 24% (Cirebon power project). For the Central Java project, loan contribution from the commercial banks is not known at current pre-financial close stage. Loan portion from the commercial banks require political risk guarantee from the export credit agencies. Survey conducted by Conrad et al. (2008) found that specific political risk such as contract breach and regulatory certainty is perceived as a high risk from Indonesian power projects. While the continuing government effort to address legal and regulatory issues is expected by the private sector, the provision of political risk guarantee is required for the current delivery of IPP projects.

Government support: a political risk mitigation strategy

Although the availability of project support the international agencies are deemed to be important for enabling project financing (Deloitte Touche Tohmatsu Emerging Markets, 2004), it requires robust due-diligence by the public sector. Indonesia has experienced with three different schemes of government support. Table 1 outlines a comparison between Paiton I CFPP (1st generation), Cirebon CFPP (2nd generation), and Central Java (3rd generation).

a) Paiton I CFPP

Table 1 indicates that Paiton I's project sponsors and lenders receive full risk coverage from the government of Indonesia. This scheme incurs a significant financial liability to the public sector budget. Even though Paiton I project was eventually success in the contract renegotiation post the 1997 Asia financial crisis, Indonesian government has to compensate Karaha Bodas' project sponsors, another project with the same guarantee cover, in the amount of US$ 261.1 million to compensate the project cost expenditure and forecasted future project revenues (Wells, 2003). These lessons motivated the Indonesian government to avoid the provision of guarantee for the second generation of private power projects.

b) Cirebon CFPP

Cirebon CFPP is part of the second generation private power projects offered by the government of Indonesia in the subsequent event of Infrastructure Summit in 2005 and 2006. Although the event attracted large attention from the potential international investors, the number of project transactions are limited (Wibowo and Mohamed, 2010). This cause was partly due to the absent of guarantee from the host government. The project eventually secured loans from the Japan Bank for International Cooperation (JBIC), Korean Exim Bank (KEXIM), and syndicated loans from commercial banks in Japan. It is because JBIC provides extended political risk coverage for commercial portions of the loan. The government of Indonesia provides counter-guarantee under bilateral scheme of Umbrella Note between the government of Indonesia and government of Japan.

Lessons learned from Cirebon power project show that support from the host government is still required to mitigate perceived investment risk in Indonesia. However, there is a significant different from Paiton I project in that the public sector only provides risk coverage for the project loan while the equity investors are not covered by the government guarantee. This finding indicates that project sponsors are more willing to take investment risk compared with the commercial lenders. It is believed other business opportunities in addition to revenues from the electricity production have motivated the project consortium to assume equity investment risks.

Sponsors' business interests in addition to the revenue generated from the project Cirebon's project shareholders are outlined as follows:

- Indika Inti Energi : secured long-term contract for project's fuel supplier
- Marubeni : improving ownership of asset portfolio in private power generation
- Korea Mindland : secured long-term contract for plant's O&M
- Samtan : secured long-term contract for project's fuel supplier

From the Paiton I CFPP, Wells and Ahmad (2007) criticised the excessive returns for the equity investment from the side financial benefits in addition to the production of electricity. Similarly, Woo (2005) commented on the project sponsor' motivation to secure Engineering, Procurement and Construction contract and equipment sales contract. However, the nature of business interest from the Cirebon power project relies on the long-term performance of the project. This shows that that risk adverse from the project sponsors can be mitigated via a trade-off with long-term business opportunities in addition to the revenues from power generation business. The alignment of long term business view from the project sponsors ensures that efficiency gain from whole-of-life cycle is considered.

c) Central Java CFPP

Central Java US$3.5 billion coal-fired power project becomes the first IPP project to receive government guarantee under the new guarantee scheme. The Indonesian Infrastructure Guarantee Fund (IIGF), the state guarantee organization, can only provide risk coverage for projects procured under competitive tendering process (Roesly, 2012). Furthermore, the agreed risk allocation between the public and private sector were agreed prior the bidders entered the tendering process. Therefore, IIGF could function as a proxy to manage risk arising from the provision of guarantee. Equally important, the new scheme improves accountability and transparency process from the provision of government guarantee for IPP projects.

Clean coal power projects: technological risk

The three Indonesian coal power projects progressively employed more energy efficient technologies. The Central Java power project adopted the most advanced super critical pulverized-coal technology, which reduces significantly carbon emissions from the production of electricity.

Power generation project, by nature, is a capital intensive project and involves a high technological risk (Ye and Tiong, 2000, Cheung and Chan, 2011). While the use of proven technology is part of financiers' due diligence to ensure a stable cash flow, deployment of clean coal technology exaggerates the magnitude of technological risk from the private power projects. Furthermore, there are limited international experiences about the performance of clean coal power project adopting advanced technology such as ultra-super critical pulverized-coal technology.

The case study shows that export credit agencies (ECAs) contribute to the largest portion of project debt. While it has been recognised that the main motivation from ECAs is to support exports of goods and equipment from the country's creditor (Inadomi, 2009), it also mitigates technological risk from clean coal power projects. As the largest debt provider, the ECA requires that the power station with a new technology has a reliable performance to ensure a stable cash flow for serving the debt obligation.

Comparative case study analysis and framework development

Comparison of the project performance among the three Indonesian case study technologies is outlined in Table 2. The critical strategic drivers derived from project financing, government support, and power station's technologies are used as a basis for comparison. The value judgments are made by comparing each Indonesian power project on its ability to mitigate systematic risks and project specific risk, namely currency exchange risk, political risk, and technological risk.

From the case comparison it can be seen that the Indonesian IPP projects have experienced an improved performance progressively. This can be seen especially in the effort from the government to improve the transparency and accountability from the provision of project guarantee. Equally important, local strategic sponsors have emerged and take more active roles in the structure of project consortium. This shows an increased confidence from the local private sector to participate with the foreign project sponsors. Thus enabling for future technology transfer and it also becomes a potential approach to mitigate currency exchange risk.

Table 2: Comparison of project performance of Indonesian IPP projects

Key assessment area	**Critical strategic drivers**	**Paiton I CFPP**	**Cirebon CFPP**	**Central Java CFPP**
Project financing structure	Foreign competent project sponsors with long term	◕	●	●
	Participation of local sponsors	◔	◑	◕
	Bankability of the project from the international	◕	◑	◑
	Debt contribution from domestic capital market	○	○	○
	Support from multilateral development agencies	○	○	◔
	Financial support from export credit agencies	●	●	●
Government support/guarantee	Transparency and accountability of the process	○	◑	●
	Mitigation to the public sector financial risk	○	◕	◕
	Improving project bankability	◕	◕	◕
	Incentive to adopt competitive tendering	○	◔	●
Coal-fired power technology	Adoption of internationally proven and mature	●	◑	◔
	Greenhouse gas mitigation technology	○	◑	◕
	Alignment between lenders' due diligence and new clean	N/A	●	◕

Remarks:

○ : poor/does not exist   ◔ : fair   ◑ : good
◕ : very good   ● : excellent

The quantum of technological risk from the deployment of clean power technology increases significantly in the current project. The inter-related dimension of technological risk and environmental risk requires for more attention from the public and private sector. The project consortium is required to demonstrate to the financiers that the adopted new clean technology has a reliable operating standard such that long term stable cash flow from the electricity production can be assured.

A proposed risk mitigation framework for clean coal private power projects

Based on the findings derived from the Indonesian case study, risk management of clean coal-fired IPP projects can be improved through a strategic arrangement of project financing scheme, mechanism of government guarantee, and clean coal power technology. A comparison of key strategic drivers between the three Indonesian projects provides useful insights to develop a risk mitigation framework (figure 3). The framework shows a dynamic process to manage systematic project risk (political risk and currency exchange risk) and non-systematic risk (project financing risk and technological risk) which is relevant in the current context of clean coal power projects from Asia developing economies.

Conclusion

It is concluded that private power projects adopting advanced clean technologies in the Asia developing economies can reach the benefits from changing landscape of the international financial markets post the 2008 global financial crisis as well as the inclusion of environmental assessment into project finance policies.The project benefits can be achieved if potential sources of systematic risks are mitigated through adoption of clear and strong legal and regulatory framework, strong project governance and support, and involvement from the international finance organisations such as the multilateral development agencies and export credit agencies. Two project specific risks, namely technological risk and environmental risk, have emerged as key consideration factors to enabling access to the commercial financial sources from the domestic and international markets.

Further research is required to explore the benefits from current change in both the international and domestic financial markets post the 2008 global financial crisis. Alternative project financing sources from the international emerging markets as well as domestic sources of finance are worth to be further investigated. While the conventional power technologies have track records of proven technology, the deployment of clean power technologies become a key consideration for structuring project financing. Further development of the framework is required to incorporate other key project risks, which could affect the performance of future IPP projects.

Project Risks	Project Risk Bearer	Mitigation Strategies
Project systematic Risk		
Political Risk		**Political risk cover from MDBs/ECAs**
Guarantee coverage from host gov.	State-funded guarantee institution **(Public Sector)** Proxy for guarantee assessment Host governments	Counter-guarantee
Macroeconomic risk (currency exchange risk)	Public sector	• Inclusion of local currency into project financial structure through domestic equity and debt contribution. • Fuel supply from indigenous fuel resources • Reduce project capital size through scope reduction, and use of equipment and contractor from local sources • Debt refinancing (commercial loans' portion) using local currency during project operation phase
Project un-systematic risks (project specific risks)		
Financing risk	Private sector	Structuring design of the project to adapt change on the international financial markets: • Employ plant technologies which comply with global environmental standard • Invite participation from MDBs/ECAs as debt provider • Seek for political risk coverage from MDBs/ECAs to enable loans from commercial finance institutions
Technological risk	Private sector	Aligning interests of project sponsors and debt providers with project's whole-of-life consideration, through: • Channelling business interests of project sponsors to the project's long term performance (fuel suppliers, packaging construction contract with O&M contact) • Assuring robust technological risk due diligence from the ECAs (largest debt provider) where ECAs' support is to promote new technology in the international market. • Maintaining present of ECAs for project's long term debt structure.

Figure 3: Risk mitigation strategy for private power projects in developing countries

References

Asian Development Bank, International Labour Organisation, Islamic Development Bank, 2010. Critical development constraints. Asian Development Bank.

Al-Sunaidy, A. ,Green, R., 2006. Electricity deregulation in OECD (Organization for Economic Cooperation and Development) countries. *Energy*, 31(6-7): 769-787.

Albouy, Y. ,Bousba, R., 1998. The impact of IPPs in developing countries – out of the crisis and into the future, public policy for the private sector.

Cheung, E. ,Chan, A. P. C., 2011. Risk Factors of Public Private Partnership Projects in China --- A Comparison between the Water, Power and Transportation Sectors. *Journal of Urban Planning and Development*, 1(1): 54-54.

Chikkatur, A. P., Chaudhary, A. ,Sagar, A. D., 2011. Coal Power Impacts, Technology, and Policy: Connecting the Dots. *Annual Review of Environment & Resources*, 36(1): 101-138.

Chowdhury, A. N. ,Charoenngam, C., 2009. Factors influencing finance on IPP projects in Asia: A legal framework to reach the goal. *International Journal of Project Management*, 27(1): 51-58.

Conrad, V., Andre, P., Tillmann, S., Tiong, R., 2008. Political risk perception in Indonesian power projects. *Journal of Financial Management of Property and Construction*, 13(1): 18-34.

David, G. R. ,John, S., 1998. The East Asian financial crisis - fallout for private power projects. *The East Asian financial crisis - fallout for private power projects B2 - The East Asian financial crisis - fallout for private power projects.*

Deloitte Touche Tohmatsu Emerging Markets, 2004. Sustainable power sector reform in emerging markets – financial issues and options.

Eberhard, A. ,Gratwick, K. N., 2011. IPPs in Sub-Saharan Africa: Determinants of success. *Energy Policy*, 39(9): 5541-5549.
Esther, C., Albert, P. C. C. ,Stephen, K., 2009. Reasons for implementing public private partnership projects. *Journal of Property Investment & Finance*, 27(1): 81.

Fitzgerald, J. P. ,Duffield, C. F., 2009. Value for Money in a changing world economy. *Symposium proceedings CIB TG72 titled 'Revisiting and Rethinking' to 'Revamping and Revitalising'*: 3 - 14.

Franco, A. ,Diaz, A. R., 2009. The future challenges for "clean coal technologies": Joining efficiency increase and pollutant emission control. *Energy*, 34(3): 348-354.

Gratwick, K. N. ,Eberhard, A., 2008. An Analysis of Independent Power Projects in Africa: Understanding Development and Investment Outcomes. *Development Policy Review*, 26(3): 309-338.

Inadomi, H. M., 2009. Independent power projects in developing countries : legal investment protection and consequences for development. Kluwer Law International ; Turpin Distribution, Alphen aan den Rijn : Biggleswade :. 390.

International Energy Agency, 2011. The IEA's World Energy Outlook 2011. *Power Engineering International*, 19(11): 16-21.

Jamasb, T., 2006. Between the state and market: Electricity sector reform in developing countries. *Utilities Policy*, 14(1): 14-30.

Jiang, M. ,Wamuziri, S., 2008. Role of export credit agencies in PFI/PPP projects. *Proceedings of the Institution of Civil Engineers: Management, Procurement and Law*, 161(4): 163.

Koh, S. L., Lim, Y. S. ,Morris, S., 2011. Potential of Advanced Coal and Gas Combustion Technologies in GHG Emission Reduction in Developing Countries from Technical, Environmental and Economic Perspective. *Energy Procedia*, 12(0): 878-885.

Malgas, I., Gratwick, K. N. ,Eberhard, A., 2007. Two of a Kind: Lessons from Tunisian Independent Power Projects. *Journal of North African Studies*, 12(4): 395-415.

Massachusetts Institute of Technology, 2007. The Future of coal: options for a carbon-constrained world.

Nagayama, H., 2009. Electric power sector reform liberalization models and electric power prices in developing countries: An empirical analysis using international panel data. *Energy Economics*, 31(3): 463-472.

Regan, M., Smith, J. ,Love, P. E. D., 2011. Impact of the Capital Market Collapse on Public-Private Partnership Infrastructure Projects. *Journal of Construction Engineering & Management*, 137(1): 6-16.

Roesly, S., 2012. The role of Indonesia Infrastructure Guarantee Fund for PPP projects development in Indonesia.

The Indonesia Today, 2011. JBIC grants $2.8 billion loan to Adaro consortium. 2012(May).

Tillmann, S., Robert, T. ,Shou Qing, W., 2007. Analysis of political risks and opportunities in public private partnerships (PPP) in China and selected Asian countries: Survey results. *Chinese Management Studies*, 1(2): 126-148.

Wang, S. Q. ,Tiong, L. K., 2000. Case study of government initiatives for PRC's BOT power plant project. *International Journal of Project Management*, 18(1): 69-78.

Wells, L. T., 2003. Double dipping in arbitration awards? an economist questions damages awarded to Karaha Bodas company in Indonesia. *The Journal of the London Court of International Arbitration*, 19(4): 471-481.

Wells, L. T. ,Ahmad, R., 2007. Making foreign investment safe [electronic resource] : property rights and national sovereignty / Louis T. Wells, Rafiq Ahmed. Oxford : Oxford University Press, 2007.

Wells, L. T. ,Ahmad, R., 2007. Making foreign investment safe [electronic resource] : property rights and national sovereignty. Oxford : Oxford University Press, 2007.

Wibowo, A., 2004. Valuing guarantees in a BOT infrastructure project. *Engineering Construction & Architectural Management (09699988)*, 11(6): 395-403.

Wibowo, A. ,Mohamed, S., 2010. Risk criticality and allocation in privatised water supply projects in Indonesia. *International Journal of Project Management*, 28(5): 504-513.

Woo, P. Y., 2005. Independent Power Producers in Thailand, working paper # 51.

Woo, P. Y., 2005. China's electric power market : The rise and fall of IPPs, Working Paper # 45.

Woodhouse, E., 2006. The Obsolescing Bargain Redux: Foreign Investment in the Electric Power Sector in Developing Countries *Journal of International Law and Politics*, 121.

Wu, X. ,Sulistiyanto, P., 2006. Independent Power Producer (IPP) in Indonesia and the Philippines. In: Ramesh, M. ,Howlett, M., eds. Deregulation and its discontents: Rewriting the rules in Asia, Edward Elgar. 109-123.

Ye, S. ,Tiong, R. K. L., 2000. Government support and risk-return trade-off in China's BOT power projects. *Engineering Construction & Architectural Management (Blackwell Publishing Limited)*, 7(4): 412-422.

Yongjian, K., ShouQing, W., Chan, A. P. C., et al., 2009. Research Trend of Public-Private Partnership in Construction Journals. *Journal of Construction Engineering &Management*, 135(10): 1076-1086.

City Branding with Sustainable Development Approach in Yogyakarta toward Economic Growth

Septiono Eko Bawono and Habib Abdillah Nurusman

Magister Teknik Sistem FT, UGM and Master of Urban Engineering of Civil Engineering of Minho University

septiono_78@yahoo.com and habibnurusman@yahoo.com

Abstract

Yogyakarta deeds great effort in terms of sustainable development. At least, it gained 21 achievements during 2008-2010 nationally. The city shows productivities in GRDP income that has a trend in tremendous values. It is shown that the city through an enlightened management, it offers services to ensure a balanced economic, social, political and environmental development. Thus, criteria would indicate its 'sustainability' and quality of life. It has prepared to improve the speed, efficiency and effectiveness with which they achieve a better image. They prioritized good governance development to carry out those on the local level, a close cooperation between decision-makers and society. An infrastructure improvement, social intervention and real sector encouragement drive high value of productivity. Its good economic growth contributes to social welfare encouragement and concerns to environment protection. This means the city's stakeholders improved the city managements and made a more attractive city to live and to work.

Global Mega Trend becomes a new trend in city development. The economic era drives the city development, which Yogyakarta indicates as an Authentic City. Emphasizing sustainable development approach, strategic planning, city branding and creative city obtain the city's distinctiveness. The city vitals indicators that consist of four success dimensions figure out the Yogyakarta distinctiveness is the most valued dimension than talent, innovative, and connected dimension.

Assessing the city vitals indicators and Yogyakarta's great effort, the research is documented throughout this paper. The paper structure is introduction, theoretical framework, research methodology, analysis and synthesis and conclusion and recommendation. The factual analysis identifies the existing of the city and selected cities branding process. The aligned SWOT analysis identifies competitive advantages, defensive capacities, reorientation needs and vulnerabilities of the city. And the synthesis synthesizes huge possibilities of the city's action program. As Yogyakarta has shown, the city is on the way of branding process. However, it still needs incorporating the action programs totally. As far Yogyakarta on the way of branding process, it has not accomplished the first level and the second level of city's brand communication yet. Based on city's brand communication strategy, this research proposes a territorial strategy, infrastructure improvement, organizational structure and behavior for Yogyakarta especially. The city's brand strategy could be implemented to other developing cities in the future.

Keywords: City Branding, Sustainable Development Approach, Economic Growth, Yogyakarta

1. Introduction

Does the city need city's brand? In worldwide context, nowadays, city in each country faces global competition. What kind of competition? The cities whole the world prepares and competes to be the best. The best categorized by several criteria such as economic improvement, social and environmental awareness. This approach will place the city in well recognized or unwell recognized in the world.

Well known position will have great opportunity to gain benefits of globalization. Those cities will have an opportunity to increase economic development that will influence the social and environmental improvement. Mercer Consulting (2011) states that Vienna is the world best livable city in 2010. It is exist and become one of the most popular cities in the world. This global image gives a good known position for the city. There are several opportunities could be adopted that appropriate with sustainable development approaches.

According to Yogyakarta in Figures 2011, Gross Regional Domestic Product (GRDP) of Yogyakarta City current price and 2000 constant price were US $ 1.3 billion and US $ 0.6 billion, are respectively. Tertiary sector played an important role on GRDP formation. It covered Trade, Hotel, and Restaurant Sector; Transportation and Communication Sector; Finance, Rent of Building and Business Services Sector and Services Sector. The contribution of this tertiary sector to GRDP was more than 75 percent. In 2008, economic growth of Yogyakarta City reached 5.12 percent. This figure was higher than that in 2007, which reached 4.46 percent and it was the highest. It is 4.98 in 2011. The economic growth was mainly supported by the growth of Trade, Hotel, and Restaurant sector, and Transportation and Communication sector. These sectors were backbones of economy of Yogyakarta. Since 2005, each sector increase, in general economic growth in Yogyakarta increases also that are indicated by the increasing value. It indicates that the city is growing up.

This research will define strategic planning development of success cities in developed countries and emerging countries around the world in order to find the appropriate model for city development. It will speed up the development program in Yogyakarta as a developing city in Indonesia.

2. Theoretical Framework

The need for economic growth is of paramount concern to policy makers around the world (Zerrillo & Thomas, 2007). They mentioned that developing nation often faces a series of economic hurdles in route to developed status. Steinberg (2007) showed the city should be enlightened management, the kind of services the city offers to ensure a balanced economic, social, political and environmental. Thus, criteria would indicate its social, economic and environmental 'sustainability' and quality of life. This means to improve the city managements and to make a more attractive city to live and to work. Law (2007) indicated that globalization has intensified competition between cities and exposed them to the global community. Internationally, many governments increase their visibility by joining transnational organization. Domestically, despite the different strategies, both world cities and aspiring candidates try to make themselves globally competitive by improving their infrastructure and policy to facilitate the flow of people, services, capital and information, and by providing wide range of additional services such as better transportation, a comfortable living environment and leisure and entertainment facilities (Bird, 2005 in Law, 2007). Anholt (2008) introduced competitive identity to address the policy change from the city. There are certainly policy approaches that enable places to improve the speed, efficiency and effectiveness with which they achieve a better image.

This theoretical framework will indicate the correlation of sustainable development concept, strategic planning approach, city branding implementation and the creative city actualization.

2.1. Sustainable Development

Sustainable Development deals with three pillars: economic, social and environmental. Nowadays, this is the way to reach people welfare and to reduce the poverty. According to Brundtland Report 1987, *"Sustainable development is development that meets the needs at the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:*

1. *The concept of needs, in particular, the essential needs of the world's poor, to which overriding priority should be given; and*
2. *The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."*[1]

Based on those development concepts, every country around the world tries to implement the concept. Even though, they face many problems and consequences. No exception, developing countries such as Indonesia. This is a way being part of globalization.

Madlener & Yasin Sunak (2011) mention that there are three contexts to realize sustainability in developing countries: a global context, the national level and the local level. The local level figure out a close cooperation between decision-makers and society is crucial. Urban agents, such as neighborhood communities, NGOs, religious groups, or self-help organizations, have to be included within the decision process.

2.2. Strategic Planning

To implement the sustainable development concept is not easy. Except the program itself, the success key of implementation is the agents and closed system. Both, still there is a gap, that is a way to implement the program. The bridge is called a strategy. At the beginning, strategy is used in military as a way to win a war such as Sun Tzu strategy. This term is adopted by business area to manage the program and activities. The agent who do the strategy is a corporate. More pro-active, the corporate strengthens strategic action as a strategic planning. Success implemented by the corporate, nowadays, strategic planning is adopted by public sector areas. It is practiced widely formally and informally. Strategic planning and decision processes should end with objectives and a roadmap of ways to achieve them. So, to implement sustainable development, derive strategic planning to achieve the main goals.

As we know, a corporate derives strategic planning to a marketing activity, territorial planning sector also. To win the competition, marketing activities is a way to promote the success. In a territorial planning sector, the marketing action used to leverage the stake holder. In business, known Ansoff dimension to describe market need, product/service technology and market geography. For a corporate, it is helpful to route to reach their objectives. This is one kind of strategy planning. As implementation in territorial planning, market geography is very important. Nowadays, every territorial wants to be linked in the global network. It’s mean that the territorial position wants to be accessed easily.

One of the success key of the Alliance is a decision to emphasize City Development Strategies (CDS) in development (Mukhija, 2006). The CDS through comprehensive action plans focused on improved urban governance,

---

[1] www.iisd.org, downloaded on 1 October 2011

fiscal responsibility and the establishment of clear priorities for action and investments. The development strategies are to be based on an assessment of each cities economic growth prospects and are aimed at enhancing its competitiveness. For example, Shanghai in the early 1990s, the state decided to speed up the development of Shanghai with the strategy of making ‘‘one dragon head and three centres’’: developing Pudong, which was a leading place in economic development east of the Huangpu river; and opening up areas in Yangtze River Delta Region, which is now a vast hinterland of support for Shanghai; and Shanghai as the international centre of three major areas-economic, financial, and trading and transportation (Law, 2007). Nowadays, Shanghai is one of the emerging cities around the world.

2.3. City Branding

A corporate promotes and keeps the success of their product by branding image. For example, Coca Cola is well known for soft drink product. In the beginning, Coca Cola is produced in small town in US. Now, we can find Coca Cola in entire the world. Learning from this success, territorial planning adopts the branding image for the places and the cities. The concept of destination branding is critical for a destination to be identified and differentiated from alternatives in the minds of the target market (Qu, Kim, & Im, 2011).

As globalization intensifies, places increasingly compete with other places for attention, influence, markets, investments, businesses, visitors, residents, talent and events. And competition is no longer restricted to the familiar places on the road, over the hill or across the water. Places now compete with cities, regions and countries halfway around the world. Places are increasingly getting caught off guard by unexpected and seemingly sudden shifts in competition and abruptly lose their historic purpose or their competitive edge, be it economic, social or cultural.[2]

Mendes (2012) shows Global Mega Trend becomes a new trend in city development. Latest development all over the world shows this trend. New economic development paradigm moves physical development paradigm. He proposes five characters of the city such as: Smart City, Innovative City, Connected City, Sustainable City, and Authentic City. They are identified as city identity based on their competences. The city identity will ease to develop brand innovation. He believes that the strengthening of small and medium cities only will create sufficient critical mass to keep alive these spaces in terms of global financial crises.

To define the brand of the city, Cortright (2007) offered city vitals concept as an analysis model. City vitals consists of four dimensions of success. The first dimension is talented city, which is the indispensable asset in a knowledge economy is smart people. The indicators are: college attainment; creative professionals; young & restless; traded sector talent and international talent. The second dimension is innovative city, which is the ability to generate new ideas and to turn those ideas into reality is a critical source of competitive advantage not just for businesses, but for regions, as well. The indicators are: patents; venture capital; self-employment and small businesses. The third dimension is connected city, which is cities thrive as places where people can easily interact and connect. The indicators are: voting; community involvement; economic integration; transit

[2]Summarized from www.placebrands.net, downloaded on 10 September 2011

use; international students; foreign travel and internet connectivity. And the fourth dimension is distinctive city, which is the unique characteristics of place may be the only truly defensible source of competitive advantage for regions. And the indicators are: weirdness index; culture/cable ratio; restaurant variety and movie variety. Those indicators will define the city's identity and will drive the city's brand.

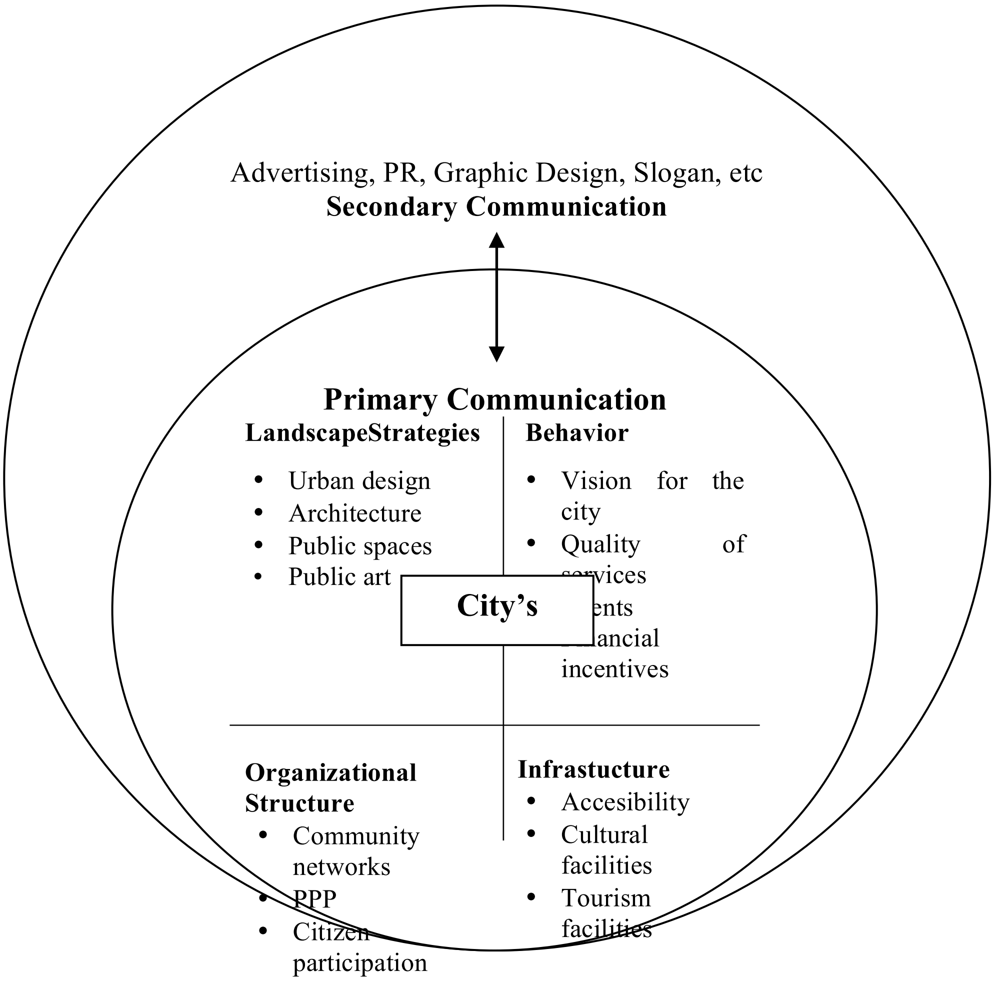


Figure 1. City's brand communication (Source: Kavaratzis (2004) in Kavaratzis & Ashworth, 2007)

Place marketing has been established as a philosophy of place management and a function complementary to planning (Kavaratzis (2004) in Kavaratzis & Ashworth, 2007). He explained within the context of place marketing and in pursuit of wider place management goals, places throughout the world are shifting the focus towards place branding and are increasingly importing the concept and techniques of product and corporate branding. He proposed the brand communication model that shown in figure 1. This scheme develops the strategy to communicate city's brand. The primary communication is based on local action. The primary level city's brand consists of four components; they are: landscape strategies, behavior, organizational structure and infrastructure. The second one is implemented by advertising, PR, graphic design, slogan, etc. The first level represents the territorial identity and core competency and the second one will boost them. Simultaneously, both will create a good image. It will be strong value in creating city's brand. It is in line with Zukin's perspective (2002) in Kavaratzis, 2005 "City branding is a cultural strategy of an entrepreneurial city trying to re-imagine a collective identity."

Anholt (2008) preferred to call the word 'brand' with competitive identity. His opinion, 'branding' is not about communication but about policy change. Anholt added that policies should not alone. Substance must be coupled with strategy and frequent symbolic actions if it is to result in an enhanced reputation.

2.4. Creative City

"We welcome the economic role of cities and towns in our globalizing world, and the progress made in forging public-private partnerships and strengthening small enterprises and micro-enterprises. Cities and towns hold the potential to maximise the benefits and to offset the negative consequences of globalization. Well-managed cities can provide an economic environment capable of generating employment opportunities, as well as offering a diversity of goods and services."[3]

City-marketing and place-branding strategies today often stress ideas and stereotypes of culture and creativity to promote attractive urban images (Vanolo, 2008). It is that creativity has become a major keyword in city-planning and urban-marketing policies around the world. In its simplest formulation, the main idea is that capitalist development today has moved to a new distinctive phase, in which the driving force of the economy is not simply technological or organizational, but human. Hannigan (2003) said that the contemporary city had become a prime site for consumption-related activities related to tourism, sports, culture and entertainment. Whereas factory towns were once at the forefront of national economies, now they are almost uniformly on the decline, a victim of changing production patterns, most notably, the flight of manufacturing industries to lower cost, offshore locations. Finally, branded environments provide a point of identification for consumers in an increasingly crowded marketplace. Branding, of course, is scarcely novel, either for cities ('Rome the Eternal City'; 'Paris the City of Lights') or for tourist destinations (Hannigan, 2003).

2.5. Research Methodology

2.5.1. Data Collection

This research encourages both qualitative and quantitative approaches. The primary data are such as deep interviews and field survey and secondary data are such as cities development plan documents of selected cities and statistical data will accomplish those approaches.

a. Deep Interview

Deep interview to key persons defines the city core competences. The key persons are groups of respondents of academics, businessmen and governments. They represent expert at the city development stakeholders of Yogyakarta. Five people are set for each group respondent. Twelve deep interviews were conducted (see appendix 1). It was done within semi-structure interview and recorded through digital recorder. Each respondent is interviewed about 60 minute. The structure of the deep interviews consists of continuity of the previous brand 'Jogja never

[3]United Nations Declaration on Cities and Other Human Settlements in the New Millenium (A/RES/S-25/2 of 9 June 2001), para 11, *portal.unesco.org/.../11055395211Creative_Citie...* downloaded on 27 December 2011

ending Asia', city's identity, city strengths and weaknesses and city brand development strategy.

b. Cities development plan documents resumes of selected cities
Secondary data such as selected cities development plan documents. The selected cities of developed countries are: New York, London, Tokyo, Hong Kong, and Singapore. The selected cities of emerging countries are: Shanghai, Rio de Janeiro and Mumbai. The selected cities of developing countries are: Bangkok and Kuala Lumpur. The data consists of two kinds of information. First, current issues such as urban growth, infrastructure, global economy and climate change as background knowledge. Second, city development plan documents that state the city's vision and the action program.

c. Yogyakarta's territorial identity
Secondary data such as Yogyakarta city development plan documents. The data consists of two kinds of information. First, current issues such as urban growth, infrastructure, global economy and climate change as background knowledge. Second, city development plan documents that state city's vision and the action program. The statistical data is acquired to accomplish the secondary data. Territorial mapping is used to visualize those information.

2.5.2. Data Analysis

a. Factual Analysis
Factual analysis is done to identify the field fact. The procedure involved in the factual analysis is the listing of every fact presented to the data and the analysis to the facts to describe them. One of the discoveries in the factual analysis is that a large number of facts can be classified as background information, which is previously known as the research. In this research, this is done to analysis city development plan documents and territorial data of primary and secondary data.

b. Aligned SWOT Analysis
SWOT analysis is a common tool to be used in organizational and strategic planning (Ramos, 2011). Here, the basic principle of a SWOT analysis is that organizations/territories must align internal activities with external realities. Usually, the traditional approach uses a simple 2 by 2 matrix as a starting point; the first two factors (Strengths and Weaknesses) are internal and involve specific organizational issues (positive and negative); the second groups include Opportunities and Threats and are related to external influence on the organization/territories environment, being again both positive and negative.
Fonseca & Ramos (2008) developed an aligned SWOT analysis to diagnose the tourism sector in the Portuguese municipality of Almeida, in order to guide a plan of development. The aligned SWOT analysis is developed to bridge internal factors and external influences. It eliminates the focus on the internal factors that are usually emphasized by the traditional analysis, the articulation of internal and external elements gives a more clearly framework faced by a specific organization or territory. The alignment of both factors improves the strategy, and the plans adopted.

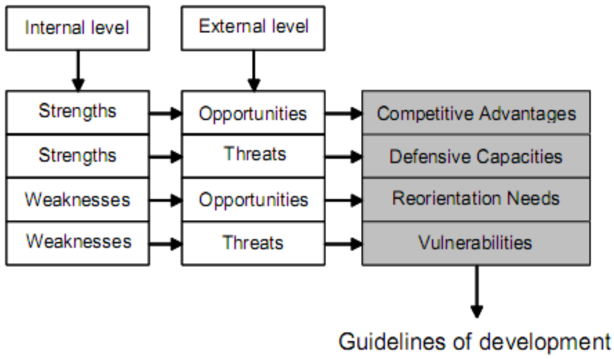


Figure 2. Aligned SWOT Analysis (source: Fonseca and Ramos, 2008)

The four main aligned are:

- Competitive Advantages (strengths/opportunities);
- Defensive Capacities (strengths/threats);
- Reorientation Needs (weaknesses/opportunities);
- Vulnerabilities (weaknesses/threats).

This research implements city vitals approach (Cortright, 2007). Based on the aligned analysis above, it asses four dimensions of success of city vitals. It is as evaluation criteria.

2.5.3. Synthesis

The synthesis is used to generate a strategic planning from the precedence. The precedence of current issues such as urban growth, infrastructure, global economy and climate change are good references to compare with existing condition in Yogyakarta. The city development plan documents that state the city's vision and the action program of housing and neighborhood improvement, brown field improvement, water supply improvement, transportation improvement, energy supply improvement, air quality improvement, solid waste improvement and climate change improvement are their action programs to improve their city's environment. Simultaneously, the current issues and city development plan documents contribute to synthesize a strategic model for Yogyakarta.

2.6. Possibility of adoption

How Vienna, New York and London are still existed with their 'the best city in the world'? It is a big question. The key success is in their consistency to keep the stake holders in a success environment. How Hong Kong, Singapore, Tokyo becomes one of the 'emerging cities in the world'? The success key is in their effort work hard to realize their goals. How Kuala Lumpur is in success progress to become 'the best city in the world in 2020'? The success key is in their ability to adopt the success of others countries such as Japan, China and Korea.

Learning from other cities success, there are a lot of possibilities of success. Adoption mechanism will be the simplest way to achieve the success. Such as sister cities and Mumbai's benchmarking, it is a way to adopt a city's success for other cities in their own linkage and city networking.

3. Analysis and Synthesis

Based on RPJP 2005-2025 and RPJM 2007-2011 city development vision is 'Yogyakarta as city of high quality education, tourism base on culture and center of services sound environmentally'. The implementation is written on city development missions, they are:

1. Strengthening the city image as education city;
2. Strengthening the city image as tourism city, cultural city and struggle city;
3. Realizing high city competitiveness in services;
4. Realizing the city's livable and sound environmentally;
5. Realizing good citizen;
6. Realizing good government and clean government;
7. Realizing city's secure and peace;
8. Realizing the high quality of infrastructure; and
9. Realizing the health city.

Realizing the city development's vision and mission, Municipality carried out them in action programs. They are improved in thematic strategic yearly. In five years mid-term development, they are:

1. Rehabilitation and reconstruction of infrastructures of settlement, city, public services and people economic activity's development in 2007.
2. The city of tourism base on the cultural and tourism attractions in 2008.
3. City of education with valued human resources in 2009.
4. Healthy and livable city with satisfy public services in 2010.
5. Good city with low air pollution in 2011.

Due to the action programs implementation, the city achieved good people-perception. Several achievements are as shown in Appendix 2.

In the last 2010 the Mayor launched 'Segoro Amarto'. The program focuses on human resources development. It deals with the poverty alleviation. It implemented kampongs as a base of action. This pilot project emphasized three kampongs improvement. It conducted to people empowerment. The people mean the people who live there. They have their own role. It does not wait for an investor. Investors are everyone does investment. Investment should not be large, so many small investments are much better. He had to strengthen the small-middle investment. He had to back up the entrepreneurship spirit.

The research does factual analysis and SWOT analysis. It will be strengthened by aligned SWOT analysis and be constructed by synthesis. The factual and SWOT analysis will assess city vitals indicators as follows:

3.1. Talent dimension

The first success dimension is talented city, which is the indispensable asset in a knowledge economy is smart people. This success dimension will emphasize the college attainment as the potential of Yogyakarta city.

Yogyakarta is known as a City of Education. Balai Perguruan Tinggi Gadjah Mada is the first university in Yogyakarta. It was established on 17 February 1946. That time was Indonesian national struggle situation. At the beginning, the university did not have building for lectures. Sultan Hamengkubuwono IX offered some spaces for the lectures at Pagelaran Kraton (Yogyakarta Palace) for the first time. It is called BPT Gadjah Mada. It offered three faculties: faculty of education, faculty of law and faculty of veterinary. The

BPT was attracting students all over Indonesia. They were interested to study in Yogyakarta. They lived in the city during studied at the BPT. Then they went back to their original region, after finishing the study. BPT Gadjah Mada was named Gadjah Mada University in 1949. It held lectures in the north part of the city after national government built the university complex in the same year. It offers 18 faculties. Since this period, a lot of students come to Yogyakarta, and then they become policy makers in regions all over Indonesia.

Until now, candidate students from all over Indonesia are interested to study at Yogyakarta. Yogyakarta has played a role in national education in Indonesia. This strengthened the role the city of Yogyakarta on education historically. The huge numbers of students in 70 private colleges in Yogyakarta City indicate this position. They comprised eight universities, 25 institutes and 37 academies. Number of lecturers was 2,547, consisting of 343 foundation lecturers and 2,204 state lecturers. Number of students registered was 57,338 students (Yogyakarta in Figures 2011)[4]. Yogyakarta has good-quality universities (Riyadi and Ristyawati)[5]. Exclude those private colleges; Gadjah Mada University, Yogyakarta State University, Sunan Kalijogo Islamic State University and Indonesian Institute of Art are state-universities in Yogyakarta. Nearby the city, there are 124 universities and colleges totally. Those colleges provide a variety of sciences, including social sciences and culture, economics and engineering. Students from all over Indonesia come to Yogyakarta to study (Riyadi)[6]. That is the city's appeal.

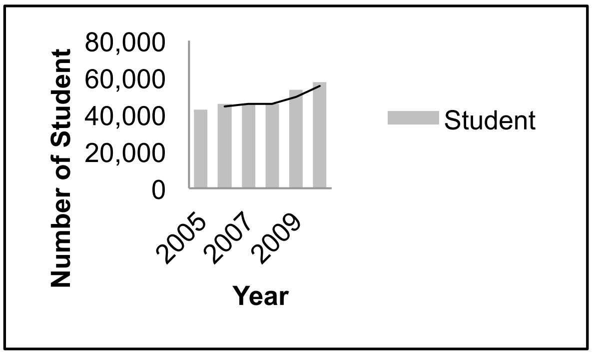


Figure 3. The increasing number of students in Yogyakarta in 2005-2010 (Source: Author Analysis)

Foreign students also come to Yogyakarta with the student exchange programs. The numbers of foreign students of several colleges increase yearly. They study in Yogyakarta with scholarship of national or international foundation. The Indonesian Ministerial of Education offers Dharmasiswa Scholarship to students all over the world to study in Indonesia. Figure 3 shows the increasing number of students in Yogyakarta.

Creating good atmosphere for education; thus produced skilful workers and creative professionals. According to RPJM 2009[7], numbers of workers in Yogyakarta are 173,483 in 2005. They are 90,273 (52.01%) in services sector,

[4] Yogyakarta in Figure 2011 is realesed by BPS of Yogyakarta
[5] Interview record
[6] Interview record
[7]Medium Term Development Plan released by City Mayor

48,280 (27.94%) in trade sector and the rest in others. Both sectors spread in various creative industries of small and middle enterprises.

SWOT analysis to identify the strength and weakness of internal aspect and the opportunity and threat of the environment. Here is the SWOT analysis of talent dimension of Yogyakarta city as follows:

Table 3. SWOT analysis talent dimension (source: author's analysis)

Strength	Weakness	Opportunity	Threats
1. College attainment increase. 2. Numbers of creative professionals increase.	1. Numbers of creative professionals are less than the need. 2. International talent is a small numbers. 3. Percentage of college attainments is less than total students. 4. There is no traded professional.	1. Dharmasiswa scholarship and other international scholarship increase student exchange. 2. There is brain circulation if creative professionals are accommodated. 3. There is possibility learning from foreign creative talent.	1. Information about universities and colleges in Yogyakarta is not much. 2. There is respect gap between original creative talent and foreign creative talent.

3.2. Innovative dimension

The second dimension is innovative city, which is the ability to generate new ideas and to turn those ideas into reality is a critical source of competitive advantage not just for businesses, but for regions, as well. This analysis will emphasize venture capital and small business actualization.

President of Indonesian Republic reshuffled the Cabinet at last 2011. He renewed the Cultural and Tourism Department with Tourism and Creative Economy Department. Culture and tourism are one integrated aspect, and the tourism creates multiplier effect for the creative industry. Last several years, creative industry drives the economic activities for several sectors. The innovation is based on fact that creative industries support the national income. The previous Depperindagkoptan paid attention to this sector. During the ministerial of 2011, they promoted creative economy from national level to the local level. They promoted creative cities to realize the creative economy in realistic action. There is a pilot project of creative city launched by the Depperindagkoptan. At the beginning, the pilot projects of creative city are three cities; Bandung, Yogyakarta and Bali (Budiman)[8].

The Mayor of Yogyakarta is a democratic figure; he established clean governance. In the period he was elected, it was transition era from 'orde baru' to 'reformasi', 'centralize' to 'autonomy'. His main focus was bureaucracy consolidation; first, 'desakralisasi' bureaucracy in which bureaucracy was not

[8]Interview record

sacred. “I preferred to call I myself the chief of servants," Zudianto said[9]. He was not the center of power but servant. He had to change the paradigm. The government had to serve the people, facilitated the service and prioritized the achievement. Those are the important issues; when he prioritized the achievement, he had to have objectives. So, there were no political interventions in a performance appraisal. He separated the politic orientation and the bureaucracy.

Creating a good atmosphere in Yogyakarta, several achievements were gained the city as shown on appendix 2. Good atmosphere in Yogyakarta is good for education, tourism and service activities. Except attracting the tourist, it attracts the trader and investor (Fauzi and Kurniawan)[10]. The mayor has developed the system. So, who is the next mayor it does not matter. In licensing, they have the good way (Widyatmoko)[11]. “When I make a business license, I enter the office and imagine the difficulties. What I get there? It is very easy and simple. No payment. That is one of his achievements. It is wonderful. Those are the points which should be joined. The follow-up is creating a campaign for imaging the city," Fauzi[12] said. It contributes the opportunity to establish new enterprises (include micro, small and medium enterprises). The good atmosphere attracts the local investor, mainly. Table 4 shows the investment for venture capital of the business sector. It shows the investment increases yearly. Those appearances push the economic activities within the city (see appendix 2).

In Yogyakarta, creative industries are dominated by the small and middle enterprises activities. Table 4 shows the numbers of small and middle enterprises. They increase yearly. The Municipality developed the synergy with small and middle enterprises actors. The Mayor initiated to strengthen the role of small enterprises in economic activities. On 2008, he initiated a Bidang UMKM in Disperindagkoptan in the municipality. The board’s job descriptions are facilitating, coaching, mentoring; there are bimtek (bimbingan teknis-technical guidance) and workshop (Widyatmoko)[13] for small enterprises development. At the first time, they identify the small and middle enterprises in Yogyakarta. They made the small and middle enterprise database. There are about 17,000 businesses such as micro, small and middle enterprises. They are dominated by micro enterprises; it is about 60% (Sugeng)[14]. The micro enterprises produce for local; the small ones produce for another province also and the middle produce for export. To support them, they held several events such as exhibitions to promote the product and widen the marketing network.

---

[9]Interview record
[10] Interview record
[11] Interview record
[12] Interview record
[13] Interview record
[14] Interview record

Table 4. The numbers of small and middle enterprises and venture capital (source: BPS, Yogyakarta in Figures 2006-2007 and 2009, ILPPD 2011)

Year	Number of Small and Middle Enterprise	Venture capital
2003	5,785	16,243,114
2004	5,814	16,498,532
2005	5,854	16,870,445
2006	N/A	N/A
2007	5,861	30,351,800
2008	5,950	31,600,000
2009	17,697	20,938,268
2010	22,091	71,869,930

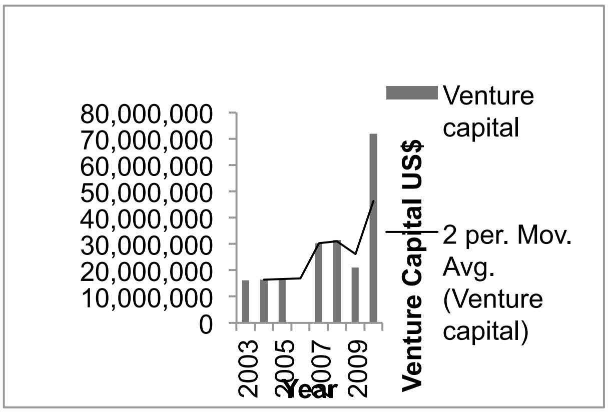


Figure 4. The numbers of venture capital in 2003-2010

In 2009 and 2010, the number of small and middle enterprises increase rapidly. Figure 5 shows the increasing of the number of small enterprises in 2003-2010. The figure also shows the growth of small enterprises number in the last two years. It is the impact of municipality policy in easing new businesses establishment. At the beginning of 2009, the city mayor released Mayor Decision on licensing; the people preferred established small enterprises industries. According to figure 4 and figure 5 the investment values of small enterprises were increasing significant since 2003. Even the number of small and medium enterprises increased, the venture capital decreased in 2009. It was caused by the people investment and private sector protected their capital related to global finance crises. The venture capitals that are invested made the economic works. Various creative industries appear in Yogyakarta that the product value of investment produced a benefit. They influence a lot of kinds of sectors such as trade and service; they create culinary, craft, many kinds of craft; wood and iron. For example, the municipality has UPT for iron craft. They produce house wares and wheels for car and motorcycle.

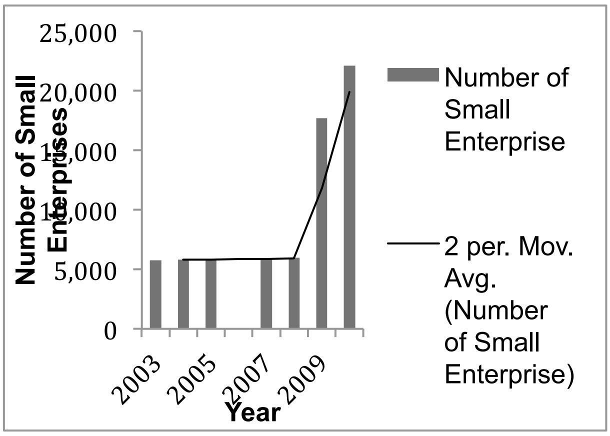


Figure 5. The increasing of the number of small enterprises in 2003-2010 (source: author's analysis)

The numbers of small and middle enterprises were 5,814 with 30,143 employees (2004); 5,854 with 30,516 employees (2005); and 5,848 with 30,486 employees (2006) (Yogyakarta in Figures 2006-2007)[15]. In 2008, the number of small and middle enterprises were 5,950 units with 31,600 employees; the number of establishment increased to 1.50 percent from that in 2007 (Yogyakarta in Figures 2009). Number of employees increased to 4.39 percent respectively.

SWOT analysis to identify the strength and weakness of internal aspect and the opportunity and threat of the environment. Here is the SWOT analysis of innovative dimension of Yogyakarta city as below.

Table 6. SWOT analysis innovative dimension (source: author analysis)

Strength	Weakness	Opportunity	Threats
1. Huge number of small enterprises. 2. Good atmosphere for doing business. 3. Political will of the government in creative industries development.	1. Patent is unpopular yet. 2. A few foreign direct investments. 3. The small business actors are lack of management and marketing. 4. The human resources are lack of skill.	1. Creating job opportunities. 2. Facilitating the small enterprises in cooperation with banks in capital cost. 3. Hold partnership meeting between UMKM and BUMN they have CSR program. 4. Foreign venture capital rising. 5. Increasing export commodities to other countries. 6. Competing in world free trade.	1. International standardization of product. 2. Global economic crises.

15 Released by BPS of Yogyakarta

3.3. Connected dimension

The third dimension is connected city, which is cities thrive as places where people can easily interact and connect. This analysis will emphasize economic integration and foreign travel.

Yogyakarta city is located at the center of DI Yogyakarta Province (Figure 6). Besides Yogyakarta city, there are four other regions surrounding it. They are Sleman regency, Bantul regency Kulon Progo regency and Gunungkidul regency. In regional context, DI Yogyakarta located at the middle of Java Island. Yogyakarta is in strategic position in both regency and regional context. This geographic position is strategic geographically; Yogyakarta is as a hub, it makes the city settle (Rustyaningsih)[16]. In economic activities, the city provides facilities and accommodation. They are facilities and accommodation for education, tourism and services.

City development focuses on education, tourism and services. In the city master plan, a convention center has been proposed that it will be joint financed by the Municipality, the province government and the private sector. Municipality prepares XT-Square for art and craft market. This facility accommodates local trading. They rehabilitated traditional market also. Yogyakarta is second after Bali, nationally. Internationally, it accommodates the tourist from Bali. Yogyakarta is as additional destination. The airport is accessed from Singapore and Kuala Lumpur directly. The potential tourists for future are Asian such as China, Korean and Japan. They are growing up; it should be a target. Both domestic tourist and foreign tourist visits Yogyakarta increase (figure 7).

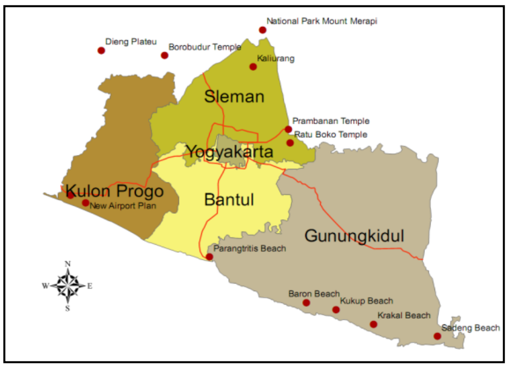


Figure 6. Yogyakarta province and touris destination

[16]Interview record

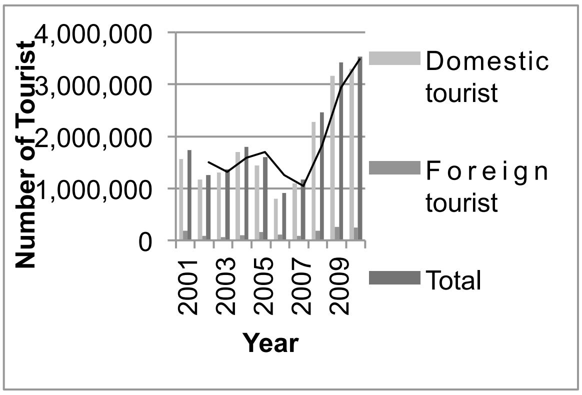


Figure 7. The increasing of the tourist in Yogyakarta

Tourism is the most important; the second is education, in education term (it is about education support) (Zudianto)[17]. The visitors are from Asia and Europe; the most tourists are Japanese (Rustiyaningsih)[18].

Before the continuous promotion, it needs to target precisely the right target. Is the target market Yogyakarta fitted? It should be studied first of market analysis. Who are the potential markets of Yogyakarta city? It had recently viewed? Take a look at some other countries, despite vigorous promotion continued sustainable market is wrong; it would be useless. The problem is how to calculate the index repeaters, calculating it is not easy. Yogyakarta has not done it (Nuryanti)[19].

SWOT analysis to identify the strength and weakness of internal aspect and the opportunity and threat of the environment. Here is the SWOT analysis of connected dimension of Yogyakarta city as follows:

Table 7. SWOT analysis connected dimension (source: author analysis)

Strength	Weakness	Opportunity	Threats
1. People involvement is high 2. There is community involvement. 3. Strategic location as hub in local, regional and national context. 4. There are good facilities and accommodation. 5. There are internet	1. There is inconvenience in infrastructure provision such as public transport and international direct flight to and from the city. 2. There are a few foreign students. 3. There are a small numbers	1. International network and cooperation. 2. Attracting foreign tourist in Bali. 3. Attracting international students.	1. International qualification in education and tourism.

[17]Interview record
[18] Interview record
[19] Interview record

connectivity's.	of foreign tourists.	

3.4. Distinctive dimension

The fourth dimension is distinctive city, which are the unique characteristics of place may be the only truly defensible source of competitive advantage for regions. This analysis will emphasize the culture/cable ratio.

Tourism sector is developed in Yogyakarta city. It based on culture (Rustyaningsih)[20]. Yogyakarta is a special region. 'Yogyakarta Sultanate was established on 13 February 1775 by Sri Sultan Hamengkubuwono I. Prince Mangkubumi proclaimed himself as the king of Yogyakarta Hadiningrat with royal title 'Sultan'. … As a center of culture and art, Yogyakarta provides vast access into Javanesse culture for a visitor through its rich traditions of art performance and ritual ceremonies.'[21]

Adrisijanti (2000) described Yogyakarta as one of the ancient cities in Indonesia that are still alive, even the increasingly growing, both in terms of community life as well as spatial terms. At the time of its establishment, the city of Yogyakarta serves as city government center Ngayogyakarta Sultanate, which lasted continued until 17 August 1945. As written in the historical record, the time that the Republic of Indonesia was proclaimed, and followed a statement of Sultan Hamengkubuwono IX to unite themselves with the state the newly established. Then the city of Yogyakarta, while changing the status of the city the central imperial government became the capital of the Republic of Indonesia, and the center Indonesian revolution. After it became capital of the province of Yogyakarta Special Region Yogyakarta, and is widely known as a city of higher education as well as one of the central Javanese cultures. According to ILLD 2011, rehabilitation and development on works, art and culture have been done. They are 125 works of art and culture, 594 groups of works of art and culture and 437 heritage buildings.

As the former capital and the center of several kingdoms in the past, Yogyakarta and its people are very rich in a variety of cultures. Yogyakarta is a tourism capital of culture and nature (Saraswati)[22]. Since it was established, the cultural heritages from the past are still shown such as the magnificent temple, the ruins of palace and monasteries, the various king of traditional ritual ceremonies, customs, traditional handicraft, architecture, and many other traditional activities. The city has been known as the center of Javanese culture by the existence of Sultan Palace, until now.

Long time before the coming influence of Indian culture, the Javanese culture had skills or knowledge, which includes 10 items (Brandes, 1889 in Novianto, 2011)[23]. Further, Novianto said the cosmology palace of Jogjakarta is inseparable from Javanese world view. Javanese society thinks about Javanese cosmology through 'pepangkataning dumadi' called Tribuwana, consisting of Guru Loka (baitul makmur), Endra loka (baitul muharam), and Jana Loka (baitul muqadas). Guru Loka in position is represented by the Mount Merapi. Mountain

[20]Interview record

[21] Summarized from Jogja at Glance by BP2KY

[22]Interview record

[23]http://senidanbudayajawayogyakarta.blogspot.com/2011/02/seni-dan-budaya-jawa-yogyakarta.html, downloaded on 31 January 2012

located north (lor, major), sublime. Middle position is Endra Loka. Endra means king. King's life is nothing but the heart (true feeling). The Jana Loka is a picture of subjects, low, and down. Third-cosmic realm of philosophy it is positioned as a central palace. The cosmology influences people surrounding the city, almost entire Java Island. The three cosmologies were implemented on city spatial. It existence still can be seen, which is the city is composed the Kraton (palace), Alun-alun (square), Masjid Agung (mosque), and Pasar Gedhe 'Beringharjo' (market).

The main attraction is the Palace and the economic growth of the city is Yogyakarta as a tourism hub. Yogyakarta is dominated by culture and tourism, so the informal sector is dominant. The development strategy is prioritizing on education, tourism and services (RPJP and RPJM)[24]. Appealing to the city, it is comfort; the Mayor is known as a visionary leader. The city plan has to be thought holistic. According to Mayor Decision no. 557, 2007 on tourism, the municipality prioritized several areas for tourism destinations are (Appendix 3): Kraton areas, Kotagede areas, Code areas, Malioboro areas, Dukuh areas, and Kotabaru areas. Almost all of city attractions are located there. Malioboro area is a long colorful bazaar of souvenir shops offering a wide collection of batik clothes and bags, leathers works, cotton clothes, puppets, masks and many others handicrafts. It is the most famous city attraction.

As known, kampongs are intangible heritages in Yogyakarta. The people living culture is interesting to the tourist. At the beginning, municipality proposed five kampongs to be tourism kampongs; one of the pioneers is kampong Dipowinatan. Periodically, foreign tourists visit the kampongs. They tried to enjoy the living culture there. It becomes cultural attraction. The tourism board program is developing the events and tourism kampongs now. Yogyakarta is promoting seven kampongs such as Pandeyan, Notoprajan, Suryatmajan, Brontokusuman, Tamansari, Prenggan, dan Sosromenduran as tourism kampongs also.[25] In kampong development, Yogyakarta could become a good example in the world. The city could not forget the kampongs. Otherwise, the kampongs could not forget the city. Whatever the city development should consider the phenomena both, in integrated way (Setiawan)[26].

Municipality promotes Yogyakarta heritages seriously. When the city suffered by Merapi eruption, they campaigned to attract the tourist. They promoted 'Ayo ke Jogja!' (Let's go to Jogja). Herry Zudianto is a person who does not know about brand. He is a leader, who has a good strategy in imaging Yogyakarta city. He is the mayor, who has a vision for the city. The best thing, he created a simple governmental mechanism (Fauzi)[27]. What the city need is creating the map of city personality. As a person what the city looks like. The new programs are rebranding the 'Jogja never ending Asia' (Budiman)[28]. There is a pilot project of creative city. It was launched by the Depperindagkoptan. Whereas, the blue print of creative economic was made by Depperindagkoptan in national level. The 'effort' for new brand is not great enough. The movement which has done, does not interest the decision maker. It has to be started. In national context, Yogyakarta is a leading in the tourism city after Bali.

---

[24] Yogyakarta's development plan documents

[25] http://nationalgeographic.co.id/berita/2012/02/7-kampung-wisata-siap-dikembangkan-di-tahun-2012, downloaded on 12 May 2012

[26] Interview record

[27] Interview record

[28] Interview record

Yogyakarta has been ready already but still need several improvements in tourism sites; street access, etc. (Riyadi)[29]. Actually, strong element what Yogyakarta has is diversity, the local value (local wisdom) and the royal family (Kurniawan)[30].

During his mayoral, Herry Zudianto proposed traditional market empowerment. Several traditional markets are Beringharjo market, Klithikan market, PASTY, etc. At the end of his mayoral, he developed XT-Square. This innovation is in order to improve the night economy in south part of the city. At the north, night economy is dominated by culinary and amusement. At the west, night economy is dominated by culinary and Klithikan market. At the east, night economy is dominated by culinary, cultural and commercial. At the center, night economy is dominated by culinary, cultural and commercial at around Malioboro and Beringharjo market. In Malioboro, daily activity start from 9.00 am-9.00 pm, afterward the long street changes into food market until early morning. Beringharjo is opened from 9.00 am-4.00 pm and serve since early morning. Those programs are in line with Nuryanti that she suggested diversification of products and intended to drive the night economy at Yogyakarta city.

SWOT analysis to identify the strength and weakness of internal aspect and the opportunity and threat of the environment. Here is the SWOT analysis of distinctive dimension of Yogyakarta city as follows:

Table 8. SWOT analysis distinctive dimension (source: author)

Strength	Weakness	Opportunity	Threats
1. The city has been known as a center of Javanese culture and heritage. 2. The people are rich in variety Javanese culture, heritage and craft. It is tangible and intangible asset. 3. There are production house' appearance. 4. There are original food restaurants and various new food stalls, bistro and restaurants.	1. Lack of innovation.	1. Integration tourism and creative economic activities.	1. Global competition.

Based on SWOT analysis above, they are described in aligned SWOT analysis as follows:

29 Interview record
30 Interview record

Table 9. Yogyakarta city competences and added values (source: author)

City Competences		**Added Value**	
Competitive Advantages (strengths/ opportunities)	Defensive Capacities (strengths/ threats)	Reorientation Needs (weaknesses/ opportunities)	Vulnerabilities (weaknesses/threats)
1. Huge number of students 2. Creative professional.	1. Traded sector. 2. International talent.	1. College attainments.	1. Standardization in legal, institutional and operational procedure.
3. Innovative new small enterprises. 4. Product diversification by small enterprises base on cultural and local richness. 5. Export potential commodities. 6. Creative city image.	3. International standard socialization.	2. Ease in financing for small enterprises. 3. Wide world interrelationship. 4. CSR for business. 5. Foreign investor.	2. Patent socialization and standardization.
7. The city's good atmosphere. 8. Internet connectivity to the people.	4. Global networking.	6. International direct flight. 7. Convenience infrastructures. 8. Tourism joint collaboration with Bali. 9. Foreign students and tourists.	3. Global economic crises.
9. Stakeholders' integration and involvement in city development. 10. Stakeholder	5. Javanese tangible and intangible culture.	10. Creative economy base on culture, heritage and craft.	4. National and international event such as Festival and Meeting,

participation in city economic development. 11. Authentic City Development.	Intensive, Convention and Exhibition (MICE).

The synthesis is based on competitive advantages and defensive capacities as city competences and reorientation needs and vulnerabilities as an added value. It emphasizes Yogyakarta as an “Authentic City." Globally, Yogyakarta is known as the center of Javanese culture. The city still needs to locate in the world map to improve it to be well known all over the world. It will attract more tourists, traveler and students. Nationally, Yogyakarta is main education destination and second tourism destination after Bali. Locally, business sectors are influenced by education and tourism. It proves that tourism and education brings multiplier effect for the city. The city has huge potential resources. On education, it has good talent and huge resources; on tourism, it has tangible and intangible resources; and on services, it has appropriate information and technology application, infrastructure and facilities.

The tourism and education effect creative industries growth. These creative industries are played role small enterprises that produce kinds of products. They drive the economic activities in the city. As previous analysis, several problems inhibit their productivities such as capital investment, human resources and marketing the product. It is right that they need worldwide connections; to invite the investor and to market the buyer and trader. Geographically, the city is good location locally, nationally and regionally, but it is not strategic in the global context. So, Shanghai gives good examples to provide Internet connectivity to the citizen. It is useful for the people all over the world to get a connection each other. It is global mega trend era where economic and information technology is a leader.

Appendix 4 shows the selected cities precedence. In development approach, Bangkok carries out good precedence. The positioning of ‘Venice in the east’ obtains strong identity for the city. In Thailand, they proposed one tampons (kampongs) one product as strong magnificent of the city. Due to Kuala Lumpur World Class City, developing cyber city is a good innovation. How Shanghai develops intelligent city? They served the residents with a good internet access. Singapore pioneers creating an efficient commercial centre. They are supported by high-tech harbor and advance city’s infrastructure. They propose the city as a home for the foreigner. New York with their great effort attracts the international talent also. Those will drive city economic activities. Tokyo proposed: Resolve the ‘negative legacy’ from the 20th century; Present a more functional and attractive Tokyo; and Make Tokyo a ‘beautiful and safe city’ to enhance Tokyo’s international profile, and leave this legacy to future generations. They tried to maintain their great history for the future. London in preparing the international sport game will give a good precedence how to maintain pre and post an international event. So does Rio de Janeiro with their yearly Festival. It is a way to maintain city’s promotion and marketing. Mumbai’s methodology followed an analysis through benchmarking studies of the peer cities (or emulate-worthy cities) and the learning from successful city transformations for laying down the aspirations of city development. Yogyakarta could precede them in a good way.

4. Conclusions and Recommendation

In terms of sustainable development, Yogyakarta does great effort. Several achievements show those efforts. It creates good city atmosphere for living and creating new business. The previous analysis' show the city productivities in GRDP income that shown on the city vitals indicators. Global Mega Trend becomes a new trend in city development. Yogyakarta is part of this globalization. The new economic era drives the city development. As Mendes (2012) proposal of five characters of the city, Yogyakarta indicates as an Authentic City. Within the proposal, he paid attention for the small and medium city development. Strengthening the proposal, researcher develops detail information of the current situation of Yogyakarta city. Then, doing analysis and synthesis concerns the city vitals indicators. It shows that concerning the local level improvement proposes national economic development contribution. This globalization implies the city in new economic development orientation. The economic growth shows valued number among the people of the city.

Developing this research, deep interview and city bench marking asses' city vitals indicators of the selected cities dig up detail information and the precedence. The aligned SWOT analysis that has done indicates huge possibilities of city's action program. Benchmarking to the selected-cities, relevant issues are formulated such as the neighborhood, infrastructure, global economy and climate change. Those issues tend to sustainable development process. Managing the issues in an action program and driving to the city's policy called branding strategic. As Yogyakarta done, the city is on the way of branding process. But, it still needs incorporating the action program totally. As far Yogyakarta on the way of branding process, they have not maintained the second level yet. In this scheme, researcher suggests territorial strategies, infrastructure, organizational structure and behavior for Yogyakarta. The city's brand scheme could be implemented at other developing cities in the future.

4.1. Proposal Structure

Based on Yogyakarta's core competency as an Authentic City, researcher proposes integrated actions program as shown on table 10. This proposal consists of two priorities; tourism destination priority and sub district priority development. Simultaneously, the proposal is encouraged by specific character of the city as its core competency. Emphasizing on two priorities will emerge each indicator. As far Yogyakarta on the way of branding process, the city has done the several action programs. It is formulated from the previous and existing success actions and combined with the proposal. According to previous benchmarking approach several actions are in line with selected-cities' action programs; it is such as Sego Segawe and public transport priority use BRT system. The Kampong Improvement Program should be enlarged to infrastructure improvement plus affordable housing provision. Moreover, national and international connectivity should be concerned either. The action plan is as follows:

1. Vision

   "Improving tourism based on Javanese culture"

2. Mission

The missions are:

Table 10. Mission of program proposal (source: author)

Tourism Destination Priority	Sub District Priority
1. Good governance 2. Private sector participation 3. Foreign students, tourists traders and investors participation 4. Cultural asset maintenance 5. Heritage and natural sites rehabilitation 6. City attraction improvement 7. Inter-city network 8. National network 9. International network	1. Citizen and community involvement 2. Commercial centre improvement 3. City park and pedestrian development 4. Public transport provision

Both priorities encourage each stake holder (municipality, private sectors and resident) responsibilities. It is described as follows (table 11):

Table 11. Stakeholder participation on total action program (source: author)

Stake Holder Responsibilities	Action Program
Municipality	Segoro Amarto, public transport, internet access for people, commercial centre, Creative City, MICE, international event, national event , City Walk, park and greenery, Kampongs Improvement Program, compulsory education and higher education diversification
Private Sectors	new business, CSR, capital investment, joint cooperation on tourism and services, world association
Residents	Sego Segawe, cultural attraction, kampongs tourism, gotong royong, new small enterprises, waste Reduce, Reuse, Recycle, night attraction, public investment, household energy efficient use, public transport priority

4.2. Proposal Implementation

Implementing the total action program needs great effort. As far the cities develop branding process with the total action programs they face the expenditure issues. Several of them should delay, pending, observe, moreover cancel. Almost the cities around the world emerge them. Always there are possibilities solve this crucial situation creatively. In case of Yogyakarta, the total action program needs structuring the city's brand strategy.

The contributions as shown on table 25 ease the action program implementation totally. Both priorities will be derived into four strategic implementations as follows:

1. Territorial strategies
   Strengthen the territorial quality with enforce the sub district abilities.
2. Infrastructure
   Increase the infrastructure capacity on serving the city activities.

3. Organizational structure
   Develop joint three party organizations among stake holder (municipal, private sector and resident).
4. Behavior
   Socialize cultural city life culture and raise fund among stake holder encourage gotong royong, CSR, joint finance, sponsorship mechanism and etc.

4.3. Branding Communication Strategy

The second level of city's brand is important. This part belongs to three party stakeholders internally and worldwide nationally and internationally. Internally, the action program above, depends on their responsibilities, should be managed and communicated among them. The municipality plays an important role and the others will complementary. Nationally, promoting Yogyakarta as center of Javanese culture and developing advertorial, PR, slogan could be done.

4.4. Recommendation

Through this research, found that Yogyakarta is a mature city. Even they have not developed city's brand yet; they are on the way of branding process. The city achievements show that they have great potential on tourism, education and services. At least, for the last ten years the city did the great efforts to encourage city's stakeholder involvement. Based on the deep interviews, each stake holder did their job. Academic representatives proposed research development partnership and responded that the city needs to develop city's city's brand in an integrated way. Business actors played their job well and suggested an improvement on city's brand management for the next mayoral as well as a corporate did. Government representatives realized that good city atmosphere and infrastructures provision will encourage the city competitiveness and boost the city's brand will create the large number of opportunities for the people, city and prospectus stake holders. It is shown the city's readiness in political, socio-economic and environmental for branding development in an integrated way. People awareness and involvement sound politically, city's wealth sound socio economically and city's conveniences environmentally are the most important city's capital to prepare to jump to be a greater and better city. As the last Mayor thought that the city has the strong foundation, it should emphasize economic orientation in a strategic action to speed up the city development.

Learning from the other success cities, implementing city's vision and action program should be complemented by the city's abilities. Accommodating stakeholder contribution, worldwide consideration orientation, and concerning the economic development sound environmental respond without compromise for future generation it will guide a utopia becomes true. After identifying Yogyakarta as an Authentic City, it is important to propose the action program for the policy maker. It should be a part of the 20-years development (2005-2025). Due to economic integration, tourism and education with their multiplier effect in services sector obtains a high number of economic growth index (4-5) for the city. Implementing city's city's brand to speed up the city's achievement should be coupled with a total action program, practically. Moreover, the city would like to achieve 6 in the economic growth index. That consideration creates consequences, financial consequence, mainly. Emphasizing the proposal with that economic integration bridges this consequence. It could be proposed in the 5-years midterm plan. It means, until 2025, it has three steps development. It is presented as follows:

1. First five years
   Prioritizing on tourism development with high value of municipal-private sector-people partnership and carrying out higher education and services sector, simultaneously.
2. Second five years
   Prioritizing on sub district development and maintain tourism development with education and services sector integration to create a better city.
3. Third five years
   Preserve both priorities to create a greater city.

The proposal above should be evaluated yearly. It will ensure the city achievement during the implementation.

Proposal above shows city's brand plan achievement answers the research question. Emphasizing city's identity and city's core competency with city vitals indicators identification founds valued indigenous city identity. The most important of city's brand development is city identity identification, indigenously. This research methodology approach which is qualitative and quantitative collaboration obtains clear analysis and improves synthesis as well. The research introduction mentions a large number of developing cities in Indonesia, this methodology is useful to identify the other cities in order develop their city identities. Based on this research experiment, researcher recommend for next research:

1. Developing city's brand could assess' city vitals indicators with empirical and statistical data accomplishment.
2. Developing city's brand refers to city's identity and city's core competency based on stakeholder references.
3. Developing city's brand emerges city's vision and action program totally.

Developing city's brand boosts the city achievement in bustling Asian economic era for Indonesian developing cities, especially. It will direct the city's management to speed up the city achievement.

References

Adrisijanti, I. (2000). Historical archeology of settlement pattern of Mataram Sultanate in Jawa Tengah Province . Yogyakarta: Jendela.

Anholt, S. (2008). Place branding: Is it marketing, or isn' t it? . Place Branding and Public Diplomacy , 1-6.

Cortright, J. (2007). CEO's for City: City Vitals.

Gospodini, A. (2006). Portraying, classifying and understanding the emerging landscapes in the post-industrial city. Cities , 311–330.

Hanna, S., & Rowley, J. (2008). An analysis of terminology use in place branding .

Hannigan, J. (2003). Symposium on Branding, the Entertainment Economy and Urban Place Building: Introduction. International Journal of Urban and Regional Research , 352–360.

Kavaratzis, M. (2005). Branding the City through Culture and Entertainment . Urban and Regional Studies Institute .

Kavaratzis, M., & Ashworth, G. (2007). Partner in coffeeshops, canals and commerce: Marketing the city of Amsterdam. Cities , 16-25.

Lanham, K. F. (2007). Planning as Placemaking: Tension of Scale, Culture and Identity.

Law, W.-W. (2007). Globalisation, city development and citizenship education in China's Shanghai. International Journal of Educational Development , 18–38.

Madlener, R., & Yunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? Sustainable Cities and Society , 45-53.

Mendes, J. F. (2012). O Futuro das Cidades. Coimbra: Minerva Coimbra.

Mukhija, V. (2006). Challenges for international development planning: Preliminary lessons from the case of the Cities Alliance. Cities , 56-62.

Qu, H., Kim, L. H., & Im, H. H. (2011). A model of destination branding: integrating the concepts of branding and destination image. Tourism Management , 465-476.

Quinn, B. (2005). Arts Festivals and the City. Urban Studies , 927-943.
Scott, A. J. (1997). The Cultural Economy of Cities. 323-338.

Steinberg, F. (2007). Jakarta: Environmental problems and sustainability. Habitat International , 354-365.

Vanolo, A. (2008). The image of the creative city: Some reflections on urban branding in Turin. Cities , 370–382.

Zerrillo, P. C., & Thomas, G. M. (2007). Developing brands and emerging markets: An empirical application. Place Branding and Public Diplomacy Vol. 3, 1 , 86–99.

Reforming Sustainable of City Living with the Indonesian Characteristic Approach

Munichy Bachron Edrees

Lecturer, Department of Architecture, Universitas Islam Indonesia

m_bachronedrees@yahoo.co.id

Abstract

Looking at the phenomena that exist, it appears that the cities in developing countries as though sporadic and without planning. So it's likely if the pleasant predicate of the cities and towns is always best achieved by the cities in developed countries. No exception to the cities in Indonesia. Sparkling of the city can make people come to earn a fortune, which in turn makes the city inhabited by different kinds of walks of life are very complex. The faces of city are influenced by both of environmental and residential patterns of upperclass people, middle class, as well as community grassroots level. The phenomenon today is the start mushrooming of residential complexes and upperclass communities are seen as 'anti-social' is inversely related to residential complexes of lower class communities are 'over-social'.

Anti-social as well as over-social each carrying consequences that have a big impact on the environment. Lack of planning on the environment will result in damage, both in social and environmental order as well as the natural environment. Good planning is thinking long-term planning and sustainable. With the concept of sustainable planning, the pattern of community life will be planned and patterned so well that minimize impacts caused by urban development (urban development is more controlled and designed).

To realize the concept of sustainable planning and designing of urban space, we must pay attention to community characteristics. In this globalization era, we should not turn a blind eye to the occurrence of mixing indigenous culture with the outside culture, which in turn will shape the characteristics of communities to form local wisdom. Local wisdom is that we must dig and utilized to form urban spatial. Local genius is local ideas that is characterized such as: wise, full of wisdom, good values, that planted and followed by society. Local genius is also a local wisdom. It stands from the outer culture, that accommodate and integrate the outer culture into inside, and give them the right way. Local genius emerge into: value, norm, faith, custom, ect. They have special meaning and function. It must be changed because of cross culture and globalization. It gives a challenge to explore and criticize it in scientific ways.

***Keywords**: patterns of occupancy and the environment that shaped the face of the city-concept of sustainable cities-communities characteristics to shape the local wisdom*

INTRODUCTION

City, a place that invites imagination of glory and the velocity of money. Different races, ethnicities, and backgrounds flocked to the city with different aims and objectives. This diversity brings a variety of cultures, which in turn brings the consequence that there is friction, but on the other hand also bring mixture to form its own characteristics. Characteristics of urban communities is not necessarily stand alone, but is often influenced by the culture of origin.

The existence of a wide range of cultural patterns affect people's lives, including in terms of social and psychological, which ultimately helped shape the face of the city. Growing city became sporadic, and the lack of shelter arrangement that makes the city fragmented and not humanist. Culture and customs of the society and its inherent character before, 'forced' to change according to the demands of the city that is often 'not friendly'. This is exacerbated by the business arrangement that does not care about the needs of society, and without any approach to cultural and community character of its inhabitants.

For that we need a cultural approach and explore the character of the community, so that planners and urban designers capable of managing a city with empathetic approach, so as to create a more humane city.

RESULTS AND DISCUSSION

Patterns of Occupancy and The City Environment

It is not a secret that many people considered that the problem of space / environment is a very crucial moment. In fact you could say a lot of problems that arise due to no accommodation of the interests of the user (users) in a space / environment. Disputes, disaster, accident, discomfort, and insecurity many problems occur, triggered by the space / environment.

In this discussion we shall use a rather different interpretation, which is both more pragmatic and behavioral, and social. At the other side, social objectives can not be separated from the economic power. Levels of economic power affect social life, while the level of community social also influence what kind of their environment. Of course, buildings can be seen in many different ways, for example, be viewed as works of art, as technical achievements, as the wallpaper of urban space, and as behavioral and cultural phenomena. It will treat architectural and urban spaces as containers to accommodate, separate, structure and organize, facilitate, heighten and even celebrate human spatial behavior. In so much as they do that, they will also be viewed as psychological, social, and partly cultural phenomena.

Space, and consequently that which encloses it, are much more central to all of us in our everyday lives than purely technical, aesthetic or even semiotic interpretation would suggest. Space is both that which brings us together and simultaneously that which separates us from each other. It is thus crucial to the way our relationships work. Space is the essential stuff of a very fundamental and universal form of communication.

Building will form space, and space will form face of the city. But most city in Indonesia have no arrangement which cause cultural friction and lack of quality of the environment. Community ‘forced’ accept and change the pattern of their life to be ‘acceptable’ in the city living. This cause environment raises new characteristic of the people who lives in city, although their origin culture often still underlie behavior.

Clearly, than, one of the role of space is to create settings that facilitate the acting out of range of identities we use in our lives. Much of this must be done not by architects but by the actors themselves, since the space is effectively and extension of their own behavioral mask. In turn, the challange for architects is how to create space that invites and facilitates taking possession and personalization. In passing, it is worth noting that this is a rather different view of the task of architects to that which seems to dominate in many contemporary schools of architecture. Here it seems the task is to create space that is a monument to the originality of the architect.

Perhaps we tend only to notice this language when it is in some way abused. Buildings (and also public space) can fail to speak the language of the space properly just as much as people can. For example:

- One of the important features of the family territory is that it must be easily distinguished in some way from all the others. Its separate location gives it a uniqueness, of course, but this is not enough. Its shape and general appearance must make it stand out as an easily identifiable entity, so that it can become the 'personalized' property of the family that lives there. This is something which seems obvious enough, but which has frequently been overlooked or ignored, either as a result of economic pressures, or the lack of biological awareness of architects. It can be seen in slum, and many government project about public housing (perumnas and rumah susun). Slum and public housing have a lack of quality of the environmental. Their environment create daily life that 'over-social', so that cause friction among residents who have different cultural. For the opposide, in the upper class of community, their environment make an expression 'anti-social'. Their lives tend to be individualistic.
- Government buildings which should be open because its fuction are public service, but what happens is the government buildings that does not seem friendly, the buildings appears secretive and forbidding. That buildings may have an interesting architectural form, but it seems consistenly to send out the wrong signals.
- Characteristic of the people of Indonesia are social interaction to gather around. So people need some of open public space. But cities in Indonesia have less open public space.

The human language of space, whilst it has its cultural variations, can be observed all over the world (Indonesia) wherever and whenever people come together. We are interested in the space created in and around architecture. Architecture organized and structures space for us, and its interiors and the objects enclosing and inhabiting its rooms can fasilitate or inhibit our activities by the way they use this language. Because this language is not heard or seen directly, and certainly not written down, it gets little attention in a formal sense. However, we all make use of it throughout all of our lives as we move about in space and relate ourselves to others.

Community Psychology Approach to Create Environmental Characteristics

There are many ways of categorizing human behavior. For the purposes of the subject in hand it is useful to recognize two important dimentions along which our behavior can be plotted as in figure 2.1.

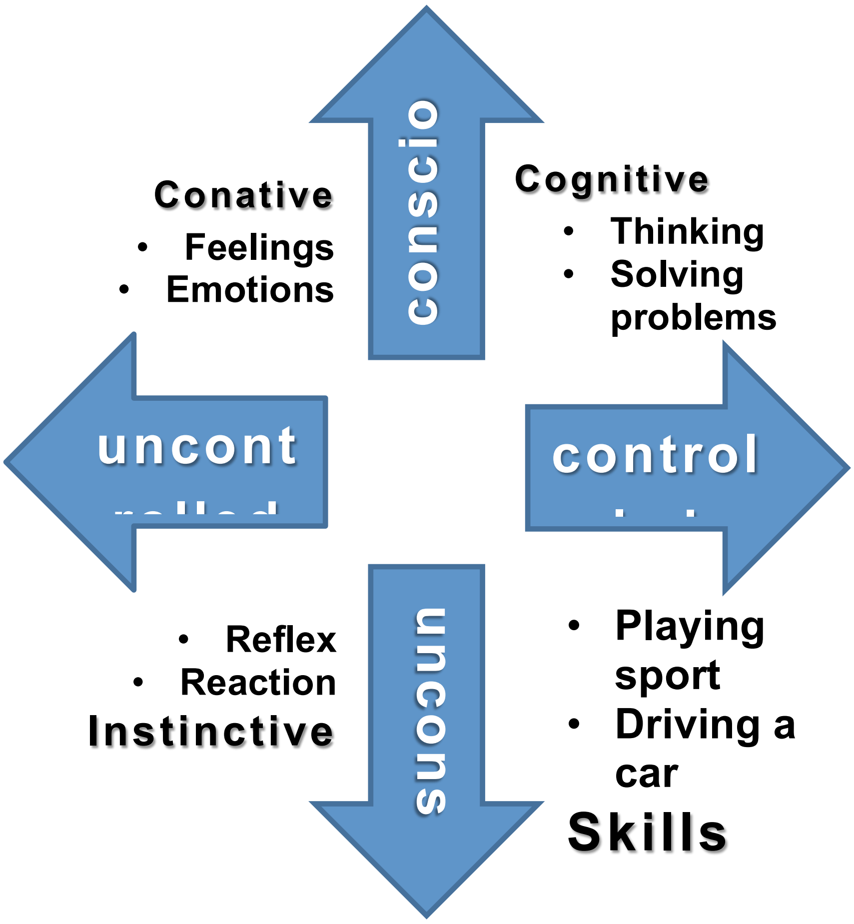


Figure 2.1 (Source: The Language of Space, Bryan Lawson)

> A very simple but useful model dividing up human behaviour. The two independent dimentions of control and consciousness give rise to four quite different forms of behaviour, each described by their own field of psychology

Since these two dimentions of conciousness and control are independent, we can usefully think of human behavior in four major sectors.

Our behaviour is influenced and even constrained by space form that comprise both the physical and the social environment. This succinctly points out that a space form really consists of the space, its surroundings and contents, and the people and their activities. Space form, whether they are parts of special territories or not, are important to us as ways of generating security.

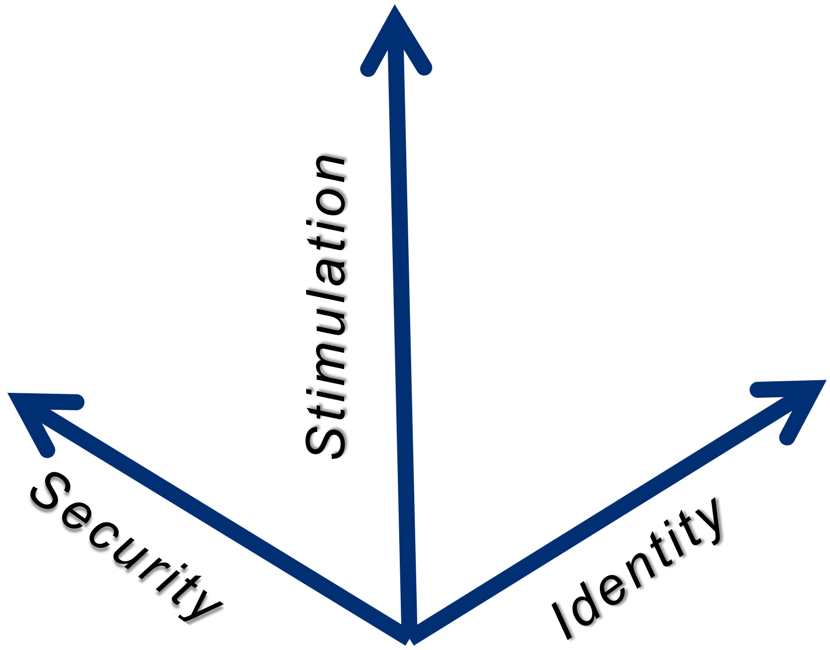


Figure 2.2 *(Source: The Language of Space, Bryan Lawson)*

The three important needs of stimulation, security, and identity, can all be satisfied by the design environment. Our balance of need at any time will depend on several factors, including personality, physical health and age, and social context.

- Stimulation is perhaps the most obvious and simplest of the three to understand; however, it turns out to be rather fundamental and less of a luxury than at first we might think. By contrast, an environment in which we are bombarded with sensation seem equally disturbing, and sadly this is exploited in many forms of torture. Actually, of course, the level of stimulation we require varies-some people simply like the quite life, while others prefer more action-but even then our needs change as our moods change and indeed as we age. If we just see this, of course impossible to produce an environment that all would feel ideal. So we also had to approach the culture and characteristics of the local community (by the group).
- Security have a very deep and fundamental need for a degree of stability, continuity, and predictability in our lives. It might sound exciting not to have this, but just imagine how stressful it would be to lead a life of constant flux and unpredictability. We depend for our sanity upon knowing the rules, as it were. Every social group that has any degree of cohesion also has norms. These norms regulate behaviour, dress, and forms of language and even in some cases define entirely local aspects of

spoken language. Social norms then are extremely powerful in that they give security to people in the group, allowing them to behave in a regulated way without fear of their behavior being thought to be inappropriate by their neighbours, colleagues, and friends. But are there spatial reflections of social norms? To some extent there are, and they form some of the most fundamental component of the language of space. Security and secure is one of psychological needs and physiological needs. Those needs can be solved with the architectural design.

- Identity is one of the most fundamental forces at work in our psychological make up is the need to create and maintain our own identity. One of the role of space is to create settings that facilitate the acting out of range of identities we use in our lives. Much of this must be done not by architects but by the actors themselves, since the space is effectively and extension of their own behavioral mask. In turn the challenge for architects is how to create space that invites and facilitates taking possession and personalization. Our need to belong and to identify places as either exclusively ours or at least associated with us is demontrated everywhere by the things people do to personalize locations. The expression of communal identity can be every bit as important as that of the individual.

Spaces, as we shall see, can always contribute to all these three requirements of stimulation, security, and identity.

Other than those already mentioned above, motivation undoubtedly plays a central role in our behaviour, and any analysis of how we behave in relation to space must recognize this powerful force. Motivations are many and varied, and not only depend on personality and culture but also change with time and situation. However, we do seem to be driven by fundamental internal needs, or so a great deal of psychological theory would have it. Certainly, those needs that architectural space can help to satisfy.

Territority is important. We have by now seen some crucial distances in human relationships. We have seen that these distances are not absolutely precise, but we have also learned that neither are they entirely abitrary. In fact they are closely linked to how we sense and than perceive other people. How we choose to allow others to relate to us depends on a number of factors: these sensory factors, our own personality, and the occasion and our wider culture. The consequence of distance for us humans is far more complex than all other species, largerly due to our sophisticated culture. It is now time to define these distance more carefully.

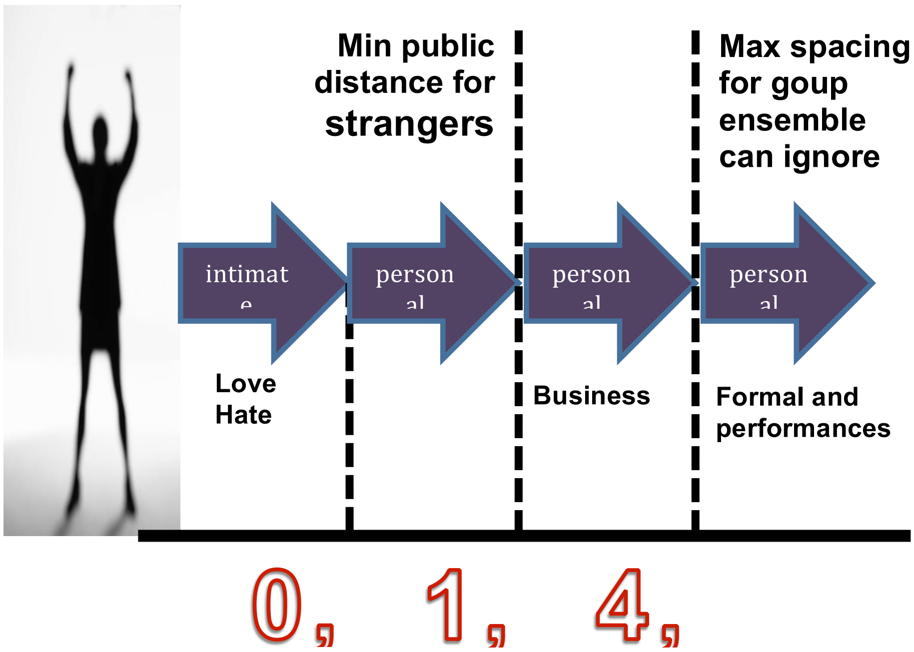


Figure 2.3 (Source: The Language of Space, Bryan Lawson)

> The most generally agreed taxonomy of human distances in space. ‘Intimate’, ‘personal’, ‘social’, and ‘public’ distances all have their uses and characteristics. The challenge of spatial design is to facilitate rather than inhibit the behavioural settings appropriate to the social purposes of behaviour in space.

In addition to these things, which must be considered also by the planners is a matter of psychology towards a common space, such as: noise problems (will affect the work activity), phobia of space, such as claustrophobia (fear of enclosed spaces), or Nyctophobia Achluophobia (afraid of the dark room).

In shape space, we will classify based on linkage with the user, namely:

As the Configuration Space

In breaking down the problem space, the required definition of the form of space and this raises two meanings, namely the composition of human beings in space and relationships between people in the room (Hiller and Hanson, 1984: 26). Interpretation of the behavior: people and buildings, where the relationship between design and use of domestic space tested, many studies in the field of environmental psychology, sociology houses, and architectural model adopts the interpretation of form or function behavior model space.

With regard to the principle that expected on the relationship between humans and space we will find at the level of the configuration of the space instead of the individual activities. It is situated on the relationship between humans and the configuration of the configuration space (Hiller 1996: 29-31).

Some important notes presented by Darjosanjoto configuration space (2006) are:

a. Syntax (syntax) in a building is defined as the space being included in the discussion of the whole arrangement of the building.
b. Configuration space is a linkage between a room with other rooms as a whole (complex). Meruang organization of the building by humans contain internal logic. This internal logic is calculated based on the knowledge space.

Space As Social Object

The fundamental problems of the theory of space in terms of sociology is to show how a group going, into as individuals, came out as the behavior and thinking. Sociology defines the behavior at the individual level should be described with the terminology of the broader group (Hiller and Hanson, 1984: 201).

Here there are two aspects of the problem. First, the idea of building compiled by social ideas. Secondly, the idea of social institutions with the idea of the building. Each show problems for the theory of architecture. First discuss the question form - function. Both talked about the question of building a social object. (Hiller 1996: 372 and Hiller and Hanson, 1984: 176).

Sustainable cities can be achieved if the space form can provide a sense of secure, security, and comfort.

Concept of Sustainable Cities

In this discussion we shall certainly consider the purely physical charateristics of space, the objects they contain and the envelopes that devine them, there is something far more important to us than that. Of course we are all different, but in general ultimately it is our relationship not directly with spaces or buildings that matters most to us, but our relationship with other people.

To create sustainable city, we must to see in advance the need of community:

- 'Personalized' property of the family that lives there.
- A place to socialize
- Secure and safety
- Place identity of the community that lives there

In connection with the theory of space in architecture, environmental psychology has a discussion of human behavior towards the relationship with their physical environment. There are several topics related to conception concept of place. Some topics are:

- How the place developed
- How do humans get the meaning
- How humans plan and place the physical and emotional reactions
- What does the concept of cross-cultural
- Making a place related to the sustainability of communities
- Environmental Psychology and its relation to environmental quality is low (in the third world countries)

There are strong relationships in the environmental psychology of human-environment relationships studies on contextual architecture. By answering this question, it will form a sustanable cities.

Architects / planners in designing should pay attention and adhere to the following five principles, to answer the questions above, namely:

- **Function.** Building functions are influenced by human activity, whereas humans are influenced by biological, psychological, social, and also influenced by reason and culture. These aspects form the pattern of human behavior, which ultimately will affect the form of space. So the form of space must consider the pattern / configuration of human behavior, which in the context of the environmental pattern is formed not by individuals, but the group trend.

- **Form.** Form a building or space is influenced by the behavior of human users, which in turn form shaped by function. For example, suppose that we will design a living room, would have been different with the design of the dining room, bedroom, kitchen, etc. So also, when we design buildings with commercial functions, of course, will also vary with the building that serves private.

- When we design, between function and form are intimately associated with one another, but in shaping the form must also consider the **technics, safety,** and **comfortability**. Safety and comfortability is a basic human need during activity. Safety and comfortability is influenced by human needs of both the psychology and physiology. All of these design principles (function, form, technics, safety, comfortability) must be efficient, which should always pay attention to the context in which the building / environment will be established / planned, because everything is back to his character and behavior of humans who will use it. Architect shall be deemed to fail if the building design / space / environment planned / establishment are not able to accommodate the needs of users, not able to regulate the negative behavior of users. For example, although a beautiful building, but that does not give comfort to its users, does not give users a sense of security, does not fit the character / culture of its users will be called a failure. Architecture is a container which contain human activities in it, so the architect should be able to design not only beautiful in form, but also able to reflect the character of its users, so it needs psychology and physiology needs can be met.

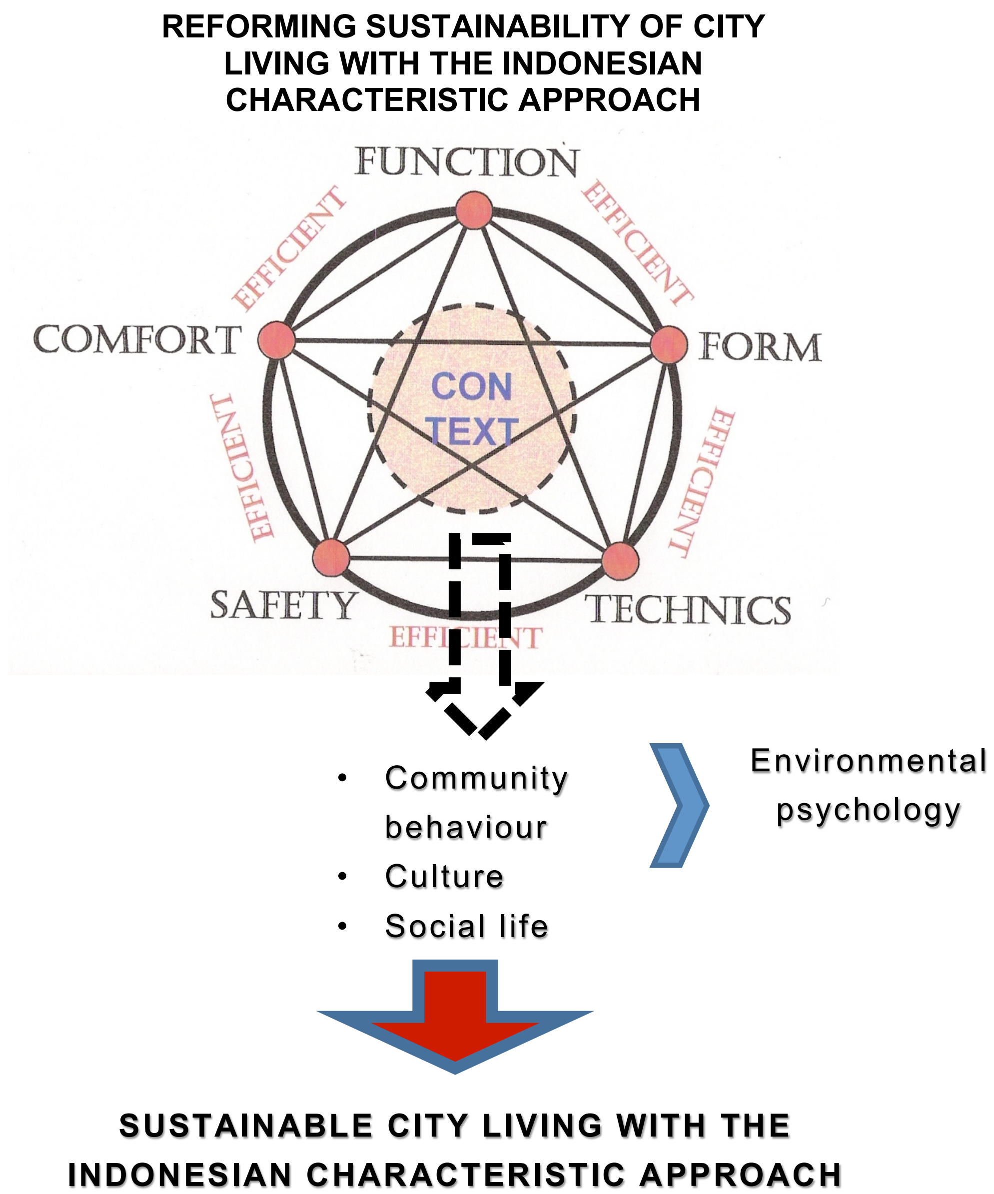


Figure 2.4 (Source: Munichy B. Edrees)

HYPOTHESIS and RECOMMENDATIONS

In the English language have two words with overlapping but distinct meanings referring to our place of residence; ‘house’ and ‘home’. The first seems to be a purely architectural concept, while the second includes overtones of humanity. One way of thinking about the purpose of this discussion is to see it as exploring the relationship between these two ideas of the physicality and humanity of the space.

From discussion above, we see that in order to establish sustainable cities must go through psychological approaches to meet the physical needs of space. Psychological needs are fundamental and the most important in human lives. The differences of psychological needs of every human being (group) are often also influenced by culture. So that the fulfillment of psychological needs as a basic for designing space and environment will create a sustainable city, while the influence of culture in psychological needs will create an environment characterized by community appropriate.

REFERENCES

C. Klein, Donald. (2005). Psikologi Tata Kota-Psikologi Pengembangan Ruang Publik Dalam Perencanaan Perkotaan Baru. Penerbit Alenia. Yogyakarta

Fox, Martin. (1982). The Best in Environmental Graphics. RC Publications Inc. USA.
Gifford, Robert. (1991). Environmental Psychology-Principles and Practice. Allyn and Bacon Inc. USA

Hiller, B., Hanson, J. (1984). The Social Logic of Space. Cambridge University Press. Cambridge

Hiller, B. (1996). Space is the machine: a configurational theory of architecture. Cambridge University Press. Cambridge

Lang, Jon. (1987). Creating Architectural Theory-The Role of Behavioral Sciences in Environmental Design. Van Nostrand Reinhold Company. New York

Lang, Jon. (1994). Urban Design-The America Experience. Van Nostrand Reinhold Company. New York

Lawson, Bryan. (2001). The Language of Space. Architectural Press. Jordan Hill. Oxford 8DP
McAndrew, F.T. (1992). Environmental Psychology. Brook Cole Publishing Company. California.

Mikellides, Byron et all. (1980). Architecture for People. Studio Vista Book. London.
Saegaert, S. and G. Winkel. (1990). Environmental Psychology, Annual Review of Psychology 41.

Vayda, A., ed. (1969). Environment and Cultural Behavior. Natural History Press. Garden City. NY

The Effect of Climate and Architectural Form on Thermal Comfort of Houses Around Dienf Plateau, Wonosobo, Central Java, Indonesia

Hermawan

Qur'anic of Science University, Wonosobo, Central Java, Indonesia

Email: hermawanarsit@yahoo.co.id

Abstract

Orientation condition of buildings which is various around Dieng Plateau, i.e. Desa Keseneng, district Mojotengah, Wonosobo Regency has created a problem related to the capability of these buildings in protecting from cold temperature. The problem is how big building orientation in this area influences its ability to protect from cold temperature.The research has two goals. The first is to know the extent of the effect of building orientation of houses in Desa Keseneng on its ability in protecting from cold temperature which is cause by humid air. The second is to know the effect of architecture form of houses in Desa Keseneng on thermal comfort of the buildings. The research uses a phenomenology approach. The method used is ethnography descriptive method. Variable studied is the effect of architecture form (orientation, form, roof and wall form, material and room arrangement) and climate (sun radiation, air movement) on thermal comfort. The result is that the comfort of houses in Desa Keseneng is influenced by air temperature, air humidity, and the speed of air movement. The activities of the people, such as the types of clothes they use, also influence thermal comfort. Beside that, the comfort of air is influenced by temperature, humidity, and the speed of air. Buildings in Dieng need warmer to make the temperature warm in the balancing level.

Key words: thermal comfort, Dieng, climate, architecture form

INTRODUCTION

There are many studies on thermal comfort of people staying in indoor environment, relatively few have investigated outdoor thermal comfort and its determinants. Potter and de Dear [1] aksed an interesting question : "Why do holiday makers deliberately seek out thermal environments, that would rate 'off the scale' if they were encountered indoors?" They investigated outdoor scenarios experimentally, which, according to the predicted mean vote (PMV) model [2], should have had a predicted thermal neutrality at 24.1^{o} C. In reality, however, they ovserved a value of 27^{o} C for these outdoor spaces. Besides general definition for thermal comfort there are many others specialising on warm or cold discomfort, e.g. the definition by Gagge [3] based on skin wetness for warm conditions, or the parameterisation of the onset of shivering as a quadraticd function of the mean skin temperature for cold streess [4].

Three parameters in physical variables, air temperature, humidity and air velocity are combined in the equation of ET (effective temperature). ET thermal index gives a value that is defined as comfortable or uncomfortable. This principle has been further developed to find a thermal index that closer represents thermal comfort [5]. Peter Hoppe [6] said that besides different clothing and activities, the predominant divergence between indoor and outdoor thermal exposure are the time ranges spent generally in the environments.

People in Indonesia have two kinds of houses in solving climatic problems, i.e. traditional and modern houses. Traditional houses are the ideal form of architecture because they can create a comfortable condition, both physically and pshychologically. Meanwhile modern houses tend to ignore climate factors. Orientation condition of building of houses around Dieng Plateau are various and authomatically, it creates different capability in proctecting from cold temperature. Therefore , something that must be given attention is how big building orientation, both in ideal and unideal condition, in this area effect its ability to protect from cold temperature.

The research has two goals. The first is to know the extent of the effect of building orientation of houses in *Keseneng* on its ability in proctecting from cold temperature which is caused by humid air. The second is to know the effect of architecture form of houses in *Keseneng* on thermal comfort of the buildings.

THERMAL COMFORT ON TROPICAL ARCHITECTURE

Salleh (2004) said that the first major issue about climate is the comfort level [7]. *Climate* comes from Greek, *klima* means region (Webster, 1984) [8]. Scientifically it means the prevailing or average weather conditions of a place, as determined by the temperature and meteorological changes over a period of years. The amount of heat got by a region depends on the length of sun light that the region gets and the angle of the sun light that comes to the region.

The performance of a dwelling house in a thermal tropical specif traditional characterless with building material and conditions of its environment that consider the traditional image has the potential to be attained optimasi [9]. Some spesific factors of climate such as (1) thermal comfort, (2) air flow through the building, (3) warm radiation, and (4) natural lightening in the afternoon, causes one region different from others in terms of architecture theory, composition, form, function, image and estetical value of the building.

Sun radiation is the cause of the charateristic of climate. It also influences human life. The ideal need of sun radiation for human is determined by (1) energy of sun radiation, (2) reflective power of earth surface, and (3) evaporation. In designing a building, people must pay attention some specific factors related to the effect of sun radiation. The factors are (1) duration, intensity of radiation, the glare and fall angle of the sun light, (2) temperature, (3) rainfall, (4) humadity, (5) air movement, (6) heat movement, and (7) time lag.

ARCHITECTURE FORM OF HOUSES

The traditional form of dwelling is the expression of cultural and climate [10]. According to brager and de dear (2001), adaptation form of the physical environment needed to achieve influenced by factors contextual, history and preference of choice (live) [11].

It is the most important thing in people life bacauce it is a place where a family lives. Javanese culture has a fuction as way of life to get a happy life. Type of houses in Desa *Keseneng* is very simple, as symbol of the simpleness of people there. The principal goal in designing a house is to creat a harmony among people in a family. The common architecture is quadrangle and square.

RESEARCH METHODOLOGY

Data were collected by four methods: a) observation, to get the real condition, b) interview, to get the valid data from the competent sources, c) documentation, to get graphic data, d) measurement, to get quantity data [12]. Based on the data in 2012, there are 278 houses in *Keseneng* which consist of 13 traditional houses, 227 semi-modern houses, and 38 modern houses. Samples were taken based on the houses grouping, material used, man power who build, and cost to build.

Variable studied are (1) independent variables which consist of (a) the effect of architecture (location, orientation, form, building and roof opening, material, colour and room design), (b) the effect of climate (sun radiation, air temperature, air movement), (2) dependent variable: thermal comfort.

Equipments and materials of research: a) the determination of measured area, b) recording and picturing, and c) equipment use.

RESEARCH LOCATION

Wonosobo regency is located in 7 South latitude and between 109 – 110 East longitude. The width of Wonosobo is 98.468 hectares. One of districts in Wonosobo is Mojotengah, north west of Wonosobo's town central. Its width is 4.506, 926 hectares. The capital of Mojotengah is Kalibeber. The distance between Kalibeber and town central of Wonosobo is four kilomenters. Mojotengah has boundary with Garung district in the north and East, Wonosobo district in the South and East, and Watumalang district in the West. There are 19 villages in Mojotengah district. One of them is Keseneng. Keseneng has boundaries with Garung District in the North, Sojopura in the South and East,and Mudal, Candirejo, Andongsili in the West.

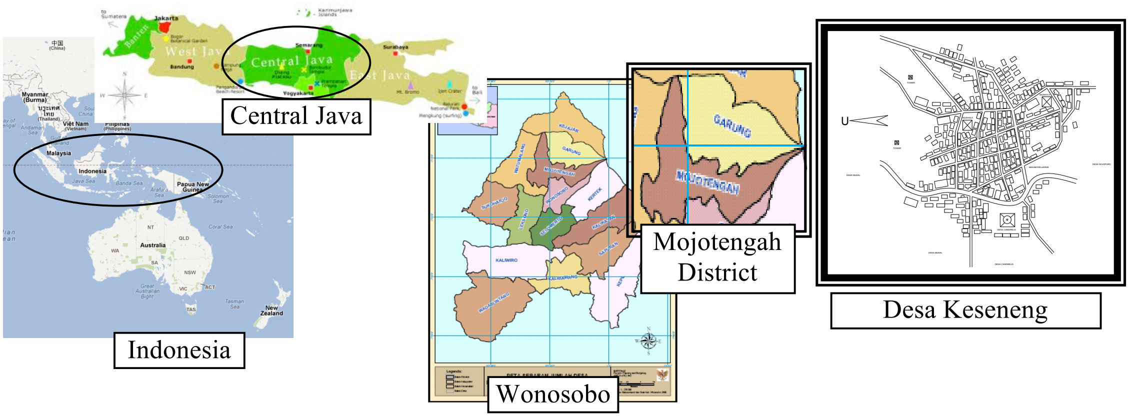


Figure 1. Research Location

Desa Keseneng has two seasons, dry and raining season. Each season is about 6 months. Rainfall is 4.326 metters. The raining days are 187days. *Keseneng* is 1.050 meters from sea surface. Its temperature is 18 – 23 C°.
Types of houses in *Keseneng* are as follows.

1. **Ancient Javanese Traditional Houses**
   These houses have Joglo architecture. The main material is wood. Generally people use local woods such as Jati, Suren, Nangka, albasia. Pillars are made from wood. The wall is made from wood board. Roof structure is *kuda-kuda, traditional framing form*. Roof is covered by black metal to absorb sun heat. The reason of using metal is because metal is stronger to protect from various types of mountain wind. Contrary, roofs covered by roof tile have two weakness; absorbing water so that invite moss to live and making rooms colder.

2. **Semi Modern Houses**
   These houses are combination between ancient Javanese architecture and modern one. The special characteristics can be seen from the form and construction. The wall is build by using brick and wood board. One meter of wall is made from bricks and the rest is wood board. Roof is covered by black metal.

3. **Modern Houses**
   People in building modern houses don't pay attention to the ethics in building ancient Javanese houses at all, both the architecture and the materials. The building has used modern architecture, both in the form and construction. Part of the wall is made from bricks and mortar, and strengthened by reinforced concrete. Principally, roof is made from wood and covered by black metals or roof tiles.

DATA AND ANALYSIS

1. Traditional Houses

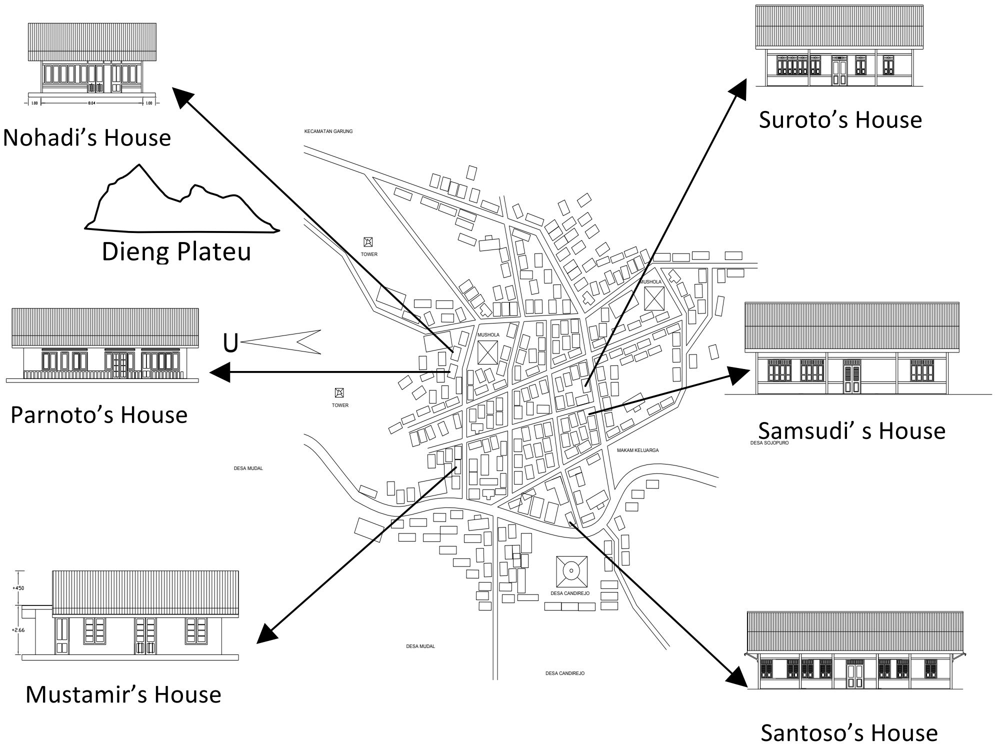


Figure 2. Location of Traditional Houses

Table 1. The Analysis of the effect of architecture forms on thermal comfort

Architecture Variable	Forms of the Houses	Javanese Culture	Comfort
Location	Around Dieng Plateau	Profession as Farmers	Cool temperature , fast wind, inadequate sun light
Orientation	Houses orient to street (social contact)	Respect/politeness and safety	Avoid over quantity of sun light
Form and Ground Plan	Long or quadrangle	Modern measurement	Protecting from wind
Opens	Wide	Protecting from outer disaster	Avoid cold and fast wind
Roof and wall	Roof is at 30 – 45 angle	Protection	Protecting from rain and sun radiation
Overstek/Shade	With Overstek	Protection	Avoid heat and rain
Materials and colors	Roof is made from black metal Floor is from tile Wall is made from wood- painted green The pillar is from jati wood	Green symbolizes wealth Pillar shows the power of Javanese Ethnic	Arrange the temperature in the room Heat can be easily absorbed by dark colors Increase the heat and humidity
Building Arrangement	The distance between houses is very close	Intimacy and harmony	Minimize the wind flow

From the analysis above, the effect of climate on thermal comfort in traditional houses in *Keseneng* can be concluded as follow.

Table 2. The Result of the effect of Climate factor on the Thermal Comfort

The Effect of climate on the thermal comfort	House condition	Recommendation
The effect of sun light	Average shade at each side of houses is 80 – 100 cm. Only on the porch the shade is maximal	To protect walls from direct sun light and to decrease the glare of the sky and land reflection, people can use area breaking sun ray and build shade along the house, 120 – 200 cm.
The utilization of sun ray	The utilization of sun ray is not so good. It is because the width of opens in the wall is only 14,7 – 16,88 % of the total width of the wall. For the house whose long side orienting to north-south, the lightening intensity fulfills the requirement recommended. Houses whose long side orienting east-west can fulfill the requirement at 12.00 – 15.00 pm.	
The Effect of Air Temperature	Temperature in Keseneng is cold because it is located in a mountainous area	It is recommended to minimize the open at the west side (upright to the wind direction), set deflector to control strong wind and to decrease humidity intensity.
The effect of humidity	To decrease humidity which can damage wooden wall, people can paint the wall and other elements or lay foundation under pillars to protect water penetrate the pillars	
The effect of the rain	Setting roof with 30 – 40 angle can speed rain to fall to the earth and avoid moss grows in roof covered by metal. Since the shade is only 80 – 100 cm, the rain can fall to the window directly.	Shades should be 100 – 200 cm. Wooden wall should be set densely to protect cold wind to enter the house
Utilization of wind flow	Since the number of opens is not adequate, the air change is not so good for family activities.	Wind can used to arrange the condition in the house. The distance among houses must be close to decrease the speed of wind flowing spaces between houses. People should grow trees to protect from sun ray and turn the wind
Thermal Comfort , based on the study conducted by Mom & Wiesebrom	Thermal comfort can be reached at 10.00 am – 04.00 pm.	

2. Semi- Modern Houses

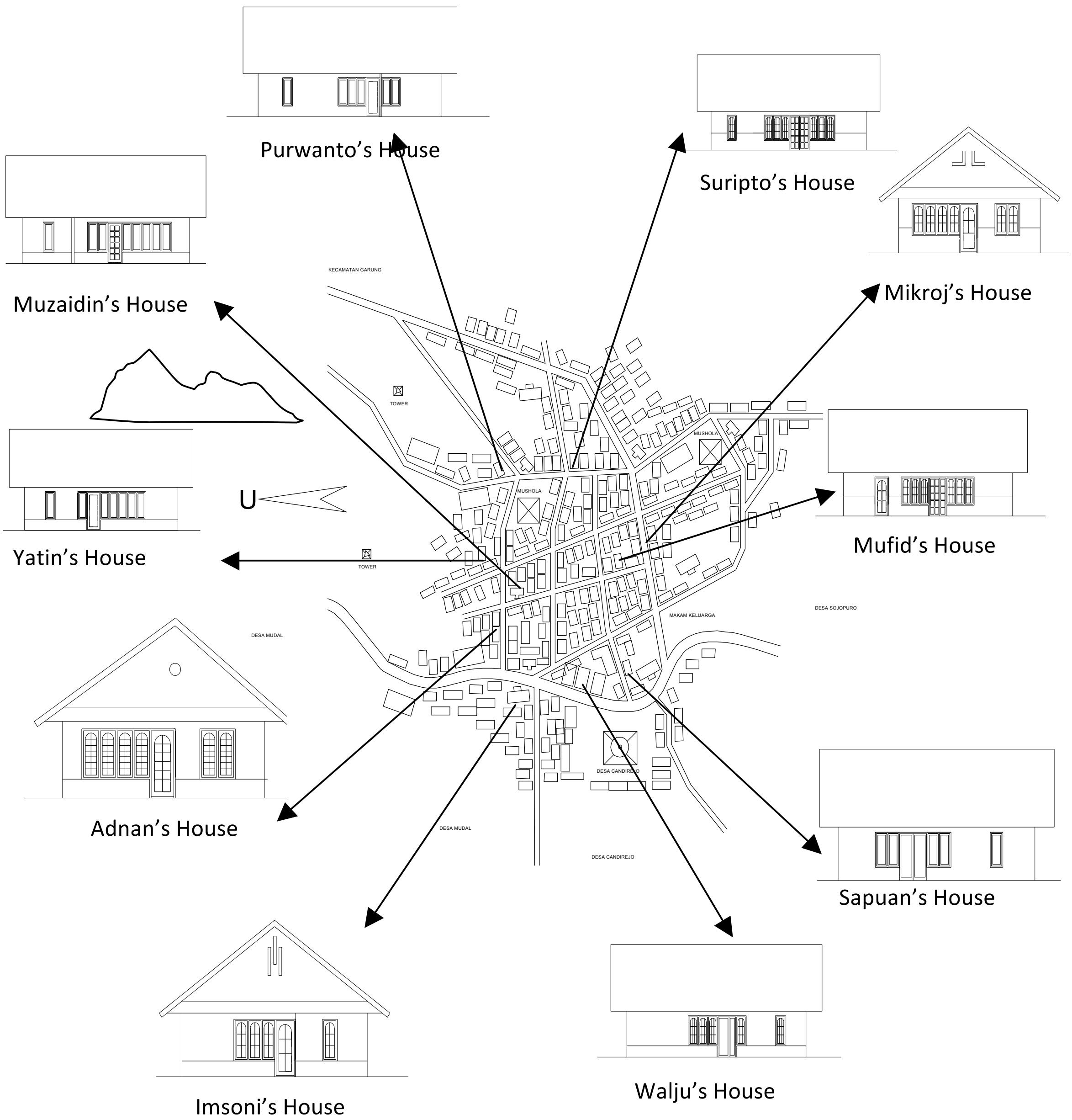


Figure 3. Location of Semi Modern Houses

Table 3. The Analysis of the effect of architecture forms on thermal comfort

Architecture Variable	Forms of the Houses	Javanese Culture	Comfort
Location	Around Dieng Plateau	Profession as Farmers	Cold temperature, medium wind, inadequate sun light
Orientation	Houses orient to the street (social contact)	Respect/politeness and safety	Catch sun ray which is still inadequate in the house
Form and Ground Plan	Long or quadrangle	Modern measurement	Turn the wind
Openings	Wide	Protecting from outer disaster	Avoid cold and strong wind
Roof and wall	Roof is at 30 – 45 angle	Protection	Protecting from rain and sun radiation
Overstek/shade	With Overstek	Protection	Avoid over quantity of heat and rain
Materials and colors	Roof is made from black metal Floor is from tile A half of Wall is made from wood wall is painted by dark colors The pillar is made from jati wood	Green symbolizes wealth Pillar shows the power of Javanese Ethnic	Arrange the temperature in the room Heat can be easily absorbed by dark colors Increase the heat and humidity
Building arrangement	The distance among houses is very close	Intimacy and harmony	Minimize the wind flow

From the analysis above, the effect of climate on thermal comfort in semi-modern houses in Keseneng can be concluded as follow.

Table 4. The Result of the effect of Climate factors on the Thermal Comfort

The Effect of climate on the thermal comfort	House condition	Recommendation
The effect of sun light	Average shade at each side of houses is 80 – 100 cm. Only on the porch the shade is maximal	To protect walls from direct sun light and to decrease the glare of the sky and land reflection, people can use area breaking sun ray and build shade along the house, 100 – 150 cm.
The utilization of sun ray	The utilization of sun ray is not so good. It is because the width of opens in the wall is only 8.30 – 14,47 % of the total width of the wall. For the house whose long side orienting to north-south, the lightening intensity fulfills the requirement recommended. Houses whose long side orienting east-west can fulfill requirement at 12.00 am – 03.00 pm.	
The Effect of Air Temperature	Temperature in Keseneng is cold because it is located in a mountainous area	It is recommended to minimize the open at the west side (upright to the wind direction), set deflector to control strong wind and to decrease humidity intensity.
The effect of Humidity	To decrease humidity which can damage wooden wall, people can paint the wall and other elements or lay foundation under pillars to protect water penetrate the pillars	
The Effect of the Rain	Setting roof with 30 – 40 angle can speed rain to fall to the earth and avoid moss grow in roof covered by metal. Since the shade is only 80 – 100 cm, the rain can fall to the window directly.	Shades should be 100 – 200 cm. Wooden wall should be set densely to protect cold wind enter the house
Utilization of wind flow	Since the number of opens is not adequate, the air change is not so good for family activities.	Wind can used to arrange the condition in the house. The distance between houses must be close to decrease the speed of wind flowing spaces between houses. People should grow tree to protect from sun ray and turn the wind
Thermal Comfort , based on the study conducted by Mom & Wiesebrom	Thermal comfort can be reached at 10.00 am – 04.00 pm.	

3. Modern Houses

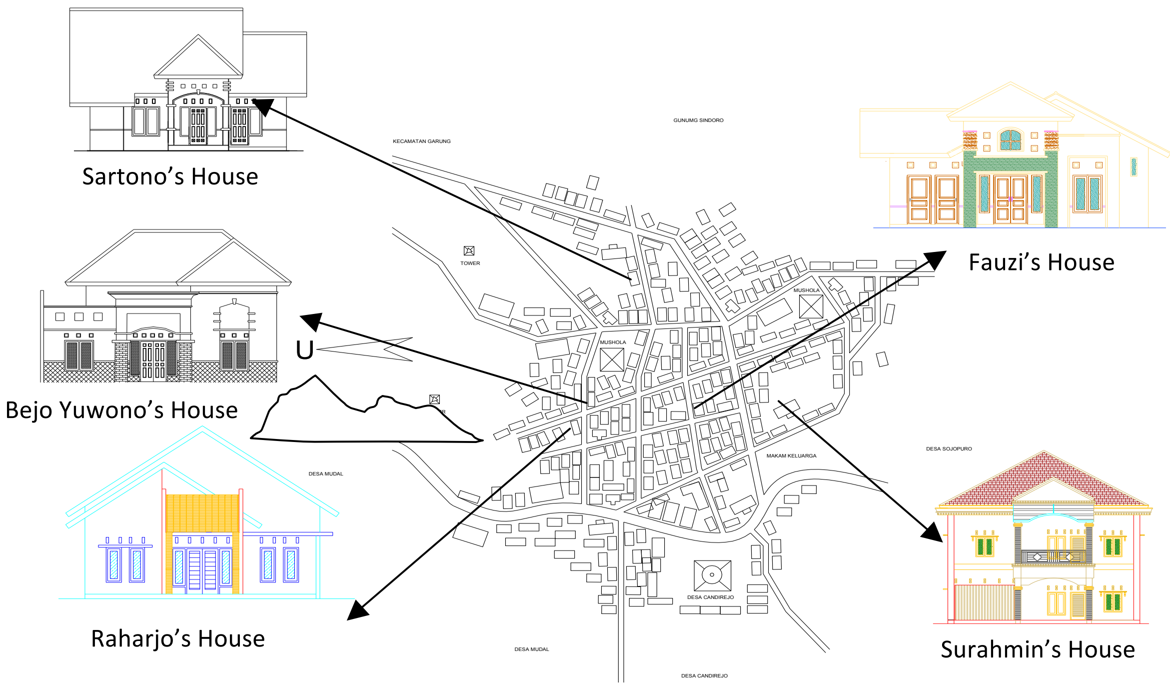


Figure 4. Location of Modern Houses

Table 5. The Analysis of the effect of architecture forms on thermal comfort

Architecture Variable	Forms of the Houses	Javanese Culture	Comfort
Location	Plateau	Profession as Civil Servants	Cold temperature , medium wind, inadequate sun light
Orientation	Houses orient to the street (social contact)	Respect/politeness and safety	Catch sun ray which is still inadequate in the house
Form and Ground Plan	Long or quadrangle	Modern measurement	Turn the wind
Openings	Wide	Protecting from outer disaster	Avoid cold and strong wind
Roof and wall	Roof is at 30 – 45 angle	Protection	Protecting from rain and sun radiation
Overstek	Overstek	Protection	Avoid over quantity of heat and rain
Materials and colors	Roof is made from black metal Floor is from ceramics Wall is made from bricks and mortar wall is painted by light colors The pillar is made from reinforced concrete	Green symbolizes wealth Pillar shows the power of Javanese Ethnic	Decrease the temperature in the house Heat can't be easily absorbed by light colors Increase the heat and humidity
Building arrangements	The distance among houses is very close	Intimacy and harmony	Minimize the wind flow

From the analysis above, the effect of climate on thermal comfort in modern houses in Keseneng can be concluded as follow.

Table 6. The Result of the effect of Climate factors on the Thermal Comfort

The Effect of climate on the thermal comfort	House condition	Recommendation
The effect of sun light	Average shade at each side of houses is 80 – 100 cm. Only on the porch the shade is maximal	To protect walls from direct sun light and to decrease the glare of the sky and land reflection, people can use area breaking sun ray and build shade along the house, 100 – 150 cm.
The utilization of sun ray	The utilization of sunray is not so good. It is because the width of opens in the wall is only 8.30 – 14, 47 % of the total width of the wall. For the house whose long side orienting to north-south, the lightening intensity fulfills the requirement recommended. Houses whose long side orienting east-west can fulfill the requirement at 12.00 am – 03.00 pm.	
The Effect of Air Temperature	Temperature in Keseneng is cold because it is located in a mountainous area	It is recommended to minimize the open at the west side (upright to the wind direction), set deflector to control strong wind and to decrease humidity intensity.
The effect of Humidity	To decrease humidity which can damage wooden wall, people can paint the wall and other elements or lay foundation under the lowest part of pillars to protect water penetrate the pillars	
The Effect of the Rain	Setting roof with 30 – 40 can speed rain fall to the earth and avoid moss grow in roof covered by metal. Since the shade is only 80 – 100 cm, the rain can fall to the window directly.	Shades should be 100 – 150 cm. wall should be set densely to protect cold wind enter the house
Utilization of wind flow	Since the number of opens is not adequate, the air change is not so good for family activities.	Wind can used to arrange the condition in the house. The distance between houses must be close to decrease the speed of wind flowing spaces between houses. People should grow tree to protect from sun ray and turn the wind
Thermal Comfort, based on the study conducted by Mom & Wiesebrom	Thermal comfort can be reached at 10.00 am – 04.00 pm.	

CONCLUSION

From the analysis above, it can be concluded that houses in Keseneng can be divided into three categories; traditional, semi modern and modern. All use Indisch architecture, which brings the spirit of mixed culture of Islam and Hindu.

1. **The effect of architecture form on thermal comfort of houses in Keseneng**
   Since Keseneng is located to Wonosobo, which got many influences from Yogyakarta Kingdom and Islam and Hindu (ancient Java), Islamic Spirit can be seen from the lay out and orientation of the houses. All kinds of houses in Keseneng are relatively closed and among rooms are separated by wall, and have relation with the following factors.

a. **Location**
Location to build a house follows the land contour and extends to the slope of Dieng mountain. The location is chosen to protect from strong cold wind, especially houses located in west.

b. **Orientation**
Wind direction and the position of sun are important factors in building a house. Houses orienting to North-South have advantages since the lowest part of the houses are upright to wind direction. This condition creates thermal comfort. Houses orienting to East-West also have benefit, for the lowest part of the house get much sunlight. It can make the rooms warm.

c. **Form and Ground Plan**
People in Keseneng in calculating size or dimension of building combine modern and Javanese calculation. The ground plan is cheek and quadrangle. Therefore, the ventilation cross system can be applied. The use of sunlight as natural lighting is very suitable for tropical areas. Traditional houses in Keseneng have Joglo architecture and follow Javanese culture. Spiritually, Javanese people do something based on three values: to get self –satisfaction, acknowledgment and love from others. Modern houses ignore Javanese tradition.

d. **Opens**
Opens have function to lightening and air circulation. At night they function to avoid cold temperature. Opens also have function to decrease humidity, and smoke from traditional fireplace. The ideal width of open in the wall is 15,8% - 20 % of the total width of the wall, but most of the houses sampled do not reach this level.

e. **Roof and Wall**
Houses have roof with 30 – 40 angle. This is designed to increase the speed of rain from roof so that it can decrease the humidity and the decaying of the roof material. Wall has function to protect from sun radiation, wind, humidity, and wind. The wall has everlasting time lag so that the heat can be got directly and conditioned well.

f. **Overstek**
Maximal Overstek only is only located on the porch. The other parts of houses are only 80 – 100 cm. actually overstek has a very important function to protect wall from wind and rain because the wall is made from woo which have a small time lag.

g. **Materials and Colors**
Most of houses in Keseneng use roof covered by metal. It is very good to use in mountainous areas, which have salty at low level. Metal is also very good for creating thermal in the rooms. Most of wall are made from wood and painted. Woods have power to reflect light at level 40 – 60%. Colors used have power to absorb heat at level 60 – 80 %. Consequently, it can increase the quantity of heat in the house.

h. **Building Arrangement**
Buildings are not arranged well so that wind flow can’t be used well to be ventilation. The spaces among buildings are still influenced by intimacy and familiarity factors.

2. **The effect of climate on the thermal comfort of houses in Desa Keseneng**
   Based on the analysis of the measurement, observation and recording, it can be concluded that houses and culture in Keseneng have responded well to climate to create thermal comfort in the building by the following ways.
   a. **The effect of Sun light**
      To avoid sunlight coming directly to the rooms, people use protector for their roof and wall. However, houses with a certain length have not been protected maximally from sun radiation. Houses whose long sides orienting to North - West have used natural lightening maximally. Meanwhile, houses whose long side orienting east – west have filled good lightening intensity at 12.00 am – 02.00 pm.
   b. **Air temperature**
      Average temperature in Keseneng is low. It is because Keseneng is located around Dieng Plateau whose temperature can reach 8 C
   c. **Rain and humidity**
      To protect walls and other part of house from the damage caused by humidity, people in Keseneng do some efforts. The first is to paint wall and other parts of house. The second is to set foundation under pillars to avoid water going up. The third is to set roof at level 30 – 40 angle. It can increase the speed of rain falling to the earth so that moss doesn't grow easily. Rainwater can easily reach windows because the *overstek* is only 80 – 100 cms.
   d. **Air movement**
      Moving air is very important in creating the comfort because it can determine the level of temperature and humidity supporting the comfort in a room. A research in big cities show that average wind speed in the highway only a third of open landscape. Wind flowing from the mountain and facing directly to the house creates funnel effect, air comes to house through holes in the wall. Most of wind flows from western. The house should orient to East - West to create cross ventilation. There are many houses in Keseneng whose long side orienting to North-South . There are many opens in the houses but most of the windows are closed to avoid cold wind from mountain. Consequently room temperature decreases so that the thermal comfort can't be got easily. This problem must be solved well.
   e. **Thermal Comfort of houses sampled**
      Thermal comfort is influenced by air temperature, humidity, wind speed, and the cloth wore by the people. Air condition can be said to reach thermal comfort if the people don't feel cold or hot. People need heater to increase room temperature at level of comfort. At 04.00 pm, the temperature must be at 2 c, at 06.00 pm the temperature must be at 4 c, and at 08.00 pm the temperature must be at 5,5 c

RECOMMENDATION

1. Javanese culture as guidelines to build a house must be treated flexibly, follow the technology and science development. Javanese houses can be perfected by adding certain design to respond to tropical condition, especially in Dieng Plateau. The behavior to burn wood in the house can create pollution. It must be solved.

2. Toward an ideal effect of climate
   a. To catch radiation of sun, and to decrease the effect of blind of sun light, the use of metal as roof cover is very effective. It can condition the heat in the house. To protect from direct sun light and blind of sky color, people can build overstek along the house. The size is 120 – 200 meters.
   b. To avoid the fast mountain wind, the distance among houses should be close. However, the houses must be arranged in line to create tidiness and to enable wind come to the houses freely
3. Building houses in the mountainous area must be done wisely, especially in the Dieng Plateau, which has extreme temperature. Using a certain construction must be done intelligently to create thermal comfort.

   It is needed to conduct further research especially related to architecture and design. However it must not ignore the heritage of our ancestor in the architecture so that it can give special thing in architecture development in Indonesia.

REFERENCES

J Potter, R. de Dear, Field study to calibrate outdoor thermal comfort index: In : Biometeorology and urban climatology at the turn of the millennium. De Dear, Kalma, Oke and Auliciems (Eds.) World Meteorolical Organization, WCASP-50, WMO/TD-No.1026, Geneva, 2000, pp.315-320.
P.O. Fanger, Thermal Comfort, McGraw-Hill Book Company, New York, 1972

A.P. Gagge, R.R. Gonzalez, Physiological and physical factores associated with warm discomfort in sedentary man, Environmental Research 7 (1974) 230-242

P. Tisuisis, G.G. Giesbrecht, Prediction of shivering heat production from core and mean skin temperatures, European Journal of Applied Physiology and Occupational Physiology 79 (3) (1999) 221-229

The Effectiveness of The PMV Model in Predicting The Quality of Thermal Comfort in Learning Environment in A Warm Humid Tropical Zone, Presented at International Seminar of SENVAR 5th, 2004.

Peter Hoppe, Different aspects of assessing indoor and outdoor thermal comfort, Energy and Buildings, 34 (2002) 661-665.

Salleh, E, Passive-Solar Design for warm humid climate, Alam Cipta, Journal of Faculty of Design and Architecture, Universiti Putra Malaysia, Issue 6 June, 2004, 48-54.

Webster, P. J., and G. L. Stephens, 1984: Cloud-Radiation Feedback and the Climate Problem. The Global Climate, (Ed., J. Houghton), Cambridge University Press, 63-78.

Yimprayoon, C, Indoor Thermal Performance of Various Building Components in Tropical Climate Baan Ua-Arthorn Low-cost Housing Project. Architecture, Energy & Environment 2003 HDM. Lund.

Xie, M. Xhang, G., dan Xu, F. Ecological Technologies of a Chinese Tradisional Folk House in Hot-Summer and Cold-Winter Zone, ICEBO2006, Shenczhen, China. Renewable Energy Resources and a Greener Future, Vol. VIII-4-5.

Brager, G. S. dan R. De Dear, R,. Climate, Comfort, & Natural Ventilation: A new adaptive comfort standard for ASHRAE Standard 55, Center for Environmental Design Research. University of California, Berkeley, 2001.

Juhana. The influence of climate on the formation of architecture and thermal comfort staying home in the coastal tribes bajo bajoe bone South sulawesi. Faculty Of Engineering Architecture. UNDIP, Semarang, 2000.

Climatic Sustainability in Cyprus Architecture (Case study: Magusa city and Korucam village)

Noor Cholis Idham

Architecture Department, Universitas Islam Indonesia Yogyakarta

Phone: +62 274 898444 (ex.3200)

Fax: +62 274 895330

Email: noor.idham@uii.ac.id

Abstract

This paper discusses issues on sustainability development focusing on climatic aspects in two areas of Cyprus Island; *Magusa (Famagusta)* and *Korucam (Kormacit or Kormatiki)*. The purpose of this study is to discover the sustainability distinctions between city and village of the island. The two places were chosen in order to characterize those two dissimilar areas; Magusa represents eastern and city area, while Korucam represents western and village region. Examination rearranged is based on climatic theoretical framework from general to detail aspects of environmental control. The method of examination is proposed for comprehensive understanding trough macro to micro aspects of the issues. The sample pictures taken are according to common typology or general style of the buildings and its environments. Data from the two areas were examined based on their advantages and disadvantages then analyzed, discussed, assessed, and compared on every aspect of climatic sustainability. Although the paper does not signify to represent the whole island's acclimatization, the two objects are adequate in order to picturing the distinctive environment and the people. The result of the study shows that building acclimatization in Cyprus are widely divers. This paper signifies how Cypriots deal with climatic sustainability concern in the different case of part of the island's environments.

Keywords: sustainable development, climatic sustainability, Cyprus, Magusa (Famagusta), Korucam (Kormacit or Kormatiki)

Introduction

Building and its environment are the most important aspects on sustainability issues since it plays a significant role to the environmental impact related to material, construction, regional relation, to energy used. This wide-ranging impact accounts for 50 per cent of energy use, 40 per cent of raw material use, 50 per cent of ozone depleting chemical use, 80 per cent of land lost to agriculture and 50 per cent of water use (Edwards, B., 1999).

Focusing on energy use, the heating, cooling, and lighting of buildings are mostly accomplished by mechanical equipments since 1960s (Lechner, N., 1991) and dramatically increase up to recent time. The built environment therefore is the greatest sector consumes of energy where the construction and operation of buildings accounts for 50 per cent of all energy resources. Building is accounted as 'the least sustainable industry in the world' (Abbey, I. and Heartfield, J 2001, Edwards, B., 1999, Hawkes, D., 1996, Smith, PF., 2001).

Climate, in other hand, deters type of building should be constructed to the environment, especially for traditional and vernacular buildings. Vernacular and traditional building forms are the most actual samples for climate concern. Trough the world, vernacular buildings have been built and success to reduce the variety of local climates; to avoid the heat of the sun in hot climates, to preserve heat in cold climate, to pass the breezes when needed for cooling, and to avoid winds when unwanted in cold environment, to admit light for lighting and to keep out excessive light (Moore, F., 1993). Amazingly, these were accomplished by simple way and low energy usage.

In temperate climate, the need for cooling is as high as the need for heating. Mild climate only happens in short period of spring and fall, for the rest, energy is needed either for summer and winter. Especially for Mediterranean climate, where characterized by long and humid summer, the cost of energy for cooling in modern building is much higher rather than older building. The utilization of air conditioner or active cooling is necessity because many aspects in the building are significantly different with the old one. Thus because modern building, according to Moore, F., (1993) never became aware of locality and sustainability of the building.

People acclimatize themselves from the climate via their buildings. Form of building is modified mainly by climatic conditions and by methods of construction, materials available, and the technology, socio-cultural forces (Rapoport, 1969). Cities in recent days are greatly believed have less sustained compare to villages. Climate change where impact on expectations more comfort in summertime especially in modern building (Artman, N, *et.al,* 2008) even made worst of it. Furthermore, from 2020, the majority of people will live in metropolitan areas where most of incomes are generated (Keiner, M, 2005). For this reason how different people in slightly dissimilar nature in Mediterranean climate between city and village, developed their environment is interesting topic of this study. Buildings in both locations are range from traditional to modern type of building. How these buildings built related to these issues is aim of this study. The discussion then focused on sustainability issues related to building design and its environment as well as with the people.

Native Distinctions

Magusa is one of the main cities in North Cyprus. It's located in eastern gulf of the island as main harbor of the country. It was founded by King Ptolemy Philadelphus of Egypt in 285 B.C, ruling by Lusignan dynasty in 1300 A.D, by Venetian in 1400 A.D, Ottoman 1570 – 1878, by British 1878-1960, After Independence 1960-1974, and Turkish Cypriot since 1974. The walled city is the most important ancient civilization in its history took a place.

Korucam, in other side, is one village located in north-west of Cyprus Island. The village is inhabited by Maronite, the one of distinctive minorities of northern Cyprus. About 140 people could remain staying in the area after found them self as neutral party when clash was happened between Turkish Cypriot and Greek Cypriot in 1974 (www.cypnet.co.uk). Maronites are Catholic Christian people of Arabic origin, who came and settled into Cyprus 1200 years ago from Lebanon. They speak their native tongue a dialect Arabic, which is mixed with many Greek and Turkish words.

From these facts, the history and the origin of the people are different. Walled city of Magusa was developed by many civilizations and finally inhabited by Turkish Cypriot while Korucam was originally from its beginning developed by Maronite (www.wikipedia.com). This difference is also give great impact on the way people built their environment alongside with the natural condition.

Climatic Distinction

Cyprus is an island which is located in high latitude 34° 32’– 35° 42’ N and longitude 32° 15’ – 34° 35’ E. The island has temperate-mediterranean climate where the two places; Magusa/Famagusta (35° 06’N, 33° 57’E) and Korucam (35° 20’N, 33° 00’E) are situated and chosen for this discussion. These latitude position data show that the locations are in about quarter of the world, which means that climate is temperate. Since the other global condition such as water body or mass of land gives significant affection to the climate, the Mediterranean Sea, in this case, is also giving specific impact as Mediterranean-climate, which is characterized by long summer and short winter. Climatic data gathered from resources show the condition of Magusa as below.

Famagusta, Cyprus. (Elev: 0m Long: 033°57'E Lat: 35°06'N)

Climatic Data	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sep	Oct	Nov	Des
Avg Max Temp (°C)	15	16	18	22	25	28	31	31	30	27	22	17
Avg Min Temp (°C)	7	7	9	12	16	19	23	23	20	17	12	9
Hours of Sunshine	5	6	7	8	10	12	12	11	10	8	7	5
Hours of Daylight	10	11	12	13	14	15	14	13	12	11	10	10
Days with Rain	12	11	10	7	5	3	2	3	2	5	7	11
MonthlyRainfall(mm)	128	89	68	34	17	6	2	2	7	46	80	137
Heat & Humidity	fr	fr	nh	nh	nh	md	md	ht	ht	md	nh	nh
UV Index (Max)	2	3	5	7	9	10	11	10	8	5	3	2
Avg Sea Temp (°C)	18	17	17	18	21	24	27	28	27	25	22	19

Note; fr (frozen), nh (no heat), md (medium heat), ht (heigh heat)

Figure 1 Famagusta Climatic Data (based on sources on www.weather2travel.com & www.weather4travel.com)

Korucam unfortunately does not have sufficient climatic data on site. Climatic data from nearest place, which has some natural similarities such as sea level and land condition was decided to represent it. Argaka, the most available-similar nearest location, then has been assumed to have similar natural condition and climatic data. Argaka’s climatic data was taken in order to have possibility to examine the climate condition as comparative assessment for the two places mentioned above.

Argaka, Cyprus (Elev: 200m Long: 032°30'E Lat: 35°04'N)

Climatic Data	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sep	Oct	Nov	Des
Avg Max Temp (°C)	13	13	16	20	24	28	30	31	28	24	19	15
Avg Min Temp (°C)	5	5	7	10	13	17	20	20	17	14	10	7
Hours of Sunshine	5	6	7	8	10	12	12	11	10	8	7	5
Hours of Daylight	10	11	12	13	14	15	14	13	12	11	10	10
Days with Rain	13	12	19	6	3	2	2	3	2	5	7	12
MonthlyRainfall(mm)	126	94	74	36	23	10	5	5	6	40	65	128
Heat & Humidity	fr	fr	fr	nh	nh	md	ht	ht	md	nh	fr	fr
UV Index (Max)	2	4	5	7	9	10	11	10	8	5	3	2
Avg Sea Temp (°C)	17	17	17	18	20	24	27	28	27	24	21	19

Figure 2 Argaka Climatic Data ((based on sources on www.weather2travel.com & www.weather4travel.com)

From the above data, annual temperature of both locations is slightly different. Magusa climatic data represents eastern while Argaka data corresponds to western condition of the island. Magusa has warmer temperature rather than Argaka. It can be assumed that western area is colder rather than eastern one. For precipitation, western part is more rain than eastern part. Western part also has less heat but faintly more humid if compare to eastern part. Although the Argaka’s numbers is not on site data of Korucam, these climatic data are physically proven to be significant conditions in order to compare eastern and western climate of Cyprus.

Deal with sustainable issues; in general, designing emphasis should be concerned in deal with longer summer rather than shorter winter. It implies for both areas; May to October (6 months) is hot times, while cold session is only in December to February (3 months), and intermediate condition comes in March, April and November (3 months). Issues regarding to the climatic condition mainly is to maintain the coolness and then heat retention of the houses in summer by using macro and micro strategies from landscape to building scale.

Regional Aspects

Regional aspect direct to the location is where places depend on surrounding environment. The proximity to natural environment such as sea, river, lake, swamp, mountain, or jungle will affect greatly to the physical quality of spaces regarding to microclimate condition. Built environment such as city is also affected by the nearby places. As climatic zone in regional scale, the place located near sea is almost more pleasant rather than in the middle of land. Temperature will relatively less range or not significantly fluctuate in seaside cities. The water bodies also correlated to the forest and jungle near the place. Like water, forest will also contribute the humidity of the air, beside its ability to convert Carbon Dioxide to Oxygen.

Topography is physical surface condition of a place. Natural relief of earth including plate or mountainous surfaces, contour, and river structure are the subsystem of topography of a place. Topography affects the local climate since it influences the flow of wind for increasing or decreasing humidity of the air, which dictates rain.

Data	Advantages	Disadvantages
 Magusa city landscape	Sea side location: More stable climate	Less in climatic concern
	Flat surface: Easy construction, access	Air and sunbeam limitation
	Less natural resources: Using only local material such as mud and coral stone which is more sustainable	Limitation on building materials triggers modern-unsustainable ones
 Korucam village landscape	Mountainous near to sea location: Abundance natural resources of water, wood, etc	Accessibility problems
	Sloped topography: Easy to get air, sunbeam, view, etc	Not simple and costly construction
	Some natural resources: Easy to get materials	The excessive usage of natural resources

Figure 3 the Natural proximity of Magusa and Korucam (Maps source: Google Earth)

Green environment such as forest, jungle, and bush are the natural condition which affect the local climate and vice versa, e.g. forest in one part of an area can be as a bank of water. The water is not only means for the people but also as one of contributing factors affecting humidity and rain. In opposite way, the number of rainy days generates the number of threes and plans in the area.

The city of Magusa, in this case, is located near the bay on eastern tip of the island; has zero level from sea surface, has flat topography, and has relatively less significant natural resources. Its proximity to the sea water has driven relatively steady climate if compared to places in middle of the island such as Lefkosa (Nicosia), the capital of Cyprus. It means that climatic problem may not as high concern as Lefkosa. However, strong cold north-eastern winter wind from the sea might be a problem for causing freezing sensation in winter time. While summer breeze which contains high humidity from the Mediterranean Sea generates less body evaporation and causes uncomforted feeling to the people. Too much mosquito in summer is another problem caused by this condition. Design consideration on the built environment should take into consideration these summer and cold condition by proper orientation and space arrangement on the buildings.

Korucam town village, in other side, is located in north-western cape of the island. It stretches along southern slope of northern mountain of Cyprus about 340 m above sea level. Unlike a Gyrne (Kyrenia), a famous tourist destination in Northern Cyprus, which stretched in northern slope of the mountain toward to north side of the island, Korucam is located somehow hide from northern sea but facing to south in higher position instead. This situation affects the climatic condition of the village that tends to be dry rather than Gyrne, since rain cloud mostly from north and trapped in northern part of the mountain. In the other hand, south inclined slope and orientation have some climatic advantages related to sun and breeze that affect the sustainability of the area.

Urban aspects

City plan configuration is a form of the city according to city's elements arrangement such as buildings, streets, and open spaces. Building and other city elements arrangement will produce solid and void spaces. The building configuration related to size and proportion results ground coverage of the city. It means that the impact of sun and rain can be managed by building arrangement. Because of this, the microclimate of older city and modern one is different.

Outdoor space is space left behind the building in a place or city. The condition of outdoor space depends on the quality affected by the man-made and natural elements. Factors affecting outdoor space quality are quantity of space itself and inside of it such as ground covering material used, street system applied, and trees-plants concerned. Using outdoor sustainable-climatic materials, which are matched with the need of environment will direct and give great impact to the climate.

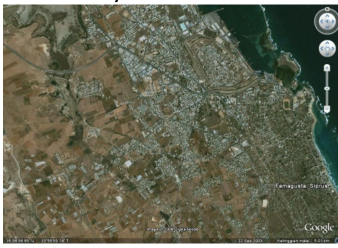
Data	Advantages	Disadvantages
 Walled city	Seaside City plan: the proximity to water transportation Walled City: Physical and natural protection	 Fresh water problem Sea water intrusion Less accessibility and may climatic limitation (breeze, sunbeam)
 Extended Magusa city	Enlargement of walled city plan: Continuation of old previous city Unplanned city development: Natural development	 Modern-non contextual development with the existing city Uncontrolled development
 Korucam village	Original village plan: Simple and natural-friendly development Organic development: Matching to the nature Social context development: Matching with the people needs	 May as 'unplanned & uncontrolled development' May has complicated infrastructure system Tend to enclosed, exclusive neighborhood

Figure 4 City plan of Magusa and Korucam (Map Source: Google Earth)

The first developed city of Magusa, the walled city, is an early primary city that located near the bay. Trading activities and defense purpose are the main reasons to locate the city. The old wall city was originally built for protection purposes as fortification of the city. Additional and enlargement of outer the city is also stretched along the coast itself. The old city is characterized by narrow street, small-compacted building, and earthen material used while the outer wall development is tend to follow 'modern' style characterized by bigger and higher building, wide street, and modern material as glass and concrete. In relation to climate acclimatization, the old walled city seems to be more appropriate. Narrowed street will offers more shadow and constructs more human scale rather than wide one, while small buildings with earthen material could restore heat enough rather than hollow brick, concrete and specially glass.

The town village of Korucam in other hand is open-end developed village, which was driven by the surrounding natural condition. Mountainous and slopped area has affected development of the village. The sloped sites tend to incline to the sea side which is facing toward south-west of the village. Sunlight and sea breeze are abundant by this slope orientation. The mountainous background in northern part not only acts as barrier from north cold wind intrusion but also serves as natural resources contains wood and water. Sloped and narrowed streets give the village proper shadow and direct breeze penetrate to inside of the village. This sloped also useful for draining the rain, which is higher than eastern part of the island.

Neighborhood aspects

Type group of buildings or typology will give significant impact to the local climate regarding the size, height, color, and material used. Accumulation of buildings covering will affect directly to the land by blocking the sunlight and rainwater to the ground, which affect the capability of the earth to absorb or to reject it. If water is directly rejected from earth, the capacity to hold rainwater then will decrease. It would not only decreasing the source of soil water but also creating more floods in lower area. Color of group buildings also contribute their capability to absorb or reflected the sunlight which is also will give significant impact to the climate as well as the level of permeability of the material related to its capacity to absorb rainwater.
Relation among these buildings is also affecting the local climate of a building. Building standing next each other without concerning the capability to gain fairly the natural resources will affect different space quality. Spatial arrangement will either block or penetrate the sunlight, wind, noise, smell, etc. to the environment.

Data	Advantages	Disadvantages
 House in walled city of Magusa	Small compacted house: Keeping heat capacity, no need more heat in winter	May not fit the bigger function
 Narrowed-shaded street in walled city	Small squeezed buildings: Keeping 'humanistic' scale space Small space between: Keeping cool by shadow but still have chance to get sunbeam in winter time	Problem with disaster events such as earthquake and fire May have problem with access limitation for emergency purposes
 sunny street gathering	Multi purposes street: Street not only as a accessibility space but also as social space	May class with street traffic
	Multi levels flat house: May fit with economic reason of land use High buildings: Fixed buildings arrangement	Public space lost and less privacy Unfair shaded area; either always shaded or never shaded

Flats in City of Magusa	All facades orientation:	
	May easier exterior air and day lighting access	Not fit with the natural orientation of sunbeam, breeze, etc
	Wide space of street:	
	Fit with the modern auto traffic Vegetation space	Never shaded street Lost human scale
Wide street of New Magusa		
	Single floor house:	
	Not to obstruct the site and neighborhood	n/a
	Inclined roof:	
	Deal with the higher number of rainy days	n/a
	Terrace / semi open space:	
One story houses of Korucam	Maintaining sunbeam in winter but shaded in summer	n/a
	Compacted two stories house:	
	Maintaining cool and heat by smaller space	May using modern material such as reinforced concrete
	Inclined and flat roof:	
	Utility function by concerning rainy days	n/a
	Semi open space:	
Two stories house of Korucam	As transition zone between outside and inside	n/a
	South orientation side street:	
	Left shaded protected space	Space left may lost orientation
Space left as narrow street in Korucam		

Figure 5 Building Types across Magusa and Korucam

The climatic sustainability of walled city buildings can be maintained by narrowed streets which offering shades, cool air, and screening sunlight. This narrowed street also functioned for replacing courtyard, not only in term of climatic purposes but also for social space usages. Unfortunately, these advantages are not easily found anymore in the modern style of buildings in enlargement of the town, which tend to neglect it but using the high energy-consume tools such air conditioner and electrical heater.

In the old city of Magusa, the traditional site organization including zoning, mass organization, and building orientation is unique according the old fashion; inner court, sundurma/sofa, fenced court. The building orientation to the narrowed street is also match with the climate since narrowed street can acts as inner court. However, the same approach cannot be applied to new development since the street is wide which is not possible taking the similar effect. The orientation to the potential natural climatic such as sunbeam and breeze is also less considered.

In Korucam village, houses are mostly located in the middle of the site. This creates front and backyard, which is more suitable in the climate rather than creating inner court or courtyard. Transitional space such as terrace using sundurma-like form is also used in Korucam. This is because facing lower sea view will have advantage to getting breeze and good panorama. South orientation is common for houses even though the street direction is north to south.

Mass organization is locating the building(s) on certain part of site and arranging them to achieve the most convenient function and space qualities. Mass organization also deals with the climatic aspect of building. Different climatic zone will have different solution in order to accomplish the best microclimate of the building. Mass organization can be done either by the building or room function connectivity or (and) climatic concern. Open spatial arrangement is preferable more in warm humid country since air movement is important, while closed organization will match in hot arid climate to share shade and block the sunbeam.

Data	Advantages	Disadvantages
 The building sites of Old Magusa	Proximity to sea: More stable climatic condition Covered by high wall: Protected from high speed wind Located in high density simple neighborhood: Climatic advantages	Limitation to water resource Lack of breeze Open space limitation May has problem with accessibility (emergency)
 The sites in Magusa town	Proximity to sea: More stable climatic condition Located in high density complex neighborhood: n/a	Fresh water limitation Strong wind disruption Less in climatic concerns
 The Village sites of Korucam	Located in slope: Has several natural advantages and resources Behind northern mountain: Protected from northern cool climate Oriented to south-western: Facing natural advantages	May not simple arrangement May less in rain and water resource n/a

	Located in slope: Easy-direct access to breeze and view, simple drainage system	May not simple construction
The Building site of Korucam	Oriented to south-western: Easy-direct access to sunbeam	n/a

Figure 6 Site Location according the Town and the Village

Site aspects

Site orientation is more subjected to advantage resources such as view, breeze, and sunlight. A site can have more than one orientation according to surrounding environmental condition such as contour and vegetation. In some cases, orientation of site is not always linking to slope but more concerned to other natural or man-made object such as street, river, or lake which also affecting the level of comfort.

The quality of site also depends on the location as ideal site as in strategic position. The site oriented to the sea is preferable since there is no significant block for sea breeze. However, for walled city such as old Magusa, the chance to get breeze is somehow blocked by the surrounding high wall. Unfortunately, to find free seaside outside the walled city is also not easy since most of the beach areas near the city are used by Turkish army.

Data	Advantages	Disadvantages
	Flat contour: Simple construction	Less accessibility to breeze and sunbeam
	Mixed orientation: Easy to street access	Less concern in sun-path orientation
Site landscape of Magusa	Some limitation in vegetation: n/a	No chance to vegetation in dense area
	Sloped contour: Easy to breeze and sunbeam	May not simple construction
	South orientation: Great concern in sun-path orientation	n/a
Site orientation of Korucam	Slope vegetation: Great opportunity for vegetation chance	n/a

Figure 7 Landscape variation in Magusa and Korucam

In Korucam case, since it is located in slope of the hill, the natural advantages of exposing summer breeze and winter sunbeam can be accessed in most part of the site. Sloped site facing to southwest direction is the most preferable location since it has many advantageous in climatic aspects.

Contour is the level difference of site surfaces. Site contour ranges from flat to very inclined slope. In some cases, contour also waved and sloped to different side. The level or type of slope can directly affect the microclimate of built environment since breeze and sunlight will diver the quality of acclimatization in different contour. Beside view from and to site, rain water and snow are also greatly driven by site contour. Thus, in this case, little bit sloped site is more preferable rather than completely flat one.

Because there is no significant sloped contour in Magusa, and vegetations are rarely, the site orientation then not depend on natural condition. Man-made objects are the most preferable orientation such as street and important buildings. Natural climatic adaptation for these built environment related to site orientation is less concerned.

In related to landscape issue, sloped site in Korucam triggers some advantageous aspects such as orientation to good view, breeze, and even for sunbeam since the direction of Korucam's slope is directed to south-west. The vegetation is abundant since the climate is wet. For these reasons buildings located in Korucam sites are having unlimited natural advantage.

Data	Advantages	Disadvantages
 Site usage of Magusa's buildin	Maximum site-used zoning: Small space concerned to climate condition (more shaded area)	Less open air space, less vegetation possibility
	Mono block-compacted mass organization: Small mass concerned to long hot and short cool climate (thermal lag)	No inner court for air and shaded light
	Mixed building orientation: May flexible in orientation	Less concerns in climatic orientation
 Site plan of Korucam's building	Building-space site zoning: More open space created	Less shaded space
	Open mass organization: Easier to choose orientation	May need more space for buildings
	Building south orientation: Match with the climatic condition	May not fit with the street orientation

Figure 8 Site Plan Varieties in Magusa and Korucam

Building aspects

Buildings in city of Magusa are characterized in two main types; the 'original' and the 'international'. However, the original type based on Turkish Cypriot traditional type of building seems little bit different with original traditional Turkish house, but not more than two floors in height, relatively small in size, utilize less veranda inside (sundurma and sofa), and rarely completed by courtyard in the backyard. Because of site limitation inside walled town, the courtyard and semi open space such as sundurma or sofa founded rarely, instead, balcony or projected windows (Jumba) is easily founded. Another reason way open space as sofa is rarely founded because the changing function as commercial space as shops. Orientation of building is also important for the acclimatization. Orientation to climate condition is one of successful keys for building design. Climatic orientation related to sunlight and breeze is mostly preferred to increase comfort quality.

Village buildings in Korucam seem completely different with the common traditional northern Cyprus houses. Instead having courtyard, the houses in the village are mostly have garden either in front or in back yard. Some gardens even wide enough since the village's site availability is more. The houses itself are mostly constructed in one and two floor levels. Inclined roof is easy to be found rather than in Magusa. Social activities are mostly done in their yard. These characters are affected by the climate itself which is more friendly compare to eastern one.

Form of building is defined by many determinant factors. Some of these are including function, structural system, construction technique, and climatic condition itself. Building form concerning the climate will have definite form in order to maintain comfort. Small-compacted form is more preferable for cold area while bigger space is fine for hot humid climate.

Data	Advantages	Disadvantages
 Older building envelope of walled city	Simple envelope forms: Concerning climatic aspects, easy to construct	n/a
	Almost no shadings: May as simple construction	Some problem in opening in summer time
	Small openings: Keeping steady air inside	Less sunbeam in winter
 Newer building envelope of walled city	Complicated envelope forms: Sunbeam-shading opportunity	May has to be constructed by modern material and construction
	With shading devices: Space arrangement between summer and winter time	May over shaded in winter
	Bigger openings: Sunbeam opportunity in winter	Relatively unsteady temperature, usage of electrical cooling/heating
 The envelope-street relation	Use of balcony: Sunbeam and breeze opportunity	May resulting privacy obstruction if frontal orientation
	Street shaded: Protected street	Decrease chance to sunbeam in winter
 Openings in walled city	Small openings: Keep steady air inside	
	Un shaded openings: less construction system	Resulting overheated in summer
	Higher openings: Hot air exhauster May be more in privacy and security	Less view
	Wide openings:	

	Easier to get sunbeam in winter	Overheated in summer
	Use of shadings:	
	Protected the openings	Concern to size of shadings
	Use of balcony:	
	Useful space for both winter (to get sunbeam) and summer (to get breeze)	May be as hindrance for light and air to the interior
The opening envelope of flat building	Some low openings:	
	View and light availability	May obstruct interior thermal comfort and also privacy
	less walled building:	
	light construction structure and less seismic vulnerability	Glass-house effect
	No openings for air:	
	May less climatic effect from exterior	Artificial systems needed
	No shadings:	
The glass envelope of commercial building	May be simpler construction	Overheated room

	Varied envelope forms:	
	Small simple envelope related to steady air inside	Less room availability
	Shading alternated by wall thickness:	
	No need of special construction for overhang	May still need shadings concern to the wider openings
Korucam building envelope small-high opening	Small openings:	
	Useful for steady air inside	Stagnant air circulation problem
	Bigger windows:	
	Sunbeam accessibility	May has obstacle to keep steady temperature inside
The finished building envelope of Korucam	Thick wall openings:	
	Give shaded opening Give protected opening Give some other function (windows vegetation, artistic appearance)	May related to expensive wall construction (thicker) for new buildings
Thick wall opening in Korucam		

Figure 9 Building Envelope variety in Magusa and Korucam

Building envelope is related to form and material of building perimeter. This envelope will govern the ability to pass, hold, or reject some physical aspects such as heat, cold, rain, air, etc. Shading and opening is building envelope components that deal with the way sunbeam, sunlight, wind, and air will be rejected, passed, or hold. In deal with climatic condition, shading and opening is quietly different each other. Since sunbeam and humidity issues are important, in hot arid area, small unshaded windows are preferable while in hot humid big and shaded window is necessary.

In modern Magusa, the building form is mostly bigger rather than the old ones. Since the compacted small space is needed in modern life, the utility of artificial cooling and heating is necessary to cover air circulation, temperature and humidity. This was not a problem to the old building where can acclimatize themselves. Shading and opening devices were always concerned to the natural climate, the level and size of shading devices for any opening in old house always be considered while rarely for the modern buildings.

In Korucam the size of building is mostly bigger compared to walled city Magusa. This is because the land availability and also related to the climate condition such as humidity. A village people activity which is based on agriculture was also another reason for the bigger space in the building. More humidity need more space volume in order to create more comfort room. In deal with the envelope, instead of having overhang where wood material and complicated details is involved, thick walled openings were used to have similar effect in order to create the shadow. This is a appropriate way to sustain with the nature.

Building materials aspects

The most detailed factor of building construction is building materials. This detail aspect will have great impact to level of building climatic acclimatization. Non-appropriate building materials are also costly.

Roof is a part of a building, which deals mostly with the force of nature. Sunbeam, wind, rain, and snow are climatic phenomena which force the building. Hot arid climate without harsh rain and snow will use flat and non waterproof material such as mud. While tropical and temperate country will have inclined roof with waterproof materials such as thatch or straw roof.

In some climatic conditions, wall also acts as the first barricade to the nature. Wall material is also important in order to deal with nature and micro climate of the building. For the extreme hot or cold climate region, even wall is the most important building element. Material used to construct building wall in hot or cold area should has long thermal lag in order to keep heat as long as possible. Earth-massive material such as rocks and mud is preferable since its thermal lag is higher. In opposite way, since heat dissipation is needed, the low thermal lag or permeable material is more preferable.

Opening is tool for a building to rule the quality and quantity of sunbeam, sunlight, wind, and even noise outside-inside the building. Material used should be match with the need of building to control some aspects related to certain climate condition. Windows and doors can use different material starting from solid to transparent, massive to permeable, or heavy to light. These options will deal with how sunbeam, sunlight, and wind will be control.

Data	Advantages	Disadvantages
 The old building material of walled city	<u>Roof materials:</u> Inclined roof (old: tiles, new: corrugated metal, corrugated asbestos) and Flat roof (old: earth, new: concrete) Older material has higher thermal lag rather than new ones <u>Wall materials:</u>	Less in age cycle Less in appearance Less hygienic form and space Less in water or weather proof Less in durability

	Older stone and earth also has longer thermal lag Wooden opening materials: No glass house effect	More in maintenance n/a
 The building material of new Magusa's building	Flat concrete roof materials: May as additional useful space Hollow bricks wall materials: Lighter materials and easy to construct Glass opening materials: better view	Decreasing air volume will affect to air circulation Small thermal lag of the material and less insulation need active heating and cooling Source for overheating
 The modern material of commercial building in Magusa	Glass, steel, aluminum, as modern materials: Deal with mass product and construction efficiency	May has extensive structural system Less thermal lag, less other physical barrier (sound, fire, etc) As one of resources for thermal unsteadiness Almost these modern materials are not sustainable in term of production, transportation, construction, function use, and after use process
 The original material of Korucam	Roof materials: Roof tiles seems preferable in deal with more rainy days Wall materials: Stone and mud-soil is abundant and match with the climatic condition Opening materials: Wooden material for openings will not create glass-house effect to the interior	May become permeable skin with less isolation purpose Routine maintenance consideration Limitation on sun lighting Material durability problem
 The new combined material building in Korucam	Combined materials: It has opportunity with the new application of materials	May problem to the appropriate material usages

Figure 10 Building Materials' variety used in Magusa and Korucam

Since precipitation level is low, material used in roofing is less considered rather than for wall. Building material for modern Magusa, like any other modern towns and cities in the world, uses the modern materials such as reinforced concrete and even glass wall while on the old city the earthen materials are used. Cooling process in long summer needs high thermal lag material in order to buffer the heat and to restore it. In winter mass protection will be achieved by the materials. This is a common principle in passive building where can be found easily in vernacular buildings but rarely in the modern ones.

Stones are the abundant material in Korucam. As earthen material, stonewall is useful to keeps the heat and then radiates after some times (mostly in the night time) and vice versa. This is very useful in this kind of climate condition where hot still longer than cold season and temperature between the day and the nighttime is significantly different.

Conclusion

As result of this study, the sustainability in two different parts of Cyprus Island has some different findings. In general, the older building and its environmental arrangement is more sustainable compare to the modern ones. In term of comparison, either the city of Magusa or the village of Korucam has its own advantages in sustainability aspects where the village is account for more appropriate in the climate accommodation. Climatic condition and social aspect differences have driven specific acclimatization of the people trough the buildings. Slightly dry and hot Magusa, flat beach site, combined with Majority Turkish Cypriot and others compared to slightly wet and cool Korucam, sloped mountainous site, occupied by Maronite habitants has affect the form of the built environment.

In Magusa, where original city was located in walled area many sustainable principles can be found easily especially in term of acclimatization to the nature. Although un-sustainability development in metropolitan areas worldwide is characterized by the continuing use of agricultural land (Storch, H 2007), since the land is less fertile and agriculture activities are rarely found nearby, this issue is insignificant here. However, degradation in term of sustainability between old and new inside the wall itself and outside specially is existent. The newer development, just similar to other cities in the world, seems neglected the natural-local aspect.

In Korucham in other hand, since it is located in the remote area as a village and inhabited by small number of distinctive people, seem has sustainability to its nature context also but has certain different approach in some aspects. The proximity the natural resources and location advantages has driven the proper acclimatization to the environment. However, newer development must be driven also to keep maintain this sustainability principles.

Although building (dwelling) form directly related to economic activity rather than climate (Rapoport, A., 1969); or it was built in order to meet needs, to accommodate the values, to spend economies and to confirm ways of living of the cultures (Oliver, P., 1997), the result of this study shows one again that sustainable development is much easy to be found in vernacular or traditional built environment. For thousands of years vernacular society have constructed their own buildings in keeping with their antecedents, environment and needs, and by themselves sustainability issues are answered (Senosiain, J., 2003). Beside climatic reason, any project on sustainability must be based on the needs of the community by facilitate into the design and sustainable policies (Keiner, M., 2005).

Old town, village, and house have their own natural and social characters that really affect the form of built environment. All these challenge the modern development to more sustainable with the all advantage of modern technology may be used. To be in harmony with environment, in modern development we must do by choice what our ancestors did out of necessity (Oktay, D., 2001). 'Design with the climate and with a sense of place' is the key of sustaining qualities of the natural context of site and surroundings

Acknowledgements

This paper was one of results of my research of my postgraduate studies in Eastern Mediterranean University of North Cyprus. My sincere gratitude is delivered to my mentor on sustainable architecture coursework; Professor Deriya Oktay who inspired me to write this report, and Professor Erdal Aksugur for his expertise in environmental control subjects.

References

Abbey, I., & Heartfield, J. (2001), Sustaining architecture in the anti-machine age, Great Britain: Willey Academy.

Artmann, N., *et.al.* (2008), Impact of climate warming on passive night cooling potential, Building Research & Information,36:2,111 — 128

Edwards, B. (1999), Sustainable architecture; European directives & building design, 2nd edition, Great Britain: Architectural Press.

Hawkes, D. (1996), The environmental tradition; Studies in the architecture of environment, London UK: E&FN Spon, Chapman & Hall.

Keiner, M. (2005), Sustainability oriented urban development. A general introduction with case studies from Gaborone, Johannesburg and Santiago de Chile. Eidgenössische Technische Hochschule Zürich, Institute for Spatial and Landscape Planning

Lechner, N. (1991), Heating, cooling, lighting; Design methods for architects. Canada: John Willey and Sons, Inc.

Mc.Lam, W. (1986), Sun lighting; As form giver for architecture, New York: Van Nostrand Reinhold Company.

Moore, F. (1993), Environmental control systems; Heating, cooling, lighting, International Edition. Singapore: McGraw Hill.

Oktay, D. (2001), Planning housing environments for sustainability; Evaluations in Cypriot settlements, Istanbul: Yapi Industri Markezi A.S.

Oliver, P. (editor). (1997). Encyclopedia of vernacular architecture of the World. vol.1, United Kingdom: Cambridge University Press.

Rapoport, A. (1969), House form and culture, Englewood, N.J: Prentice-Hall, Inc.

Senosiain, J. (2003), Bio-Architecture. United Kingdom: Architectural Press.

Smith, PF. (2001), Architecture in a climate of change; A guide to sustainable design. United Kingdom: Architectural Press.

Storch, H (2007), Assessing the Spatial Dimension of Sustainability in Asian Megacities: An Indicator-Based Approach, REAL CORP 007 Proceedings, ISBN: 978-39502139-3-5, 835-844

http://www.cypnet.co.uk/ncyprus/people/cypmaronites/index.html

http://www.ethnologue.com/show_language.asp?code=acy

http://en.wikipedia.org/wiki/Cypriot_Maronite_Arabic
http://en.wikipedia.org/wiki/Famagusta
http://www.weather2travel.com/climate-guides/index.php?destination=famagusta
http://www.weather2travel.com/whentotravel/index.php?destination=argaka
http://www.weather4travel.com/travel-weather/index.php?destination=famagusta
http://www.weather4travel.com/travel-weather/index.php?destination=argaka

Community Engagement: The Pending Pressing Topic for Engineering Education

Fouad Kamel[1], Faeka El Sayed[2]

[1]*Department of Electrical & Computer Engineering, Faculty of Engineering & Science, Curtin University Sarawak, Malaysia, Phone W: +60 85 443816,+60 85 443822,*
E-mail: fouad.kamel@curtin.edu.my

[2]*Faculty of Business, University of Southern Queensland, Toowoomba, Queensland, Australia*

E-mail: fes232@yahoo.com.au

Abstract

The destruction of nuclear power plants in Japan due to the Tsunami in 2011, the oil leaks in the gulf of Mexico in 2010, the overwhelming expansion of communication towers and power transmission lines and many other examples of engineering projects made communities at large sensitive to engineering projects. It is likely to be increasingly challenging to initiate, plan, finance and implement engineering projects, large or small, due to community and public opinion apprehension. Accordingly, a major field of skills for engineering education, which seems increasingly imposing, is community engagement. Those skills shall allow engineers address issues of relevance in projects that, in the life span of a project, concerned communities will be raising. In contrast, such skills shall enhance the competencies of engineers for transforming every project into a community serving one, with indispensible benefits to the community at the present and for future generation. A project, which e.g. secures better roads, transportation, education and health care, is a well regarded project to almost every community. On the other side, to an investor, those community beneficial actions are merely added cost. This study presents types of competencies, analytical and managerial, which engineers need to acquire in order to be able to present a project and secure backing from communities and stakeholders. Needed competencies include new experts with fresh ideas, analytical approaches, interdisciplinary R&D skills, and intimate ability to lead to a harmony: Community, Environment, and Economy. The purpose of this paper is to give an outline of key principles and processes of community engagement competencies and to identify the importance of community engagement contents into the engineering curriculum.

Keywords: Community Engagement, Engineering Education, Project-based Learning

Introduction

On 11 March 2011, a 9.0 magnitude earthquake off the north-eastern coast of Japan – the strongest ever recorded in the country – triggered a tsunami of up to 30 meters in height that washed up to 5 kilometres inland, resulting in massive loss of life, environmental devastation and infrastructural damage. The tsunami also damaged the Fukushima nuclear power plant, leading to serious risks of contamination from radioactive releases into the environment [1]. On April 20, BP's Deepwater Horizon oil rig exploded in the Gulf of Mexico, killing 11 workers and commencing months of oil leaking unrestrained into the ocean. Efforts to manage the spill with controlled burning, dispersants and plugging the leak were unsuccessful until BP capped the well in mid-July, temporarily halting the flow of oil into the Gulf. The well was then successfully plugged and declared "effectively dead" on September 19 [2]. Communication towers in North America kill millions of birds annually [3], and most of these are Neotropical species that migrate at night [4], [5]. Estimates of total annual mortality in the United States are about 4–5 million to an order of magnitude greater [6], [7]. This and many other examples of engineering projects made communities at large sensitive to engineering projects. It is likely to be increasingly challenging to initiate, plan, finance and implement engineering projects, large or small, due to community and public opinion apprehension.

Community engagement at least in planning and construction stages of a project is essential in order to secure backing from communities and stakeholders [8]. At the present, in many countries environmental impact assessment (EIA) became mandatory prior the construction of such projects. Engineers play a vital role in delivering these projects and they need to engage the community during the project planning, design and construction period, even sometimes during the project operation period. Community engagement involves communicating with a community group and facilitating to empower community members' interests. This creates a demand to share the development issues, working closely with the developing party [8].

Hence Engineer students need to learn the principles and processes of community engagement through to a proper training and/or education course at post graduate or undergraduate engineering education.

Community serving engineering projects with evidenced longevity and sustainability get likely approved and supported by the pertinent community. Such projects are expectedly internalized and thus defended by the community. Thus, engineering curricula that emphasize physical, social, economic and environmental analytical competencies are regarded to deliver successful future engineers.

In previous studies [9] large-sample surveys have measured competency deficiencies in engineering graduates that in Europe and US the largest indicated gaps were in communication, leadership, and social skill. And in an international survey from 63 countries the study showed the rating for quality management methods, project management methods, management skills, effective communication and leadership indicated relatively high deficits.

Universities should take their roles educating the energy managers by restructuring their second tier of engineering programs. Engineering curricula whose graduates will thrive in practice must develop *competencies* beyond the traditional emphasis on “math, science, and engineering knowledge” [10].

This study addresses and suggests types of competencies needed to be involved in engineering curriculum, which could support engineer in their community engagement’s roles. Curriculum can be designed to address these competencies:

1. Analytic competencies
2. Managerial competencies
3. Interdisciplinary R&D
4. Leadership competencies
5. Understanding the community

In the following a description of the above competencies:

Analytic competencies

Engineers need to demonstrate ability to explore, quantify, plan and manage resources in a sustainable fashion. Besides, successful engineer possesses the ability to investigate, understand, value and serve the community in a way to achieve community appreciation and engagement.

A person with these competencies regularly questions basic assumptions about work and how it gets done, identifies underlying principles, root causes, and facts by breaking down information and data and their implications, and draws conclusions based on analyses. Acquiring those skills engineers may understand the complexity of certain issues and crystallize the components of those issues to make them more manageable by applying sound reasoning, [11]. The following illustrative behaviours summarize those analytic competencies:

- **Illustrative Behavior 1:** Challenges established thinking, processes, or protocols with company success in mind.
- **Illustrative Behavior 2:** Quickly and systematically analyzes the root cause of work-related problems before taking corrective action.
- **Illustrative Behavior 3:** Recognizes and communicates the implications of data/information.
- **Illustrative Behavior 4:** Is able to clearly frame a problem, identify and collect the necessary data, and make recommendations for solving the problem.
- **Illustrative Behavior 5:** Takes complex issues or problems and breaks them down into manageable components.
- **Illustrative Behavior 6:** Understands how data and recommendations may impact other functions and departments.
- **Illustrative Behavior 7:** Relates problems to one another and to strategic objectives to recognize opportunities for dealing with several related problems at the same time.

Managerial competencies

Employee Development Systems Inc. [12] summarizes managerial competencies in the following skills/elements:

1. Appraising People and Performance
2. Disciplining and Counselling Employees
3. Listening and Organizing
4. Setting Goals and Standards
5. Thinking Clearly and Analytically
6. Giving Clear Information to Employees
7. Getting Unbiased Information
8. Identifying and Solving Problems
9. Making Decisions and Weighing Risks
10. Planning and Scheduling Work
11. Training, Coaching, and Delegating
12. Time Management and Prioritizing

Successful engineers are good managers of demonstrated ability to operate projects to achieve the following:

1. timelines
2. cost constrains

3. mange diverse human resources
4. mange natural resources in a sustainable context
5. professional standards
6. governmental regulations
7. Long-term harmony among community, economy and resources.

Interdisciplinary R&D

Contemporary technologies are by nature interdisciplinary. Control and computer engineering for instance are currently common ground for electrical and mechanical projects. Mechatronic and system engineering are typical modern applications for multidisciplinary amalgamation of electrical, electronic, mechanical, physical, chemical and environmental knowledge. Likewise, environmental engineering in many instances is encompassing civil, ecological, water and energy engineering in addition to social science. Engineers are expected to provide interdisciplinary knowledge and expertise besides extended competency for R&D in wide-range areas of mingled expertise.

Alves el al. [13] Identifies conditions to promote academia-industry interdisciplinary R&D. Changes in organizational design, in motivation and team capabilities are necessary. First, an appropriate organizational design and a strategic vision are crucial. It is necessary to create structures dedicated to the support and promotion of interdisciplinary R&D initiatives in the academia or between academia and industry, with a horizontal view that allows generalist discussion, facilitates contacts and helps organizing and inspiring interdisciplinary R&D teams [14], [15]. It is also essential to define a global realistic interdisciplinary R&D strategy and promote a small number of specific interdisciplinary R&D projects with sufficient charisma and mobilizing potential to succeed and to lead to the appearance of more similar projects [16], [17], [18].

Second, it is indispensable to motivate and mobilize researchers for interdisciplinary R&D. It is important to create opportunities for regular informal gatherings between researchers from various disciplines, where people can meet, talk, change opinions (i.e. organizing thematic meetings on issues of interest of various disciplines). These encounters create trust, open communication and stimulate partnerships [14], [17]. It is also important to distribute relevant information about: a) the necessities of the industry, the competencies of the academia and their work practices and b) success cases of interdisciplinary R&D, which helps acknowledging that this type of R&D is possible and brings benefits [17]. The existence of an effective academic reward system that recognizes the importance of interdisciplinary R&D and has instruments to evaluate the results of research activities (new products, new solutions and new scientific production) can help overcome the lack of motivation [17],[19], [16].

Finally, the complexity associated with the functioning of interdisciplinary teams can be tackled through different means. Training in specific areas (i.e. interdisciplinary team management, principles and ways of functioning of interdisciplinary R&D, etc) allows shaping the behaviour of the individuals and also helps to better manage and organize interdisciplinary team work [17], [18], [20]. A clear definition of the organization, functioning and monitoring of interdisciplinary R&D team activities (task definition, responsibilities, procedures, control mechanisms etc.) allows for the optimization of the communication processes (and of the inherent knowledge share) and for the evaluation of team performance [21], [14]. As interdisciplinary R&D is a group process, careful selection of researchers is essential. This goes on two levels. It is important to choose individuals with particular characteristics (i.e. he/she shows interest in other fields and is ready to ask for explanation and test ideas and concepts, has strong communications skills and is willing to work cooperatively and learn), which helps overcoming the communication barriers inherent to these projects. It is equally important to ensure the complementary of participants' knowledge, thus increasing the efficacy of the process and ensuring optimum knowledge integration [21], [18].

Overall, if interdisciplinary R&D is to be promoted, as advocated by the academic political discourse, universities must change their management practices and adopt and implement strategies to pro-actively promote interdisciplinary R&D, defying established cultural and behavioural patterns.

Leading competencies

General definition for engineer leadership is the aptitude to demonstrated skills and abilities needed to coordinate, facilitate, and participate in a collaborative approach to the completion of tasks or assignments [22]. Due to the competitive nature of engineering activities, industry is demanding not only technically proficient engineers for their companies but also engineers that are prepared to take on leadership positions ([23]. To be effective leaders, engineers must possess the 'soft skills' necessary to solve business challenges. Crumpton-Young [24] claimed these skills include written and oral communication, self initiative, teamwork abilities, customer relations and decision making. During the preliminary stage an engineering student group was assigned a teaching episode to present to peers in the classroom context. [25], [26] stated there is ample evidence that graduate engineers lack the required standard of communication skills, particularly when compared to the needs of industry internationally. [27], [28] argued this can be traced back to engineering education curricula which predominately focused on scientific and technical knowledge at the expense of communication skills such as negotiation and presentation.

Understanding the community

It is vital for engineers to develop an understanding of the community or industry they are working in or with and its values [29]. Engineers seeking to be involved with communities without awareness may not create successful outcomes.

Gibbings et al. [30] described a research project to develop a model based on a regional university's investigation of a strategic alliance with the extractive energy industry to engage high schools in the local communities in engineering related activities, and ultimately to encourage participation by students in higher education. A key component of the model and adopted strategy was the design and conduct of engineering camps. This involved year 10 to 12 students in 2010-2011, from 13 regional high schools attending the university to work on real-life projects surrounding coal seam gas extraction. The planned outcomes would help to engage the local communities to industrial activities.

Goldfinch et al. [31] addressed issues of intercultural competencies in engineering. As a major component of this project, observational research techniques are being employed to assess the current state of intercultural competencies in first and second year engineering students. The research described a process to observe cultural interactions between students in first or second year design subjects. As well as establishing an overview of the current state of intercultural intelligence amongst engineering cohorts, these research outcomes are used to develop packaged teaching modules for developing intercultural intelligence amongst both engineering students and teaching staff.

Wideman [32] states: today's project manager also needs to be attuned to the cultural, organizational and social environments surrounding the project. Understanding this environment includes identifying the project stakeholders and their ability to affect its successful outcome. This leads to the possibility of influencing this environment in a positive way, for the better reception of the change which the project is designed to introduce.

Gossage [33] found in a study of Latino-Hispanic engineering students in USA that the students who were engaged with community based project were more positive to their community development as well as to involving the community in their future project planning and management.

Conclusions

The study presents a position: analytic competencies, managerial competencies, interdisciplinary R&D, leadership competencies besides understanding the community are essential faculties/skills engineers need to acquire in order to match a long-term sustainable development. This should allow engineers to be able to present a project and secure backing of communities and stakeholders. Needed competencies include new experts with fresh ideas, analytical approaches, interdisciplinary R&D skills, and intimate ability to lead to a harmony between community, environment, and economy. The paper presents outlines of key principles and processes of community engagement competencies and identifies the importance of including community engagement contents into engineering curricula. Emphasizing those competencies throughout engineering education ensures engineering practices appreciated by the pertinent communities.

References

[1] United Nations Environment Programme (UNEP) (2012), environment for development, Great East Japan Earthquake and tsunami. Internet entry: http://www.unep.org/tsunami/ accessed 29 May 2012.

[2] Green (2012), Louisiana Oil Spill 2010 PHOTOS: Gulf of Mexico Disaster Unfolds. Internet entry:
http://www.huffingtonpost.com/2010/04/30/louisiana-oil-spill-2010_n_558287.html accessed 29 May 2012.

[3] Travis Longcore, Catherine Rich and Sidney A. Gauthreaux (2008), Height, Guy Wires, and Steady-burning Lights Increase Hazard of Communication Towers to Nocturnal Migrants: A Review and Meta-analysis, The Auk, Vol. 125, Number 2, pages 485–492. ISSN 0004-8038. Internet entry:
http://www.urbanwildlands.org/Resources/Longcore_06-253.pdf accessed 29 May 2012.

[4] Banks, R. C. (1979). Human related mortality of birds in the United States. U.S. Department of the Interior, Fish and Wildlife Service Special Scientific Report—Wildlife No. 215.

[5] Shire, G. G., K. Brown, and G. Winegrad. 2000. Communication towers: A deadly hazard to birds. American Bird Conservancy, Washington, D.C.

[6] U.S. Fish and Wildlife Service. 2000. Service guidance on the sitting, construction, operation and decommissioning of communications towers. U.S. Fish and Wildlife Service, Washington, D.C.

[7] Erickson, W. P., G. D. Johnson, and D. P. Young, Jr. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. Pages 1029–1042 *in* Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference 2002 (C. J. Ralph and T. D. Rich, Eds.). U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-191.

[8] Delwar Akbar, Mohammad Rasul (2011), Community engagement in engineering education, Proceedings of the 2011 AAEE Conference, Fremantle, Western Australia.
[9] Male, bush& Chapman 2010, Perception of competency deficiencies in engineering graduates, Australasian Journal of Engineering Education Vol 16 No 1. Internet entry: http://www.engineersmedia.com.au/journals/aaee/pdf/AJEE_16_1_Male%20F2.pdf accessed 29 May 2012.

[10] Honor J. Passow University of Michigan Ann Arbor, Michigan, USA, 2007, what competencies should engineering programs emphasize? A meta-analysis of practitioners' opinions informs curricular design, Proceedings of the 3rd International CDIO Conference, MIT, Cambridge, Massachusetts, USA, June 11-14, 2007. Internet entry: http://www.cdio.org/files/document/file/T2A1Passow.pdf accessed 29 May 2012.

[11] Aztenk (2008) Core Management Skills and Competencies – Critical and Analytical Thinking, AZTENK – Business & Life Success Resources. Internet entry: http://business2success.wordpress.com/2008/09/26/core-management-skills-and-competencies-critical-and-analytical-thinking/ accessed 29 May 2012.

[12] Employee Development Systems Inc. (2012), Crucial Management Skills. Internet entry: http://www.employeedevelopmentsystems.com/media/pdfs/SkillsforManagers.pdf accessed 29 May 2012.

[13] Jorge Alves, Celeste Amorim, Irina Saur, Maria José Marques (2004), How to promote interdisciplinary R&D in the academia: the case of the "House of the Future" , Department of Economics, Engineering and Industrial Management, University of Aveiro, Campus Universitário de Santiago, 3810 – 193, Aveiro, Portugal. Internet entry: http://ria.ua.pt/bitstream/10773/6914/1/D.28.2004_R%26D%20Management%20Conference%202004_Paper.pdf accessed 29 May 2012.

[14] Naiman, R. (1999): A Perspective on Interdisciplinary Science, in: *Ecosystems*, 2, p. 292 – 295.

[15] Golde, C.; Gallagher, H. (1999): The Challenges of Conducting Interdisciplinary Research in Traditional Doctoral Problems, in: *Ecosystems*, 2, p. 281 – 285.

[16] Pickett, S.; Burch, W.; Grove, J. (1999): Interdisciplinary Research: Maintaining the Constructive Impulse in a Culture of Criticism, in: *Ecosystems*, 2, p. 302 – 307.

[17] Pellmar, T; Eisenberg, L. (2000): Bridging Disciplines in the Brain, Behavioural and Clinical Sciences, Washington D.C.: National Academy Press.

[18] Bradley, E.; Hoeppner, D. (1991): Startup and management of a highly complex, interdisciplinary project, in: Technology Management: the New International Language, p. 258 – 261.

[19] Wear, D. (1999): Challenges to Interdisciplinary Discourse, in: *Ecosystems*, 2, p. 299 – 301.

[20] OCDE (1999): *University Research in Transition*, Paris: OECD Publications Service.

[21] Holmes, G. (1994): Putting Concurrent Engineering into Practice, in: *World Class Design to manufacture*, Vol. 1, 5, p. 38 – 42.

[22] ENGINEER Competency Profile, 2008. Internet entry:
http://www.doc.state.nc.us/docper/Classification/Engineering/Engineer-cp.pdf accessed 29 May 2012.

[23] Kamel, F., Baguley, M., & Thorpe, D. (2010). Work in progress - Assessment of how engaging in teaching may enhance the learning journey of engineering and education students. Paper presented at the 40th Annual Frontiers in Education Conference: Celebrating 40 Years of Innovation (FIE 2010), Arlington, Virginia, U.S.A.

[24] Crumpton-Young, L., McCauley-Bush, P., Rabelo, L., Meza, K., Ferreras, A., Rodriguez, B., et al. (2010). Engineering Leadership Development Programs a Look at What is needed and what is being done. [Article]. *Journal of STEM Education: Innovations & Research, 11*(3/4), 10-21.

[25] Riemer, M. J. (2007). Communication Skills for the 21st century Engineer. *Global J. of Engng. Educ, 11*(1).

[26] Jansen, D. (1998). Speak out: the engineer as Communicator *Journal of Management in Engineering 14*(2), 19-22.

[27] Dannels, D. P. (2003). Teaching and Learning Design Presentations in Engineering Contradictions between Academic and Workplace Activity Systems. *Journal of Business and Technical Communication, 17*(2), 139-169.

[28] Darling, A. L., & Dannels, D. P. (2003). Practicing Engineers Talk about the Importance of Talk: A Report on the Role of Oral Communication in the Workplace. *Communication Education, 52*(1), 1-16.

[29] Gregory Tibbits (2011), Understanding the community: getting engineers on track, Proceedings of the 2011 AAEE Conference, Fremantle, Western Australia.

[30] Peter D Gibbings, Frank Bullen, Development and Validation of a Regional University's Model for Community and Industry Engagement, Proceedings of the 2011 AAEE Conference, Fremantle, Western Australia.

[31] Thomas Goldfinch et al. (2011), Observing cultural interactions in engineering design projects, Proceedings of the 2011 AAEE Conference, Fremantle, Western Australia.

[32] R. Max Wideman (1990), Managing the Project Environment, *AEW Services, Vancouver, BC* Chapter 5 in the GPM state-of-the-art book Dimensions of Project Management edited by H. Reschke & H. Schelle and published by Springer-Verlag in 1990.

[33] Gossage, L. (2011), On Exploring the Connection between Hispanic Engineering Students' Educational Goals and Communal Obligations: for Project-Based Learning through Community Engagement, *Proceedings of the Pacific Southwest Regional ASEE Conference Transforming Engineering Education through Community Engagement, Entrepreneurship and Service Learning* (pp. 148-169). California: Frenso

Southeast Asian car users' acceptability on urban travel demand management measures

Berlian Kushari

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Islamic University of Indonesia

Email: 015110101@uii.ac.id

Abstract

Major Southeast Asian cities are experiencing severe road traffic congestion that leads to various urban problems such as air pollution, environmental degradation, economic losses due to delays and longer travel time, and psychologically distressing environmentperceived by road users during their daily trips. Deeply disproportionate growths between urban transportation demand and supply has been identified as a root problem for the described situation. In fact, many studies have recommended city governments to incorporate demand management into their urban transportation planning and policies to tackle the imbalance. Instead of traditionally feeding the demand with reactive measures such as building more roads, various measures under Travel Demand Management (TDM) concepts have been suggested to effect limited use of private cars and, on the other hand, to facilitate substantial use of mass or public transportation. At conceptual level, policies aimedat managing travel demandmay be well accepted. Experience shows, however, that thesepolicies become rarely acceptable when it comes for the motorists to examining real measures and programs. In a democratic society, people's acceptability is an important precondition for a successful policy. An effort was made in this studyto understand and discuss some factors that may play role in determining acceptability on TDM measures among Southeast Asian motorists. A relevant sample was drawn from car users inJakarta, Bangkok, Kuala Lumpur, and Manila. Understanding these factors would be of a valuable contribution for engineering public attitude towards sustainable urban transportation development.

Keywords: urban transportation, demand management, acceptability, Southeast Asia, sustainable

Introduction

The shape of urban transportation development in many major Southeast Asian cities has long been formed through biased policies aimed at providing infrastructures and facilities that accommodate automobile traffic. As long as the assumption that the majority of people use car to travel holds, and by that the objective of urban transportation might be reduced to 'vehicle mobility', these devoted-to-car policies may be justifiable. However, many unresolved transportation and environmental problems caused by these policies show that theydo not lead to a sustainable development.

Supply-biased policies have been criticized for many reasons. Studies (e.g. Goodwin, 1996; Hansen, 1995; Noland, 2001) show that traffic tends to increase time to time, filling the additional capacity provided for it, and at a certain point its increase would eradicate almost all benefits expected from capacity expansion. From urban economic view point, studies (e.g. Maddison*et. al.*, 1996 and Litman, 2003a) see traffic congestion as a symptom failure to correctly set the market price of a scarce good (i.e. road space) that would bring demand for road space into balance with the supply. On contrary, the costs of utilizing road facility, which is often free or very cheap, normally do not reflect the actual costs the society has to bear. Therefore, road users use road space inefficiently, up to the point where congestion delays limit further use.

Extensive supply-side policies has also generated substantial environmental and social and land use impacts to the society. Motorized transportation consumes a large amount of oil energy and simultaneously contribute to degradation of air quality in urban areas. In social contexts, devoted-to-car policies encourage people to own private vehicle, grow acute automobile dependency, disregard a large part of car travel costs, and look down upon the use of public transportation and non-motorized mode services, and with that reduce mode choice and make people without a car worse off (SUSTRAN, 2004). These facts beg urban planners and city governments to reconsider their preference for private car and devoted-to-car policies.

Sustainable urban transportation development (Greene and Wegener, 1997) regards demand management as a vital complementary policy to the traditional approach of facilitating the demand by continuously providing and expanding supply infrastructures and facilities. The term Travel Demand Management (TDM), which was first coined in 1970s, refers to a wide scope policy that essentially aims to make the utilization of transportation resources more efficient (Litman, 2003b). Through its measures and strategies, TDM has the potentialsfor reducing vehicular traffic volume, promoting shifts toward more sustainable modes of transportation, and supporting efficient mobility of people and goods.

Battling the problems caused by severe traffic congestion, many metropolitants in Southeast Asian region have been considering to manage urban travel demand. A common problem for them, though, is excessive and inefficient use of private vehicles. Manila, for example, has been for long enforcing the Unified Vehicular Volume Reduction Program (UVVRP), under which it bans roughly 20 percents of its car population to commute the city’s road network based on their plate-license number (Magbanua and Villoria, 1999). Jakarta has been using another restraining measure by disallowing low-occupancy cars (less than 3 occupants) to access congested roads (Jakarta Metropolitan Authority, 2003). Other cities, such as Bangkok and Kuala Lumpur, are keen on promoting mass transportation services to reduce private vehicle domination on their roads.

As the society is apparently moving toward automobile dependency, it can be hypothesized that the current level of acceptability toward TDM measures among the motorists is rather low as TDM seems to disapprove the prevailing attitude and discouraging the use of private cars. As a result, people may oppose the implementation of such measures and be reluctant to change their habits in accordance with the measures. Acceptability is the key of social feasibility and is considered an important precondition for a succesful implementation of any policy in a modern democratic society. It is important, therefore, to understand factors that influence public attitude toward TDM policies. Understanding these factorswould further help planning additional measures to increase the acceptability of TDM.

TDM and acceptability concept

Travel Demand Management

Practically, TDM can be understood as planning and implementation of programs that influence the amount, composition, or timing of demand for transportation

(Lim, 1997). Based on this definition, many TDM programs and measures are recognized. Vlek and Michon (1992) categorize TDM programs into six groups, including physical changes (e.g. closing out car traffic and providing alternative transportation), law regulation, economic incentives, education, socialization and social modeling targeted at changing social norms, and institutional and organizational changes. Steg and Vlek (1997) suggests a simpler grouping that lists TDM measures under two broad groups: ‘push measures’ or ‘stick’ for measures that discourage car use, and ‘pull measures’ or ‘carrot’for those that encourage the use of other more sustainable modes. A non-exhaustive list of TDM strategies includes land use development controls, parking management systems, traffic regulatory controls, automobile restrictions, road and congestion pricing, improvement of public transit and rideshare services, and non-motorized transport promotions.

Acceptability as an attitude

The terms *acceptability* and *acceptance*do not bear the same meaning. Acceptability is understood as an affirmative attitude toward a specific object, whereas the acceptance is more related to behavior, as an action or reaction toward the object (Schade and Schlag, 2000). In social sciences, attitude itself is defined as a psychological tendency expressed by evaluating a particular entity with some degree of favor and disfavor (Eagly and Chaiken, 1993). As a hypothetical construct, attitude is not directly observable but can be inferred from observable responses. As an attitude, acceptability of TDM strategies is assumed, among other things, to guide people’s behavior toward such strategies (e.g. resistance, support, act in accordance with the measures, etc.).

Investigations for the factors influencing acceptability toward transportation policies have been employing heuristic approach. Some psychological and socioeconomic factors have been identified to play role. Authors have reported some of these factors in their reports. These include the following.

Perception of problems

Any policy measure directed to overcome transportation problems is likely more acceptable if people perceive the existing problems brought by car use to them and their society as critical (Schade and Schlag, 2000; Steg, 2003). Problem perception is two dimensional: personal and societal. A person who is personally affected by the problems will likely regard problem-solving measures as necessary. But without being affected personally, people may support for the measures by evaluating the states as societal problems. Greater support for the measures may be further expected if people anticipate worsening future state of the problems. Some studies (e.g. Rienstra et al., 1999) did not simply account for the problems in a general view but rather differentiate them into categories such as safety, environmental, and congestion related problems and look further their correlations with acceptability of specific measures.

Important aims to reach

Motorists may have many different and conflicting mobility interests. However, when it comes to consider public policies, people often not only regard them against their personal interests (selfish perspective) but also value the policies in accord with common social aims (Jaensirisak *et al.,* 2003). TDM policies can be framed to be in accord with common social aims. Therefore, a society that appreciates a higher valuation for social aims will likely more supportive toward TDM measures. In contrast, individuals pursuing mainly personal aims are expected to reject the measures because of threatening restrictions to their personal mobility interests (Schade and Schlag, 2000; Jaensirisak *et al.,*2003).

Attribution of responsibility

The complexity of inter-dependent relations and effects in transportation problems may lead people to attribute the responsibility of solving the problems to external entities (e.g. traffic police, city government, transportation operators) and underestimate the participation of internal entity (i.e. themselves) because either they think their contribution is worthless or they do not trust each other to cooperate. However, if people feel personally responsible for the problems and if they are convinced that their own contribution to the solution of these problems is useful, then it may be expected that they are more willing to support TDM measures and to behave in harmony with the measures (Steg and Vlek, 1997; Schade and Schlag, 2003; Steg, 2003).

Mobility related social norms

In the theories of reasoned action (Ajzen and Fishbein, 1975) and planned behavior (Ajzen, 1991), social norms and perceived behavioral controls are important in attitude formation and behavioral engagement. Social norms refer to one's assumption of his or her important others (family, friends, etc.) whether they think he or she should accept, in the context of this study, the introduced TDM measures. A person that perceives the social norms as a pressure to his or her behavior would likely be more favorable to the presented measures.An influential positive correlation between social norms and TDM was identified for pricing strategies (Schade and Schlag, 2003)and other strategies (Steg, 2003).

Perceived effectiveness

In evaluating the acceptability of a measure, one is assumed to think of its effectiveness to which the aims of the measure can be reached. Ideally, a more effective measure is more attractive and should be more acceptable for its greater potential in reaching goals. However, studies identified a paradox in the case of urban transportation. It is often the case that the most acceptable measure is less effective and the most effective measure is less acceptable (Steg, 2003). For instance, it is widely found out that people rated 'improvement of mass transit' as the most acceptable measure though this was not perceived as the most effective strategy. In addition, Reinstra *et al.* (1999) stated that "strategic responses on perceived effectiveness may occur when respondents try to justify their rejection of painful policy by claiming that they perceive them as ineffective".

Knowledge of options

The influence of knowledge of TDM options on acceptability is rather unclear. There are indications of a direct influence and also indirect influence, i.e. mediated through third-order variable (Schade, 2003). Studies showed that well-known demand management measures received a higher acceptability than unknown measures (Schade and Schlag, 2000). However, knowledge may have a negative effect because higher knowledge would lead to a higher assessment of effectiveness but to a significantly lower acceptability of restrictive measures (Steg and Vlek, 1997). Nevertheless, the importance of information in influencing acceptability should not be underestimated, since no innovation can be accepted without appropriate and early information (Schlag and Teubel, 1997).

Personal outcome expectation

Acceptability of TDM measures is evidently influenced by how people perceive the measures as fair enough in distributing costs and benefits (e.g. Jacobsson *et al.*, 2000; Schade and Schlag, 2000; Bamberg *et al.*, 2003). Perceived justice in some studies is mediated by personal outcome expectation. It may be assumed that the more people perceive advantages following the introduction of TDM measures the more they will be willing to accept it.

Socio-economic features

Acceptability of TDM measures may also be influenced by socioeconomic backgorund, such as one's income level (Rienstra *et al.*, 1999; Jacobsson *et al.*, 2000), although not many reasonable assumptions can be made. An economic rationale would expect people with higher income to support price-based TDM strategies because of their lower marginal utility of money and higher marginal utility of time. However, based on the Netherlands data, Rienstra *et al.* (1999) found out that the lowest income group perceived pricing measures as most effective; also, income level had no significant impact on the support for pricing measures. Schade and Schlag (2000) reported that income level, sex, household size, occupation status and primary mode of mobility, had a lower influence to acceptability of pricing strategies compared with psychological variables. The low influence of socio-economic features onTDM acceptability was also reflected in a study conducted in Bangkok (Bhattacharjee, *et al.*, 1997).

TDM acceptability survey

Survey design

A questionnaire for capturing information related to public acceptability of TDM measures was developed following the structure depicted Figure-1. Acceptability and its assumed determining factors are latent constructs by nature, of which necessitates the use of manifest variables for their measurement. A five-degree semantic differential scale was chosen for its wide use and popularity in measuring attitudes in contemporary research (Himmelfarb, 1993).

Respondents for the survey were motorists, i.e. a group of people who own and use private car as their primary mode of traveling in urban area. Field surveys were conducted in early 2005 in CDB areas in Bangkok, Jakarta, Kuala Lumpur, and Manila. The respondents evaluated TDM strategies as appear in policy packages, each of which combines pull and push measures. The reason for this is the fact that many factors make car use very attractive, and therefore relying on a single measure may not be a useful approach. Various single strategies might supplement or strengthen each other and the combined application of several strategies, linked to a consistent set of policy goals, is likely to be more effective and might be more acceptable (Thrope *et al*., 2000).

Personal and societal problem perception about the present state of various urban transportation problems and expectation of future state of such problems

Perception of whether traffic volume needs to be reduced

Internal and external attribution of responsibility for resolving transportation problems

Personal and societal important aims to reach

TDM policy package A	**TDM policy package B**	**TDM policy package C**
Knowledge of option Perceived effectiveness Acceptability Expected outcome Social norms Behavioral intentions	Knowledge of option Perceived effectiveness Acceptability Expected outcome Social norms Behavioral intentions	Knowledge of option Perceived effectiveness Acceptability Expected outcome Social norms Behavioral intentions

Personal expectation if internalization of some external costs of driving is imposed

Self-reported demand elasticity of driving for various trip purposes against increased costs of driving

Socio-economic features and mobility patterns

Figure-1. Questionnaire's structure

Table-1. Packages of TDM measures evaluated in the questionnaire

Name of package	Description
Package *A*	• Improve public transport/transit/rideshare services • Impose zone access control measure on congested areas with the following scheme: From Monday to Friday, 7.00 am to 9.00 am (morning peak) and 4.00 pm to 7.00 pm (evening peak), access to congested areas is granted only for public transportation and private cars with at least three passengers in one car. • Increase the cost of parking in congested areas by 100% increase.
Package *B*	• Improve public transport/transit/rideshare services • Impose zone access control measure on congested areas with the following scheme: Access to congested areas is not granted (prohibited) in Monday for private vehicles with the *last* plate-license number being 0 and 1; in Tuesday for 2 and 3; in Wednesday for 4 and 5; in Thursday for 6 and 7; and in Friday for 8 and 9. In Saturday and Sunday, access for all private cars is granted. • Increase the cost of parking in congested areas by 100% increase.
Package *C*	• Improve public transport/transit/rideshare services • Charge private vehicles a fixed-price charge of US$ 1.00 for accessing congested areas. • Increase the cost of parking in congested areas by 50% increase.

Sample description

The sample size was 691 persons with Manila and Jakarta share the largest (N=219) and the smallest (N=122) number sample sizes, respectively (see Table 2). The sex distribution of the sample reflects a fair approximation to the women to men ratio of active car drivers. The mean age was 31.15 years with standard deviation of 9.6 years. This shows that the data was biased toward the young motorists, especially for the Manila case where one-third of the sample was from the first age group (20 years old and below).

Table-2. Sample sizes

	Bangkok	Jakarta	Kuala Lumpur	Manila	Total
total	199	122	151	219	691
female	33.67%	27.87%	43.05%	31.51%	34.01%
male	66.33%	72.13%	56.95%	68.49%	65.99%
mean age	33.20	29.54	31.07	30.21	31.15

Suvey results and discussion

In this section, survey results of the four cities will be compared with respect to the main measured variables of the public acceptability. Mostly, frequency distributions and mean values are reported.

Table-3. General problem perception – confirmative response (%)

Problems	General problem perception				
	Total	Bangkok	Jakarta	Kuala Lumpur	Manila
traffic congestion	90	96	91	83	88
inadequate parking spaces	67	75	62	72	58
inadequate public transportation	63	81	68	51	52
air pollution from motor vehicles	82	95	87	64	80
traffic noise	59	76	67	52	44
unsafe roads	72	88	72	52	71

Table 3 shows the percentage of respondents by sites who rated the transportation problems as a ‘serious problem’ or a ‘very serious problem’. In Bangkok, all problems were rated as problematic by nearly all respondents. Jakarta respondents also perceived high problem awareness. However, all the problems in Jakarta were rated less serious than in Bangkok. Both Kuala Lumpur and Manila samples indicated lower problem perception as compared to Bangkok and Jakarta. A similar pattern for general problem perception between cities was identified that the two-most pressing problems perceived by a vast majority of the respondents were *traffic congestion* and *air pollution from motor vehicles*. The only exception was in the case of Kuala Lumpur, where more motorists perceived inadequate parking spaces as more problematic than air pollution from vehicles. These results indicate that in addition to traffic related problems, the motorists asked during the survey also perceived traffic induced environmental problems.

Table-4. Problem expectation (%)

Expectation of the state of problems after 5 years	getting worse				getting better			
	BKK	JKT	KL	MNL	BKK	JKT	KL	MNL
traffic congestion	58.29	76.23	58.28	69.41	19.60	7.38	22.52	14.16
inadequate parking space	58.79	68.85	59.60	60.73	17.59	6.56	18.54	17.81
inadequate public transportation	43.22	41.80	28.48	44.29	33.67	23.77	39.74	27.85
air pollution from motorized vehicles	64.82	83.61	53.64	74.43	22.11	9.84	19.21	14.61
traffic noise	52.76	75.41	49.01	52.05	20.60	7.38	19.21	13.70
unsafe roads	49.25	50.82	35.10	44.75	29.15	18.03	30.46	29.68

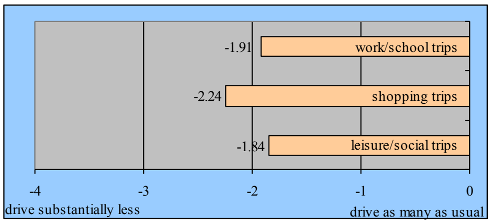
Respondents were also asked about their perception on the development of the problems in the next 5 years. In general, Table-4 shows that significantly more people expected the problems to get worse. Worsening state of problems, among other things, seemed to make the majority of motorists anticipated increased costs of driving in the future (Table-5). However, their high dependency on car use made many of them feel difficult to reduce automobile trips substantially (Table-6). Deeper investigation on the types of trips revealed self-reported elasticities for reducing different types of automobile trip (Figure-2). No consistent pattern was found across the cities. In Jakarta, the motorists would give up driving more for mandatory (work/school) trips, in contrast to the Kuala Lumpur motorists. Meanwhile, Bangkok and Manila motorists would drive less for shopping and social/leisure trips, respectively. Nevertheless, responses to question whether car traffic should be limited showed a similar high rating (Table-7). At least two-third of the respondents in each city indicated that car traffic needs to be restricted.

Table-5. Expectation that driving will be more expensive in the future (in %)

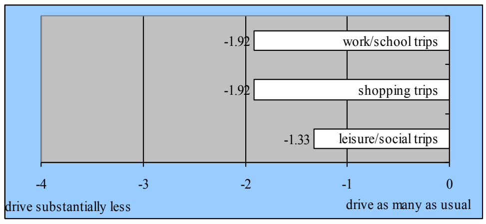
	not at all	probably no	Probably	almost certainly	certainly
Bangkok	3.02	0.50	11.06	22.61	62.81
Jakarta	1.64	2.46	21.31	31.97	42.62
Kuala Lumpur	0.66	4.46	20.53	31.13	43.05
Manila	2.74	14.61	35.16	32.42	15.07

Table-6. Perceived difficulty to reduce automobile trips substantially (%)

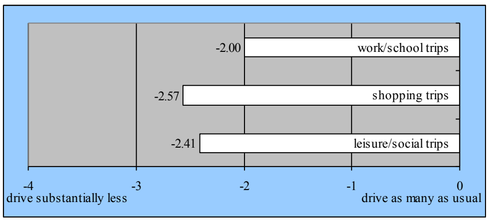
	not difficult at all	not really difficult	difficult to some extent	difficult	very difficult
Bangkok	6.03	3.02	21.61	34.17	35.18
Jakarta	4.10	18.85	25.41	27.05	24.59
Kuala Lumpur	5.30	7.95	31.79	28.48	26.49
Manila	2.74	14.61	35.16	32.42	15.07



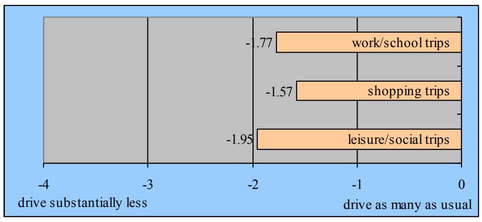
Bangkok



Jakarta



Kuala Lumpur



Manila

Figure-2. Self-reported elasticities for different types of trip.

Table-7. A need to limit the traffic? (confirmative responses in %)

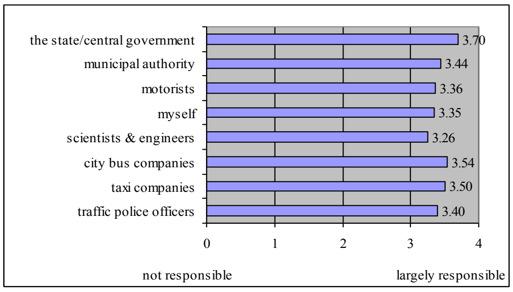
Total	Bangkok	Jakarta	Kuala Lumpur	Manila
72	63	86	62	79

Further analysis using factor analysis and regression methods reveals that there were different types of correlation between problem perception and support for traffic limitations between the four cities (Table-8). Generally, all problem perceptions (mobility–environmental, personal–societal), have positive correlations with support for traffic limitations (except for environmental problems in Bangkok), although their level of significance vary between cities.

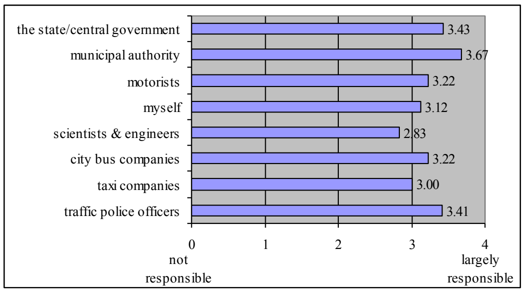
Table-8. Correlations between problem perceptions and support for traffic limitations

Correlations (r)		Personal problem perception		Societal problem perception	
		Mobility	Environmental	Mobility	Environmental
A need to limit vehicle traffic	Bangkok	.2781 p=.000	-.2493 p=.000	.3812 p=.000	-.2559 p=.000
	Jakarta	.1696 p=.062	.1470 p=.106	.2078 p=.022	.0876 p=.338
	Kuala Lumpur	.0908 p=.267	.1742 p=.032	.2019 p=.013	.2266 p=.005
	Manila	.1569 p=.021	.0920 p=.178	.2466 p=.000	.0780 p=.253

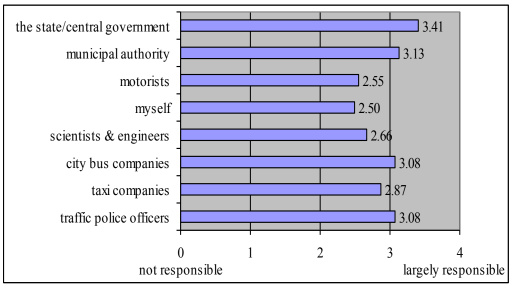
The discussion so far has highlighted how the motorists in four major Southeast Asian cities perceived urban transportation-related problems and future consequences they would likely experience regarding driving for their daily trips. In addition to this, the motorists in the four cities in general did not seem to highly regard themselves as part of the solution to the problems as much as other parties (Figure-3). This was especially the case for the Kuala Lumpur and Manila samples. In the end, however, the majority of the motorists participated in the survey agreed that there should be a limit for vehicular traffic. This agreement essentially corresponds to the practical aim of TDM policies, i.e. to limit private car use and to encourage modal shift to the more sustainable public transportation services. However, as discussed earlier, support at conceptual level may not continue when it goes further to deciding support for real programs and measures.



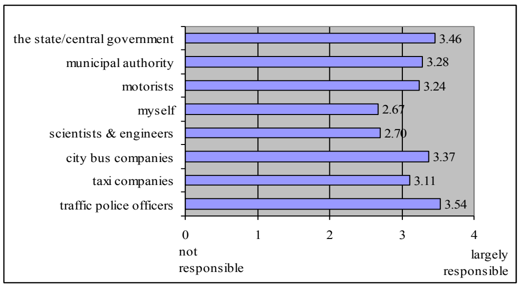
Bangkok



Jakarta



Kuala Lumpur



Manila

Figure-3. Attibution of responsibility for the solution of perceived problems

Discussion is now focused on issues related to motorists' evaluation on the presented TDM measures that were arranged in the three policy packages. Table-9summarizes the descriptive results (mean values) for the evaluation of the three proposed packages. The lowest level of subjective information was found for Package *C*. This is not surprising since transportation policy that constitutes road pricing strategy was relatively unheard of among the respondents in the study area.

Regarding the effectiveness forreducing inner city traffic, each sample seemed to have its own perception. In Bangkok, altough Package *C*was less known to the other two packages, it was rated more effective. In Jakarta, the already-known Package *A*was perceived as the most effective policy package. The same package was also rated the first place in Kuala Lumpur. Both respondents in Jakarta and Kuala Lumpurconsidered Package *C* and *B* as less and the least effective package, respectively. Only in Manila, Package *B*was rated the most effective.

Table-9. Overall evaluations of Package *A*, *B*, and *C*(mean).

	Package	Information	Perceived effectiveness	Personal outcome expectations	Acceptability
Bangkok	A	1.90	1.98	-0.39	-0.04
	B	1.19	1.85	-0.53	-0.38
	C	0.95	1.98	-0.51	-0.33
Jakarta	A	1.84	1.97	0.08	-0.07
	B	1.64	1.41	-0.52	-0.54
	C	0.84	1.47	-0.66	-0.44
Kuala Lumpur	A	2.18	2.20	-0.16	-0.07
	B	1.30	1.72	-0.50	-0.42
	C	1.30	1.98	-0.36	-0.19
Manila	A	1.48	2.32	0.01	-0.13
	B	2.42	2.50	0.31	0.54
	C	0.77	1.81	-0.44	-0.47
Total sample	A	1.82	2.13	-0.13	-0.08
	B	1.68	1.95	-0.26	-0.13
	C	0.95	1.84	-0.48	-0.36

Mean values for *information* and *perceived effectiveness* can vary from 0 (i.e. never heard, will not work at all) to 4 (i.e. know a lot, work very effectively). Mean values for *personal outcome expectation* and *acceptability* can vary from -2 (i.e. disadvantaged, totally unacceptable) to 2 (advantaged, totally acceptable).

Concerning the personal outcome expectations, the respondents generally expected to be disadvantaged by all packages. TheBangkok and Kuala Lumpursamples expected to be most disadvantaged by Package *B*, while Jakarta and Manila respondents anticipated more disadvantages from Package *C*. However, there were just a slight expectation to be advantaged by Package *A* in Jakarta and Manila. In particular, Package *B* is rated benefiting by respondents in Manila.

The last column of Table-9 deals with acceptability evaluation. As indicated, all mean values for the evaluation of acceptability are negative, expect for one case: acceptability of the locally famous Package *B* by the respondents in Manila. This fact is interesting in particular, because in all other cities Package *B*was found as the most unacceptable solution among the three proposed packages. In addition to the last column of Table-9, the following Table-10 shows the percentages of respondents in each city who rated the packages as rather acceptable or totally acceptable. All packages were therefore generally rejected by the respondents, except for the aforesaid case.

These results, drawn from a South East Asian sample, evidently resound in large proportion the similar results drawn from elsewhere (e.g. Schade and Schlag, 2000) where the motorists' support for a general idea of limiting vehicular traffic turns to opposition when it comes to evaluating a more detailed policy for actually limiting it after they saw that the policy could bring negative impacts on their personal mobility aims. The 'not in my backyard' attitude is therefore identified in this case.

Table-10. Acceptability (% who rate the package as rather or totally acceptable)

	Acceptability				
	Total	Bangkok	Jakarta	Kuala Lumpur	Manila
Package *A*	25	20	26	30	26
Package *B*	29	14	16	20	55
Package *C*	23	20	20	28	23

Lastly, Table-11below summarizes Kruskal-Wallis non-parametric ANOVA tests to find out whether information, perceived effectiveness, personal outcome expectation, and acceptability were rated significantly differently across the cities. As shown, the low *p*-values ($p<.05$) indicated in most cases imply that these aspects had been rated differently across places, at least between two out of four cities. However, the ratings are not significantly different between cities in the cases of personal outcome expectation of Package *C*, and acceptability of Packages *A* and *C*.

Table-10. Summary of Kruskal-Wallis non-parametric ANOVA tests

	Package A	Package B	Package C
Information	H =27.79485 p =.0000	H=87.83738 p =.0000	H =19.67476 p =.0002
Perceived effectiveness	H=16.72153 p =.0008	H=91.98442 p =0.000	H =16.89635 p =.0007
Personal outcome expectation	H=16.30154 p =.0010	H=85.19419 p =.0000	H =4.228943 p =.2378
Acceptability	H=.6073226 p =.8948	H=113.3997 p =0.000	H=6.799610 p =.0786

N=691. No of groups = 4.

The foregoing discussion has presented descriptive figures about the issues related to the acceptability of TDM strategies, particularly the three packages specified in this study. To analyze further the relations between the different variables, further statistical investigations are necessary to be carried out.

Table-11. Pooled Ordered Probit regression models for acceptability of Package *A*, *B*, and *C*

Variable	Pooled models								
	Dep. Var.: Acc_*A*			Dep. Var.: Acc_*B*			Dep. Var.: Acc_*C*		
	Coeff.	Stdr. Error	p-value	Coeff.	Stdr. Error	p-value	Coeff.	Stdr. Error	p-value
Knowledge of option	0.2074 ***	0.038	0.000	0.1362 ***	0.036	0.000	0.1433 **	0.044	0.001
Perceived effectiveness	0.3319 ***	0.047	0.000	0.5647 ***	0.050	0.000	0.2559 ***	0.042	0.000
Personal outcome exp.	0.4042 ***	0.054	0.000	0.3561 ***	0.062	0.000	0.1924 **	0.060	0.001
Perceived social norm	0.3525 ***	0.057	0.000	0.3605 ***	0.063	0.000	0.7471 ***	0.062	0.000
Personal mobility problem perception	-0.0265	0.048	0.579	-0.0201	0.048	0.677	0.0924	0.048	0.055
Personal environmental problem perception	0.0824	0.047	0.082	-0.0114	0.047	0.810	0.0825	0.048	0.086
Car use as important aim to reach	-0.0488	0.048	0.306	0.0003	0.048	0.995	-0.0426	0.048	0.371
Internal attribution of responsibility	-0.0307	0.047	0.510	0.0470	0.046	0.309	0.1111 *	0.046	0.015
Sex type (0: female; 1: male)	-0.2884 **	0.097	0.003	0.0001	0.097	0.999	-0.1728	0.097	0.074
Education level (1: undergrd or higher; 0: otherwise)	-0.0471	0.125	0.705	-0.2026	0.126	0.108	0.0460	0.127	0.717
Age	0.0093	0.005	0.052	0.0064	0.005	0.181	-0.0016	0.005	0.747
Household size	-0.0044	0.019	0.816	0.0443 *	0.020	0.024	-0.0191	0.019	0.320
Car as primary moving modus	0.0200	0.103	0.846	-0.0605	0.104	0.56	0.2135 *	0.103	0.039
Model summary:									
No of observation:	611			611			611		
LR chi-sqr:	442.89			541.04			504.58		
Prob > chi-sqr:	0.000			0.000			0.000		
Pseudo R^2:	0.2576			0.2961			0.2736		
Log likelihood:	-638.2			-643.23			-670		

legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Ordered probit regression models were estimated for both cases: the whole sample and the separate city samples, because of the assumption that possible relations between the variables could vary between the examined cities. However, only the pooled models (whole sample) is reported here (Table-11). For all cases, the variable to be predicted was 'acceptability', that is the degree of approval or disapproval of the respective policy package (symbolized as Acc_*A*, Acc_*B*, andAcc_*C*). The dependent variables comprise of two groups: the psychometrical and socio-economic variables. The former consists of 'knowledge about the package', 'perceived effectiveness', 'general personal outcome expectation', 'perceived social pressure to accept the policy', 'personal problem perception', 'attribution of responsibility', and 'car use as important aim to reach'. Meanwhile, 'gender type', 'household size', 'income', 'age', 'education background', and 'car as primary moving modus' constitute the later.

As seen in Table-11, higher level of knowledge about the policies, higher valuation of perceived effectiveness, of benefit expectation, and of perceived social pressure are expected to increase the acceptability of policy packages significantly. These variables could be thought of as among the aspects 'directly' involved in the evaluation process for deciding the acceptability level towards a measure. Meanwhile, 'background' aspects such as problem perception variables (mobility and environmental) are found to be insignificant in affecting acceptability. Attribution of responsibility, another ‘indirect’ aspect, was found significant only in the case of Package *C*. A person with a high sense (score) of internal attribution of responsibility would likely accept the proposed measures and behave accordingly because he/she consider his/her personal contribution as an important part to solving transportation problem.

As for the socio-economic variables, there are only few factors that can be interpreted meaningfully. Male is found significantly to likely rejectTDM measures, especially in the case of Package A. Higher dependency on car use to a lesser significant level surprisingly positively effect acceptability of road pricing strategies (Package *C*). An explanation for this is perhaps related to their lesser marginal utility of money as compared to their marginal utility of time.

Interaction between the independent variables were not taken into account for the above models. Multicollinearity is possible to occur, for examplein the case of ‘social norm’ and ‘outcome expectation variables’. However, this threat did not seem to cause severe problems to the models.

The variables examined in direct connection to the policy packages (i.e. information, perceived effectiveness, personal outcome expectation, and social norm) are highly significant and positively influence acceptability evaluation of the packages. These aspects therefore should be considered seriously in TDM policy formulation if it is to be socially feasible.

Social norm, which is understood as the pressure towards acceptability exercised by one’s important others is assumed to affect personal opinions, feelings and behavioral intentions, especially in a situation where there is no certain basis for making evaluation (Schade and Schalg, 2000). This hypothesis was confirmed in this study as this aspect appeared to be one of the strongest determining factors for acceptability evaluation. Therefore, if the social norm could be changed, or engineered, in a way favorable for TDM policies, a relevantconvergence of personal attitudes could be expected.

Personal expectation outcome was also among the strong determinants of acceptability. Those who expect certain benefits would show a significant higher acceptability for the specific strategies, while those who anticipate disadvantages would reject the strategies. In connection with the perceived effectiveness (another strong determining factor for acceptability), Rienstra et al (1999) stated that ‘*strategic responses on perceived effectiveness may occur when respondents try to justify their rejection of painful policies by claiming that they perceive them as ineffective’*. Personal expectation outcome can be included to test this statement. The hypothesis is that those who expect mainly disadvantages would tend to opine the policies as being ineffective. This is so to justify their disapproval of the proposed policies (Schade and Schlag, 2000). Table-12 shows the correlations between ‘perceived effectiveness’, ‘acceptability’ and ‘personal outcome expectation’.

Table-12. Correlation of perceived effectiveness, outcome expectation and acceptability

	ACC_A	ADV_A	ACC_B	ADV_B	ACC_C	ADV_C
Bangkok						
Perceived effectiveness (EFF_A)	0.262**	0.039				
Personal outcome expectation (ADV_A)	0.568**					
Perceived effectiveness (EFF_B)			0.371**	0.005		
Personal outcome expectation (ADV_B)			0.465**			
Perceived effectiveness (EFF_C)					-0.057	0.062
Personal outcome expectation (ADV_C)					0.526**	
Jakarta						
Perceived effectiveness (EFF_A)	0.686**	0.492**				
Personal outcome expectation (ADV_A)	0.645**					
Perceived effectiveness (EFF_B)			0.648**	0.410**		
Personal outcome expectation (ADV_B)			0.580**			
Perceived effectiveness (EFF_C)					0.749**	0.578**
Personal outcome expectation (ADV_C)					0.565**	
Kuala Lumpur						
Perceived effectiveness (EFF_A)	0.630**	0.487**				
Personal outcome expectation (ADV_A)	0.693**					
Perceived effectiveness (EFF_B)			0.775**	0.457**		
Personal outcome expectation (ADV_B)			0.567**			
Perceived effectiveness (EFF_C)					0.695**	0.526**
Personal outcome expectation (ADV_C)					0.633**	
Manila						
Perceived effectiveness (EFF_A)	0.458**	0.400**				
Personal outcome expectation (ADV_A)	0.554**					
Perceived effectiveness (EFF_B)			0.503**	0.449**		
Personal outcome expectation (ADV_B)			0.577**			
Perceived effectiveness (EFF_C)					0.567**	0.393**
Personal outcome expectation (ADV_C)					0.632**	

** significant at $p < 0.05$

Based on Table-12, the idea of a strategic response could be dismissed for the case of Bangkok motorists since there is no evidence of significant correlation between perceived effectiveness and outcome expectation. In other cities, however, significant correlations between the expectation of disadvantages and low effectivenesswere found. These correlations were relatively lower than the correlations between outcome expectation and acceptability and between perceived effectiveness and acceptability. The strategic response hypothesis is further checked by performing partial correlations while controlling for the effect of acceptability. Table -13 reports the results of this analysis.

Table-13. Partial correlations controlling for the effect of acceptability variables

Controlling for Acceptability of Package A, B, and C, respectively				
		Personal outcome expectations		
		A	B	C
Jakarta	Perceived effectiveness A	0.0884		
	Perceived effectiveness B		0.0534	
	Perceived effectiveness C			0.2838***
Kuala Lumpur	Perceived effectiveness A	0.0907		
	Perceived effectiveness B		0.0319	
	Perceived effectiveness C			0.1533*
Manila	Perceived effectiveness A	0.197***		
	Perceived effectiveness B		0.2248***	
	Perceived effectiveness C			0.0539

note: *** $p< 0.01$; ** $p<0.05$; * $p<0.100$

Table-13 shows that strategic responses likely occurred in Jakarta, in the case of Package *C*. Kuala Lumpur sample also likely produced strategic responses in the case of Package *C*, altough in a considerably lesser significance level. Manila sample produced strong correlations between the two variables as well. However, checking back to the distribution of the two aspects for the Manila sample, these relations evidently tended to go more on the ‘expect mainly advantages – perceived as effective’ side, not to the ‘expect mainly disadvantages – perceived as rather ineffective’side.

Concluding remarks

The fact that many studies have been constantly suggesting the local governments of Bangkok, Jakarta, Manila and Kuala Lumpur to seriously consider car use and ownership restraining programs is well known. It has been widely realized by city planners that such programs are urgently required to curb the imbalance between transportation demand and supply. Unfortunately, many of the suggestions have remained unused, and some attempts to realize such suggestions have been opposed by the public. In connection with this fact, a relevant question to ask is how people’s acceptability of TDM measures could be increased. This study has tried to explore some factors that play important roles in determining public acceptability on some TDM measures based on South East Asian data. If these factors could be changed in a favorable way, acceptability of TDM measures may be expected. Experience elsewhere shows, however, that there are no simple solutions for winninghigh acceptability of TDM measures. Effective communications, social modeling and education programs are perhaps needed to change the prevailing social norms and attitudes. On the other hand, convincing programs that provide people with decent options to their private modes of transportation in urban areas have to be made avaliable through a careful planning.

Acknowledgements

The author is at all time indebted to the ASEAN University Network/Southeast-asian Engineering Education Development Network (AUN/SEED-Net) and Japan International Cooperation Agency (JICA), which have provided the support and the funding needed to carry out this study. Valuable contributions from individuals including Dr. Saksith Chalermpong and Mr. Aphisit Phooworawuttipanich of Chulalongkorn University, Dr. Jamilah Muhammad and Mr. Zul Azman bin Zakaria of the Universiti Malaya, and Prof. Alexis Fillone and Ms. Agnes Galang of De La Salle University and others are highly acknowledged.

References

Bamberg, S., Rolle, D. (2003). Determinants of people’s acceptability of pricing measures – replication and extension of a causal model. In: Schade, J. and Schlag B. (eds.). Acceptability of transport pricing strategies. Oxford: Elsevier.

Bhattacharjee, D., Haider, S. W., Tanaboriboon, Y., Sinha, K.C. (1997). Commuters’ attitude towards travel demand management in Bangkok. Transport Policy 4 (3): 161 – 170.

Eagly, A.H., Chaiken, S. (1993) The Psychology of Attitude. Forth Worth: Harcourt Brace College Publishers.

Goodwin, P.B. (1996). Empirical evidence on induced traffic. Transportation 23 (1): 35 – 54.
Greene, D.L., Wegener, M. (1997). Sustainable transport. Journal of Transport Geography 5: 177 – 190.

Hansen, Mark (1995). Do new highways generate traffic? *Access* 7: 16 – 22.

Himmelfarb, Samuel. (1993). The measurement of attitudes. In: Eagly, A.H., Chaiken, S. (1993) The Psychology of Attitude. Forth Worth: Harcourt Brace College Publishers.

Jacobsson, C., Fujii, S., Garling, T. (2000). Determinants of private car users' acceptability of road pricing. Transport Policy 7: 133 – 158.

Jaensirisak, S, May, A.D. and Wardman, Mark. (2003). Acceptability of road user charging: The influence of selfish and social perspectives. In: Schade, J. and Schlag B. (Eds.) Acceptability of transport pricing strategies. Oxford: Elsevier.

Jakarta Metropolitan Authority. (2003). Regulation No. 12/2003 on Traffic and Highway Transportation, Rail and Water Transportation in Jakarta Metropolitan Area. Chapter VI article 50 verse 1 point c5.

Lim, Clark C. (1997). The status of transportation demand management in Greater Vancouver and energy implications. Energy Policy 25 (14–15): 1193 – 1202.

Litman, T.A. (2003a). London congestion pricing, implications for other cities. Victoria Transport Policy Institute. Available from: www.vtpi.org

Litman, T.A. (2003b). Measuring Transportation: Traffic, Mobility and Accessibility. The ITE Journal 73 (10): 28 – 32.

Maddison, D., Pearce, D., Johansson, O., Calthrop, E., Litman, T., Verhoeff, E. (1996). Blueprint 5: The true costs of road transport. London: Earthscan Publication.

Magbanua, Joel and Villoria, Olegario G. (1999). Work trip distribution in large scale CBD. In: Future Direction of Transportation Policies. National Center for Transportation Studies. University of Philippines.

Noland, R. B. (2001). Relationships between highway capacity and induced vehicle travel. Transportation Research A 35: 47 – 72.

Rienstra, S.A., Rietveld, P. and Verhoef, E.T. (1999). The social support for policy measures in passenger transport. A statistical analysis for Netherlands. Transportation Research D 4: 181 – 200.

Schade, Jens and Schlag Bernhard. (2003). Acceptability of urban transport pricing strategies. Transportation Research F 6: 45 – 61.

Schade, Jens and Schlag, Bernhard. (2000). Acceptability of Urban Transport Pricing. VATT Research Report 72. Government Institute for Economic Research, Helsinki.

Steg, L., Vlek, C. (1997). The role of problem awareness in willingness-to-change car use and evaluating relevant policy measures. In: Rothengatter, T., Carbonell V, E. (eds.). Traffic and Transport Psychology. Oxford: Pergamon Press.

Steg, Linda (2003). Factors influencing the acceptability and effectiveness of transport pricing. In: Schade, J. and Schlag B. (Eds.) Acceptability of transport pricing strategies. Oxford: Elsevier.

Sustainable Transport Action Network for Asia and the Pacific. (2004). Available from: http://www.gdrc.org/uem/sustran/sustran.html.

Thrope, Neil, Hill, P., Jaensirisak, S. (2000). Public attitudes to TDM measures: a comparative study. Transport Policy 7: 243 – 257.

Vlek, C., Michon, J. (1992). Why we should and how we could decrease the use of motor vehicles in the future. IATSS Research 15: 82 – 93.

Perspectives of Integrating Sustainability Principles in Engineering Education

King Hann Lim, Fouad Kamel, and Alpha Agape Gopalai

Department of Electrical & Computer Engineering, School of Engineering & Sciences, Curtin University Sarawak Malaysia, CDT 250, 98009 Miri Sarawak, Malaysia.

Email: glkhann; fouad.kamel; alpha.agape @curtin.edu.my

Abstract

Sustainability is increasingly gaining potential for projects to fulfill community and government's acceptance and satisfaction and thus acquiring ever rising importance in the engineering profession. This paper draws the importance of implementing sustainability elements in engineering courses throughout the course of study. To enable students identify the key issues for company and community, some industrial related analytical skills should be introduced in the engineering curriculum to evaluate a project quality in terms of environment, social and economic concerns. This new area of curriculum encourages students to appreciate the needs of the (1) stakeholders and the community, (2) objectives of sustainability, and (3) prior technical knowledge on assessing performance of engineering materials and systems. The need for integrating a diverse range of activities and engineering based knowledge should also be taken into account during the design of educational coursework. Throughout the design of final year projects, which are based on the principles of sustainability, students' generic skills such as comprehension, communication, teamwork, and sustainability could be improved effectively. This makes engineering graduates ready for industrial engagement after the engineering degree.

Keywords: Sustainability, Engineering Education, Project-based learning

Introduction

In recent decades, the massive growth of population has exceeded our planet capacity (Dodds, 2005). Furthermore, the quantities of earth resources are limited due to the slow rate of resources formation, unique geological topology being demolished, and the vast changes in the ecosystem (Chau, 2007). Infinite resource harvesting without consideration of its sustainability has emerged as a critical alert for next generations. The matter of understanding the need to live within constraints and to have a rationale plan in handling limited resources, can be resolved by implementing the principles of sustainability and sustainable development in engineering courses (Dodds, 2005).

Generally, 'sustainability' is defined as the consideration to meet the needs of current generations without infringing upon the needs of future generations or compromising their abilities to maintain a similar standard of living with minimal environmental degradation (Chau, 2007). Sustainability encompasses three concerns, i.e. environmental, social and economical concerns (Dodds, 2005). Environmental concerns include the natural resources such as energy resources existing on earth and the after-usage effect, which impacts the environment through emissions and wastes. Social concerns refer to human lifestyle expectations and aspirations besides government control and regulations. For economical concerns, technology development or products manufactured are crucial to assist in increasing efficient use of resources. These developments are mainly based on the engineer's skills and ingenuity.

Sustainable development is usually referred to as the process of refining human activities in terms of environmental integrity, economic viability, and socio-consciousness to a pattern that can be sustained in perpetuity. It is an approach to environmental and development issues that seek to reconcile human needs with the capacity of the planet to cope with the consequences of human activities (Dodds, 2005). Therefore, engineers are considered to be the key players in sustainable development to self-possessing the responsibility and ability to evaluate sustainability of resources by creating a new infrastructure, new design of products or analytical tools etc. Achieving sustainability through sustainable development will require some significant shifts in behaviour and consumption patterns. One implication is that engineers must recognise and exercise their responsibility to society as a whole through the modification of engineering skills learning and educational programmes. Environmental impact assessments are recently introduced for projects to fulfill community and government's acceptance and satisfaction.

In this paper, the implementation of project-based learning will be drawn in the engineering course to incorporate basic elements of sustainability. The importance of principles of sustainability will also be highlighted and discussed. The elements of sustainability such as social, economic and environmental will be incorporated in the final year project design. It is critical to introduce analytical skills to evaluate process design, the ability to find alternatives and identify the key issues for the company and the community. The need arises to equip engineering students with a broad consideration on concepts of environmental, economic and social factors, for decision making sensitive to sustainability.

Literature Review

Project-based learning is a multidisciplinary approach to use in-depth and rigorous methodologies in projects to facilitate learning and assess student competence of innovative, critical thinking and problem-solving skills. It is a key learning approach in the engineering curriculum design. Each project based learning course is designed, so that students could gain additional technical knowledge and enhanced generic skills from one project to a new project (Jollands, 2011). The curriculum for technical knowledge reflects con-current theory courses (Jollands, 2011). The activities to develop generic skills focus on communication, teamwork and sustainability.

Coles (2001) proposed a sustainable design course for all engineering and technology students. He suggested some industrial related project scopes such as Alternative Fuel Vehicle and capstone design course for multidisciplinary teams. As a result, his study stated that students could also achieve learning the importance of teamwork and responsibility through the industrial-based project besides the practical knowledge of the project.

Chau (2007) pinpointed the needs to incorporate sustainability concept and principles in both professional and education in the field of civil engineering. They analyzed the efforts made to reorient civil engineering education to promote the concept of sustainability in an undergraduate curriculum. They believed that cross-disciplinary thinking and skills are key elements of sustainability relevant knowledge.

Costa and Scoble (2006) introduced interdisciplinary project-based course revolving around sustainable mining with the involvement of local industry, government, non-government organizations (NGOs) and the mining community. Positive outcomes of this effort include interdisciplinary research, innovation in education, and lifelong learning skills.

Miller and Olds (1994) described a capstone designed course that incorporates problem solving, graphics, computing, technical oral/writing communication skills and team works. They found out that students who participated in the multidisciplinary capstone course report a significantly greater appreciation for non-technical skills than students who do not take the multidisciplinary capstone.

Van Kasteren (1996) described a course in sustainable design that concluded multidisciplinary project learning to be an excellent teaching method and addition to the engineering curriculum. On the other hand, Jansson (2007) described a public policy project involving wind energy undertaken in an engineering clinic for upperclassmen. The clinic generally attracted a variety of engineering majors and provided work outside the coursework normally required for an undergraduate degree.

Jollands et al. (2011) proposed a project-based learning in sustainability for fourth year engineering degree. They evaluated the project learning using the Triple bottom Line (TBL) in terms of economic, environmental and social impacts of each process based on research. The key sustainable development competencies were identified as "critical thinking, systemic thinking, ability to work in trans-disciplinary frameworks, and capacity to live values consistent with the sustainability paradigm". Their belief was that engaging an engineering consultant who is an expert in sustainability was the most critical success factor in implementing the project.

O'shea (2011) identified tertiary education curriculum design approach based on Montessori approach, which has been very successfully in enhancing the success of equity groups within primary education. These principles have been applied to the context of first year engineering 'micro-curricular' design. They applied Montessori approach for curriculum refinement for mentally handicapped children. Different perspectives of Montessori curriculum design principles were analyzed and positive preliminary outcomes were obtained in the study.

Principles of sustainability in Final Year Project

In engineering courses, final year project is the key curriculum to emphasize learning activities that are: (1) for the future, (2) interdisciplinary and (3) student-centered. The final year project, which is designed based on project-based learning approach, is a challenging opportunity for students to experience real-life problem solving, project management, interpersonal skills consisting of written and verbal communication, working productively as a team, work integrated education, and personal skills development (Jollands, 2011). The notion of project-based learning is that real-world problems capture students' interest and stimulate critical thinking as the students make use of the new knowledge in a problem-solving context. A supervisor's role in the project is a facilitator, who works with students to frame worthwhile questions, structures meaningful tasks, coaches both knowledge development and social skills, and carefully assesses what students have learned from the experience. Implementing project-based learning approach helps preparing students for the thinking and collaboration skills required in the workplace (Chau, 2007).

Furthermore, it is important to include elements of sustainability development in the final year projects scope (Chau, 2007). The core idea of this is to encourage students to not only focus on self development, but also obtain sensitivity towards critical issues in the surrounding environment, community and economy. In addition, one of the objectives of the project is to furnish students with an understanding of sustainability issues in relation to engineering industry and develop practical skills to support the application of sustainability principles to engineering design. A main emphasis is on greener production, and the crucial issues in practice are to transform these abstract theoretical paradigms into meaningful practical educational experiences that appeal to both engineering students and the larger community. Students have to make decisions on the most appropriate solution from the knowledge being taught in engineering modules, engineering principles as well as sustainability concepts, which include awareness, institutional factors and social-ethical aspects.

Therefore, to develop the final year project based on project-based learning approach and sustainability, the general architecture of engineering final year projects is suggested to be deliberately designed with the following characteristics:

1. Goal-achievable principle
   It is important to describe a project with clear goal and objectives, Students should know the final outcomes of the project, so that they could have well planning of their project time frame and have higher possibility to achieve the final results.
2. Knowledge-based driven
   Reflection of what they have learned throughout the engineering course is crucial in the final year project design. The project should be designed in the way that it possesses a slightly portion of relevant identities to their studying material. In other word, final year project is the best module to relate the engineering knowledge to the practical usage.

3. Open-ended problem or challenges in real world
   Final year project provides a training process for students to understand and address the problematic matter precisely, through debate, enquiry and critics. In addition, students could challenge the research findings by making their own hypothesis and setup their milestone to overcome the problems.

4. Solution-generation
   Feasible solution generation involves creativity, innovation and critical thinking to address the root of a problem. Students should be able to look for alternatives and variety of ways to create their unique solution in either conceptual view or theoretical proven stage and therefore, they could solve a problem in either a cost-effective or performance-efficient way.
5. Team-based assignment
   Working in a team can establish personal skills such as communication, leadership, assistance to balance out each another's weaknesses. Participation of a supervisor, a mentor, or an industrial people in a team could facilitate students in inspiring them with a proper guidance during the project period.
6. Multidisciplinary
   The diversity of group member's background can actually build a stronger team to solve variety of problems. In addition, faculty engagement, broadly defined as all activities to create conditions conducive to student engagement, tends to be increasingly high for the project design involving multidisciplinary. The design of final year project for multidisciplinary could interlink different discipline in the work and understand individual characteristic of different engineering role playing in a team.
7. Industrial-relevance
   The design of project should be practical and useful to society and stakeholder. The project should have linkage with an industrial collaborative work and it should not be too futuristic/ abstract to be understandable. Students can perceive a practical work better if the piece of work is related to real life application instead of imaginary work. It enables student to get ready to the industrial project once they have completed the graduate courses.
8. Economical issue
   Cost effective project is always a concern for community and stakeholders. Therefore, students should be able to budget their project implementation within a restricted given cost. They should know the way to find the alternatives to replace costly parts in order to achieve the final goal.
9. Environmental friendly
   Green technology is always a key consideration nowadays to reduce the green effect to the earth. Project design should be well fitted to: (1) well use of resources, (2) not creating a waste/pollution, (3) not damaging the ecosystem life cycle, and (4) thought of a possible disposable solution to manage the unused created product.
10. Socio-consideration
    In the socio-consideration, final year project should be designed with regards to long term sustainable vision, direction and regulation. In addition, it is important to ensure that the project developed by students is beneficial to individuals and society. It would be a better if the project is evaluated and reviewed by outside experts and/or project sponsors.

The application of solar panel in various engineering work is a good example of final-year project, which possesses sustainability elements. Solar panels can be found in many energy-driven machines to allow the machines self-sustain its process by absorbing the energy of sunlight. From the environmental aspect, solar panel generates electrical power without any emission of carbon monoxide or dioxide. With the intensive research work continues on with solar panel, the cost production of solar panels is being reduced. This engineering trend has brought to us to a better future planning in order to prolong the use of natural resources and sustainability.

Conclusion

The recent awareness of environmental degradation prompted pressing concerns over the sustainability of the natural environment. Engineering is the key profession to the incorporation of sustainability into the society. A team-based design project incorporating sustainability dimensions into the curriculum and project-based learning approach has given a great impact to the community and stakeholders. The design of final year project in engineering education conveys the principles of sustainability to engineers to consolidate competencies of social, economic and environment nature.

References

Chau, K. W. (2007). "Incorporation of sustainability concepts into a civil engineering curriculum." Journal of Professional Issues in Engieering Education and Practice 133(3): 188-191.

Coles, E. (2001). Sustainable design in engineering and technology education: A multidisciplinary model. Proceedings of the ASEE Annual Conference and Exposition: Peppers, Papers, Pueblos and Professors. Albuquerque, New Mexico: 9261-9265.

Costa, S. and M. Scoble (2006). "An interdisciplinary approach to intergrating sustainability into mining engineering education and research." Journal of Cleaner Production 14: 366-373.

Jansson, P. M., W. Riddell, et al. (2007). Engineering students transforming public policy to promote green power. American Society for Engineering Education Conference. Honolulu, HI.

Jollands, M., R. Parthasarathy, et al. (2011). Implementation of industry sustainability metrics in undergraduate design projects. Proceedings of the 2011 AAEE Conference. Fremantle, Western Australia: 38-43.

Miller, R. L. and B. M. Olds (1994). "A model curriculum for a capstone course in multidisciplinary engineering design." Journal of Engineering Education 84(4): 1-6.

O'Shea, P. and G. O'shea (2011). A curriculum design approach which creates increased opportunity. Proceedings of the 2011 AAEE Conference. Fremantle, Western Australia: 94-99.
Van Kasteren, J. M. N. (1996). "Interdisciplinary teaching with engineering education." European Journal of Engineering Education 21(4): 387-392.

Dodds, R, Venables R. (2005) "Engineering for Sustainable Development: Guiding Principles.", The Royal Academic for Engineering.

Occupants' Perception on the Quality of the Housing Complexes (A Study on Some Housing Complexes in Yogyakarta Region)

Albani Musyafa

Ficky Arif Ardinta

Joko Heriyanto

Department of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Email: albani.musyafa@uii.ac.id; albani_musyafa@yahoo.com

Abstract

Along with the population growth in Indonesia, the number of housing complex (*komplek perumahan*) continues to increase. The construction of the housing complexes is needed to meet the needs of the community. However, recently there are indications that the development of housing complexes tends to decrease their quality. Generally, the decrease can be seen on the quality of house construction and availability of the infrastructures. If this trend keeps continuing, the quality of life of the housing community tends to decline. The purpose of this study was to make the ranking of factors and variables of the quality of the housing complexes. The research method can be divided into two steps, i.e. methods of the data collection and the data processing. The data was collected by interviews based on questionnaires. The data was processed so that the ranking of the factors and variables were achieved. The rankings were validated by statistics tests. The result of this study indicates that the infrastructure in the housing complexes is the factor that should be prioritized to improve the housing.

Keywords: Quality of live, housing complex, infrastructure of housing

1. Background

Studies related to the quality of life (livability) have been carried out by some International agencies. There are research institutions that compare the level of livability of major cities in the world such as the Economist, Mercer, and Monocle (Wikipedia, 2011). The results of the research get extensive attention from the public. In fact they became a reference in decision making by the some communities.

However, at the national level, such a study is not popular yet. Therefore, research on the quality of life needs to be done. Because of the resource requirements for livability study is quite large; these studies can be initiated with limited scope. The small scope may include certain areas, such as residential complexes (*komplek-komplek perumahan*) that recently grown rapidly in Indonesia (Budihardjo, 1992).

To increase the livability of the community residents, the development of residential complexes/ housing should prioritize the quality. The quality includes the quality of houses, infrastructures (Budihardjo, 1992). Therefore, this study measured the quality of residential complexes in some areas in Yogyakarta.

2. Objectives

The research was conducted based on the fact that: the number of people living in residential complexes is increasing; and quality of the housing complex must affect the quality of life for the community. The objective of this study was to rank the quality of elements in the housing complexes.

3. Benefits

Basically, the quality of residential development is the responsibility of various parties in society. Construction industry should play an active role for the achievement of quality housing. The result of this study is expected to provide benefits to various parties. For the developers, the result of this study can be used as input in the planning of the housing. For regulators, the results of this study can be used for making guidance to improve the quality of live and the livability. For society at large, the results of this study provide a more real about the quality of the housing complex.

4. Limitations

Limitations of this study are:

1. The study was conducted only on several residential complexes in the northern part of the Yogyakarta.
2. The data were taken based on the perception of the residents.
3. The residential complexes were divided into residential home building and infrastructure.

5. Theory

The quality of human life must to be improved continuously. Improvement the quality of life can be done to improve the quality of human and environmental needs. One of the basic human needs is the residential and the support facilities or infrastructures (Sastra M and Marlina, 2006)

Housing is essential for human life, because the house is a place where communities do their activities. A house can be a place of family, rest, work, and education (Budihardjo, 1992). Therefore, the quality of the housing should be improved as an effort to improve the quality of human life. The efforts could be was initiated by identification of the quality of some elements in housing. By knowing the quality of each of the elements of housing, improvement of the quality of residential can be done based on results of scientific research.

Research on the quality of housing is increasingly important because many community members tend to choose to live in housing complexes (Sastra M and Marlina, 2006). With a qualified housing, the quality of life or community livability is expected to increase.

6. Literature Review

The purpose of this review is to determine the definitions associated with this research. Based on the definitions and the theory, indicator variables were defined.

Housing

Housing is defined as a group of houses that are supported by infrastructures such as water supply, waste disposal, electricity, telephone, roads etc (Sastra M and Marlina, 2006). Thus, in a residential complex, there are elements of house and infrastructure.

House Buildings

A house is a physical building for permanent shelter for individuals or groups so that healthy life can be maintained (WHO, 2001). Therefore, qualified houses must meet certain requirements, such as lighting and air circulation, room layout (Gunawan, 2009). The indicators of qualified houses are shown in Table 1.

Table 1. Indicators of the quality of home building

No	**Indicator**
1	Condition of the foundation and floor
2	Conditions of walls, beams, columns, and frames
3	Conditions of ceiling, roof and frame
4	Lighting and air circulation
5	The layout and function of rooms
6	Utility (water, electricity, etc.)
7	Yard and garden
8	Legality (property certificate)

Infrastructure

As the definition, qualified housing complexes should be provided facilities like roads, sanitation, recreation, safety, health, communication, business, social-religious affair that can not be separated from the housing (Gunawan, 2009, Sastra M and Marlina, 2006). The qualifications of the facility depend on characteristics of the housing. Infrastructures to support the housing are shown in Table 2.

Table 2. Indicator infrastructure

No	Facilities and infrastructure
1	Roads and sidewalks in the residential complex
2	Cleaning (drainage, trash)
3	Park and playground
4	Security (Post security guards, security system)
5	Health facilities
6	Business amenities, shops
7	Facilities of religious and social
8	communication facilities (telephone, TV, internet, etc.)

Definition of Quality

There are many definitions of quality. One of them is a matching between the performance of the products to the needs of consumers, including availability, delivery, realibility, maintainability and cost effectivenes (Yamit, 2001). Based on the definition, the quality of housing complex was defined as an assessment of fulfilment of expectations on the building and infrastructures, which they had occupied. The measurement of quality based on the point of view or perception of the consumer. This definition is in accordance with statements that a quality must begin from the needs of consumers and finish on consumer perceptions (Yamit, 2001). The quality was measured in five levels as shown in Table 3.

Table 3. Assessment of the quality and the scores

Quality level	Score
Very low	1
Low	2
Somewhat	3
High	4
Very high	5

7. Methodology

This research method describes the data collection and data processing to achieve the research objectives.

Place and Time

The research was conducted in three housing complexes located in Sleman territory i.e. Nandan, Bale Ageng, and Pesona Merapi in 2012.

Population and Sample

Samples used in this study were from the housing complexes. Sampling in this study carried out at random. Population is considered to be represented by this sample is housing complexes, which have the same characteristics especially that located in the northern Yogyakarta. This population is a group that is generalized by the results of this study (Sugiyono, 2009).

Data Sources

The data used in this study consisted of primary data that is obtained directly by surveyors. The data source is 31 housing residents, i.e. 11 people of Nandan, 10 of Bale Agung, and 10 of Pesona Merapi. The variables are determined based on literature review as presented in Table 1 and Table 2. Thus, the main data of this study consisted of 31 samples and 16 variables. In order the data from respondents can be analysed, the data were scored as Table 3.

The quality of the housing complex consisted of the quality of home building and the quality of infrastructures. Variables in each group were ranked and then validated by Kendall W.

Data Collection

The data collection was conducted by using questionnaires. The scale of measurement was 5-point Likert scale with intervals from Very low to Very high as shown in Table 3 (Sugiyono, 1999).

Data Analysis

The collected data are ranked for determining the sequence of quality level of components in the residential complex which. The significance of the ranking was calculated by Kendall-W test (Kendall's Coefficient of Concordance) that the formulae shown in Equation (1) and (2) (Sugiyono, 1999).

$$W = \frac{12\sum Ri^2 - 3n^2k(k+1)^2}{n^2k(k^2-1)} \quad \textbf{(1)}$$

$$\chi^2 = n(k-1)W \quad \textbf{(2)}$$

Notes:

W = Kendall W
k = Number of variables
n = Number of samples
Ri = Sum of the value of each variable
X^2 = Chi Square

Findings and Discussion

The findings are the result of data analysis, while the discussion is intended to demonstrate the validity of the findings. These data sets form the matrix 31 samples and 25 variables. For efficiency, the data of this study appeared in the form of description tables.

Quality of Home Building

The results of measuring the quality of house building in residential complexes consisting of eight variables were summarized in **Error! Reference source not found.**. The table shows description of the data and the ranking of the quality of home building elements. With regard the top two ranked variables have a high quality and the lowest two ranked variables have a low quality, the ranking order indicates that the legality of building (R8) and the foundation and floor of the house (R1) got a high ranking or a relatively high quality. While the utilities such as water supply (R6) and the ceiling and the roof system (R3) has a relatively low quality.

Table 4. Description of the quality of home building in the housing complexes

Indicator Variable	N	Median	Std. Dev	Min	Max	Mean Rank	Ranking
Condition of the foundation and floor (R1)	31	4.0000	.63246	3.00	5.00	5.19	2 (High)
Conditions of walls, beams, columns, and frames (R2)	31	4.0000	.70176	2.00	5.00	4.15	6
Conditions of ceiling, roof and frame (R3)	31	4.0000	.59928	2.00	4.00	3.94	7 (Low)
Lighting and air circulation (R4)	31	4.0000	.54674	3.00	5.00	5.09	3
The layout and function of rooms (R5)	30	4.0000	.50742	3.00	5.00	4.50	4
Utility (water, electricity, etc.) (R6)	31	4.0000	.78288	2.00	5.00	3.37	8 (Low)
Yard and garden (R7)	29	4.0000	.65841	2.00	5.00	4.28	5
Legality (property certificate)(R8)	30	4.0000	.53067	3.00	5.00	5.48	1 (High)

Based on the ranking, the condition of the floor and the foundation were considerably good. It is due to the soil condition in northern Yogyakarta and the availability of the materials. Legality of home building was also well managed. Conversely, the condition of the roof and ceiling are considered poor because the material was not good. Many residents could not know the quality of the material because it is covered by a ceiling and roof. Water supply facilities were still complained by residents. However, the water and electricity problems are more related to infrastructures that must be guaranteed by the government.

The ranking is based on an assessment of about 30 respondents from the three housing complexes. Nevertheless, as Kendall W test results with 95% confidence level, there is a tendency of respondents to provide a similar judgment. Thus, the ranking can be considered valid.

Quality of Infrastructure

The results of measuring the quality of infrastructures in the residential complexes consisting of eight variables are summarized in Table 5. The table also describes the data and the rank of the quality of infrastructure elements. With regard the two top ranked variables have a high quality and the two lowest ranked variables have a low quality, the ranking indicates that the street / sidewalk (S1) and sanitation (S2) in the residential complexes have a relatively good quality. While the quality of health (S5) and business facilities (S6) have a considerably low quality.

Based on the ranking, the roads, sidewalks, drainage have been well assessed by residents because the developer built them to be the main attraction. In contrast, health facilities and businesses are considered poor, while the residential complexes were located far from urban areas.

Table 5. Description of the quality of facilities and infrastructure in the housing complexes

Indicator Variable	N	Median	Std. Dev	Min	Max	Mean Rank	Ranking
Roads and sidewalks in the residential complex (S1)	31	4.0000	.44721	3.00	5.00	6.05	1 (High)
Cleaning (drainage, trash) (S2)	31	4.0000	.51222	2.00	5.00	6.00	2 (High)
Park and playground (S3)	30	4.0000	.93526	1.00	5.00	4.75	4
Security (Post security guards, security system) (S4)	31	4.0000	.86385	2.00	5.00	5.07	3
Health facilities (S5)	31	3.0000	.77460	1.00	5.00	3.05	7 (Low)
Business amenities, shops (S6)	31	3.0000	.96498	1.00	4.00	2.68	8 (Low)
Facilities of religious and social (S7)	31	3.0000	.66073	2.00	4.00	4.05	6
communication facilities (telephone, TV, internet, etc.) (S8)	31	3.0000	.67680	2.00	5.00	4.35	5

Ranking is based on an assessment of about 31 respondents from the three residential complexes. Nevertheless, based on Kendall W test results with 95% confidence level, there is a tendency of respondents to provide similar judgments to the quality of infrastructure in the housing complexes. Thus, the ranking can also be considered valid.

In addition, by combining the eight variables of house building in one group and eight variables of infrastructure in the other groups, it provides the total assessment for each group. Comparison of these assessments indicates that the respondents' assessment of infrastructures (862 points) is relatively lower than the score of the home building (960 points). This suggests that quality of infrastructure is lagging behind the quality of homes building.

Because of the validity of these findings, these findings may be used as a guide to improve the quality of the housing complexes. Finding indicated that improvement of housing complexes should be more focus on the infrastructure rather than the house building. These results are in accordance with the opinion that the arrangement of the infrastructures is a key to improving the quality of housing (Sastra M and Marlina, 2006).

Conclusions and Recommendations

The conclusion of this study is that residential infrastructure such as health and business facilities re more urgent to be improved. However, the quality of the house component that needs to be increased is the ceiling frame and roof truss.

The recommendation for improving the quality of the housing is as follows. Homeowners should check the quality and guarantee of the home, especially for the roof and the ceiling. The developers should add health and businesses facilities for the housing complexes. Developers and government should ensure the supply of electricity and clean water for residential complexes.

References

Budihardjo, E. (1992). "*Sejumlah Masalah Pemukiman Kota,* Alumni, Bandung

Gunawan, R. (2009). "*Rencana Rumah Sehat,* Kanisius Yogyakarta

Sastra M, S. & Marlina, E. (2006). "*Perencanaan dan Pengembangan Perumahan,* Andi.Yogyakarta

Sugiyono (1999). "*Statistik Nonparametris,* Alfabeta, Bandung

Sugiyono (2009). "*Metode Penelitian Kuantitatif Kualitatif dan R&D,* Alfabeta, Bandung

Wikipedia (2011). *World's Most Livable Cities,* Received on 16 Maret, From http://en.wikipedia.org/wiki/Word %27s_most_livable_cities

Yamit, Z. (2001). "*Manajemen Kualitas Produk dan Jasa,* Ekonosia.Yogyakarta

Determining Energy Conservation Opportunities of Terminal 3 Soekarno - Hatta International Airport Using Energy Simulation Software

Laksana Gema Perdamaian[1], Rachmawan Budiarto[2], M. Kholid Ridwan[3]

[1,2,3]*Department of Engineering Physics, Faculty of Engineering,*

Universitas Gadjah Mada

[1]laksana_gp@mail.ugm.ac.id

[2]rachmawan@ugm.ac.id

[3]kholid@ugm.ac.id

Abstract

In 2009, Soekarno-Hatta International Airport introduced Terminal 3 to expand its capacity to meet the continuously improving passenger traffic. Terminal 3 is designed with a new and unique paradigm, called eco and modern terminal. This paradigm emphasizes eco-friendliness and modernity in service of the terminal. Energy conservation is one of vital issuesfor this paradigm. Electricity consumption in airport terminal buildings can be identifiedvia Low Voltage Main Distribution Panel or LVMDP which each of them serves individual distribution block.Overall electricity consumption based on distribution blocks does not describe operational characteristics of building systems, whereas energy conservation opportunities is determined from analysis on operational characteristics of building systems.Utilization of building energy performance simulation software offers solution by providing electricity consumption data based on building systems. Simulation result shows that overall electricity consumption of Terminal 3 is 27700.107 GJ or 7.694 MWh per year, with 86.59% of that is consumed by HVAC system, 9.33% consumed by lighting system, 2.41% consumed by electricity equipment, and 1.76% consumed by transportation system. Energy Use Index (EUI) of Terminal 3 is 277.786 kWh/m^2/year. Three energy conservation scenariosare applied in simulation in this research, i.e. increasing temperature setpoint, AHU rescheduling, and window films replacement. Increasing temperature setpointcould give 4.40% energy consumption reduction. Increasing temperature combined with AHU rescheduling could give 5.10 % energy consumption reduction. Window film replacement combined with increasing temperature setpoint and AHU rescheduling could give 5.16% energy consumption reduction.

Keywords: *Energy conservation opportunities,building energy simulation, electricity consumption, Energy Use Index (EUI).*

Introduction

The business of Indonesian air transportation entered a new era in the beginning of 2000s with the establishment of several new airlines which offer low-cost carrier services. Since then, air transport became more affordable for the middle-economy class, therefore more people can use air transport. The geography of Indonesia, which has many airports serving cities scattered over the archipelago also plays a significant role on the growth of Indonesian air traffic.

Soekarno-Hatta International Airport, is a large hub for domestic and international flights. The growth of air traffic, which mainly domestic traffic, gives large effect to the airport. Every year, passenger movement of the airport increases while the capacity of the airport terminal is constant. The airport needs expansion to handle more than twenty million passengers, which increases every year.

On April 15, 2009, Soekarno-Hatta International Airport introduced new terminal to expand its capacity to meet the continuously improving passenger traffic. The new terminal bears the name Terminal 3 after the two older terminals, Terminal 1, which is established in 1982 and Terminal 2, which is opened in 1992. Terminal 3 is designed with a new and unique paradigm, called eco and modern terminal. This paradigm emphasizes eco-friendliness and modernity in service of the terminal. In this paradigm, energy conservation is one of vital issues.

An airport terminal is one of the entities of tertiary sector, which majority of energy consumed is in the form of electricity. Airport terminal, especially that handles international flight, operates 24 hours a day. It meansthat they will consume electricity all day long. Electricity consumption in airport terminal buildings, like other large buildings, can be known via distribution panels called Low Voltage Main Distribution Panel or LVMDP. Each LVMDP serves one specific block of electricity distribution, hence recorded electricity consumption is based on distribution block.

Overall electricity consumption based on distribution blocks is ineffective in improving energy efficiency because it does not describe operational characteristics of building systems, whereas energy conservation opportunities is known from operational characteristics of building systems.

Utilization of building energy performance simulation software offers solution by providing electricity consumption data based on building systems. Building energy performance simulation software have a capability to simulate building electricity consumption in a specified long term, such as yearly, with a relatively short interval, such as hourly or daily.

Literature Review

Building energy consumption data obtained from simulation software can be used for various research objectives. Andarini, et.al.used building energyperformace software to analize a cooling load sensitivity with the variation of building variables [1]. Zerenimplemented building energy simulation to find the dynamics of bulding energy consumption and to evaluate various energy conservation strategies, such as variation if building orientation and HVAC systems [2]. Zhu applied building energy simulation as a tool for energy auditing in the form ofevaluating various energy conservation opportunies and their impact to overall building electricity consumption [3].

Fundamental Theories

Estimation process of energy consumed by buildings includes three basic components, i.e. space load, secondary equipment load, and primary equipment load calculations. Secondary equipment is equipment that distributes heating, cooling, or ventilating media to the conditioned space, whereas primary equipment is equipment that converts fuel or electricity to heating or cooling effect [4].

Heat Balance Method

Heat balance method is a method for calculating sensible load which applies first law of thermodynamics or energy conservation law and principles of matrices algebra [4]. The basic assumption apllied in the heat balance model is that air in every thermal zone can be modelled as well stirred with a uniform temperature [5].

Calculating space sensible load using heat balance method consists of four elements, they are [5]

1) outside-face heat balance,
2) inside-face heat balance,
3) zone air heat balance, and
4) wall conduction process.

Occupant Cooling Load Estimation

Cooling load generated by occupant depends on occupancy rate of the building or thermal zone. Occupant dominating the airport terminal is airplane passengers, therefore estimation will be focused on the number of passengers.

Estimation of passenger rate at the airport terminal building is conducted based on IATA Arrival Earliness Distribution. Ahyudanari and Vandebona [6] used time blocks to calculate rate of passenger arrival to the check-in area. The length of each time block is ten minutes.

Basically, IATA Arrival Earlines Distribution can only used for domestic flight. According to observation by Ashford (1976) in Ahyudanari and Vandebona [6], IATA Arrival Earliness Distribution can be used for international flight by way of postpone the time for 60 minutes.

Depending on the occupation pattern, areas of an airport terminal building can be divided to two types. The first type is an area which has queues of passengers inside and the second one is an area which does not have queues of passenger inside. Estimation of number of occupant in an area which has queues of passengers can be conducted using Equation (1).

$$O_{A(t)}=P_{A,q(t)}+P_{A,p(t)}+S_{A(t)} \tag{1}$$

where
$O_{A(t)}$ = number of occupant in a specific area at time$t$,
$P_{A,q(t)}$ = number of queuing passengers during time$t$,
$P_{A,p(t)}$= number of queuing passengers being processed during time t,
$S_{A(t)}$ = number of staffs at time$t$.

For an area which does not have passenger queues inside, estimation of number of occupant can be conducted using Equation (2).

$$O_{A(t)}=(P_{A,i(t)}-P_{A,o(t)})+S_{A(t)} \tag{2}$$

where
$O_{A(t)}$ = number of occupant in a specific area at time t,
$P_{A,i(t)}$= number of passengers entering area at time$t$,
$P_{A,o(t)}$ = number of passengers exiting area at time t,
$S_{A(t)}$ = number of staffs at time t.

Rate of occupant's cooling load can be obtained using Equation (3).

$$Q_o = O_A \times Q_W \tag{3}$$

where
Q_o = rate of occupant's cooling load (W),
O_A = number of occupant in a specific area,
Q_W = cooling load rate of activites done by occupants (W).

Energy Consumption and Cooling Load Rate Estimation of Lighting Systems

Electricity consumed by lighting systems is transformed to three fraction of heat, i.e. shortwave radiation, longwave radiation, and convection. Those fractions can be distributed to the space or also called space fraction. Those fractions can be also distributed to the plenum, therefore will interact with return air of the HVAC systems and called plenum/return air fraction. Generally, division of heat generated by lighting systems can be calculated using Equation 4 [7].

$$f_{conv} = 1{,}0 - (f_{ret} + f_{lw} + f_{sw}) \tag{4}$$

where
f_{conv} = convective fraction,
f_{ret} = plenum/return air fraction,
f_{lw} = longwave radiation fraction, and
f_{sw} = shortwave radiation fraction.

Energy Consumption and Cooling Load Rate Estimation of Transportation Systems

In this research, estimation of energy consumption and cooling load rate are done for two types of building transportation systems, escalator and lift. To obtain the cooling load rate estimation, power required by transportation system has to be estimated first.

Estimation of power required by escalator conducted using Equation (5).

$$P_{m,e} = \frac{(Pax \times n_{pax,e(t)}) + P_{m,e,H}}{\eta_e} \tag{5}$$

where
$P_{m,e}$ = power required by motor of the escalator (watt),
$n_{p,e(t)}$ = number of passenger carried by the escalator
$P_{m,e,H}$ = power required to move handrail (watt), and
η_e = escalator system efficiency.

Estimation of power required by lift system conducted using Equation 6 for upward-moving lift and Equation 7 for downward-moving lift..

$$P_{ml} = \left| \left(\left(m_{l,c} + \left(n_{p,l} \times m_{l,p} \right) \right) \times (A_l(t) + g) \times V_l(t) \right) - (m_{CW} \times g \times V_l(t)) \right| \tag{6}$$

$$P_{ml}=|(m_{CW}\times(A_l(t)+g)\times V_l(t))-\left(\left(m_l+\left(n_{p,l}\times m_{l,p}\right)\right)\times g\times V_l(t)\right)| \quad (7)$$

where
P_{ml} = power required by lift's motor (watt),
$m_{l,c}$ = mass of lift cab (kg),
$n_{p,l}$ = number of passengers,
$m_{p,l}$ = total mass of passengers (kg),
g = gravitational acceleration (9.81 m/s^2),
$A_{l(t)}$ = lift acceleration at time$t$ (m/s^2),
$V_{l(t)}$ = velocity of lift at time$t$ (m/s), and
m_{CW} = counterweight mass (kg).

Cooling load rate of transportation systems can be obtained using Equation (8)

$$Q_{tr}=\eta_{tr}\times P_{tr} \quad (8)$$

where
Q_{tr} = cooling load of the transportation system (watt),
η_{tr} = transportation system efficiency
P_{tr} = power required by transportation system (watt).

A. Energy Consumption and Cooling Load Rate Estimation of Electric Equipment

Electricty consumed by electric equipment is transformed to heat and work. Electricity which converted to heat is divided into three fractions, i.e. latent heat, wave radiation, and convection.

Heat fraction division of the electric equipment can be obtained using equation (9) [7].

$$f_{cv}=1,0-(f_t+f_r+f_w) \quad (9)$$

where
f_{cv} = convective heat fraction,
f_l = latent heat fraction,
f_r = radiation fraction, and
f_w = work fraction.

Implementation

Data input to simulation software consists of primary data and secondary data. Primary data is obtained from direct measurement and observation and secondary data is obtained from equipment specification or interview with the building management staffs.

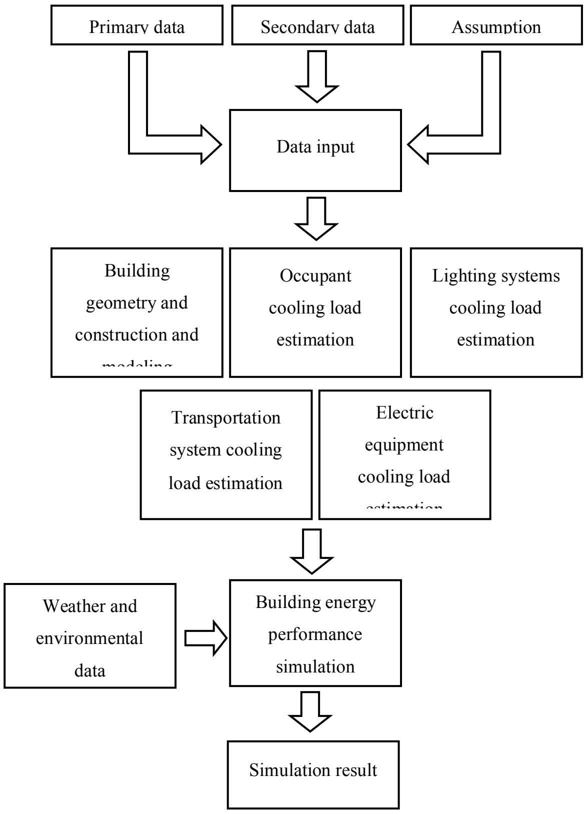


Figure 1.Data input process to the sofware.

As displayed in Fig 1, there are several assumptions made in this research. The assumptions are applied on the calculation of the number of occupants and its cooling load, estimation of the cooling load of the transportation system, estimation of the cooling load of the electric equipment and HVAC system sizing.

This research was conducted in October 2011, when the Terminal 3 was in very low load, because one of the two client airlines was temporarely suspended. Therefore the number of occupant represents the low-load condition, not the ideal condition. The number of occupant is assumed in accordance with the calculation based on IATA Earliness Arrival Distribution.Cooling load of occupants is determinedbased on assumption that all of the occupants are in same activity. The activity done by the occupant depends on the area they occupied.

The cooling load of transportation system is obtained from calculation which combines assumptions and secondary data. Operation scheme of the transportation system is assumed appropriate with the occupation rate obtained from IATA Earliness Arrival Distribution-based calculation.

Electrical equipment calculated in this research includes office and entertainment equipment but not airport operational equipment such as baggage carousel and x-ray machine. The cooling load of the electric equipment is assumed based on the data obtained from ASHRAE 2009 Handbook of Fundamentals.

HVAC system sizing is not obtained from actual equipment specification but from autosizingwhich is a load-based sizing mechanism of the simulation software. Therefore, the electricity consumption of the HVAC system represents the amount of electricity needed by HVAC system based on the setpoint of the system, not the size or the specification of the equipment of the system.

Result and Discussion

HVAC System Electricity Consumption

Simulation result of HVAC system electricity consumption divided into four components, i.e. air loop, chiller, pump, and cooling tower system. Chiller is the largest consumer of electricity among other components, with 17675.832 GJ of electricity consumed per year. Pump comes in second place with 4066.040 GJ of electricity consumed per year, followed by cooling tower and air loop system with 1142.938 GJ and 1101.208 GJ of electricity consumed per year, respectively.

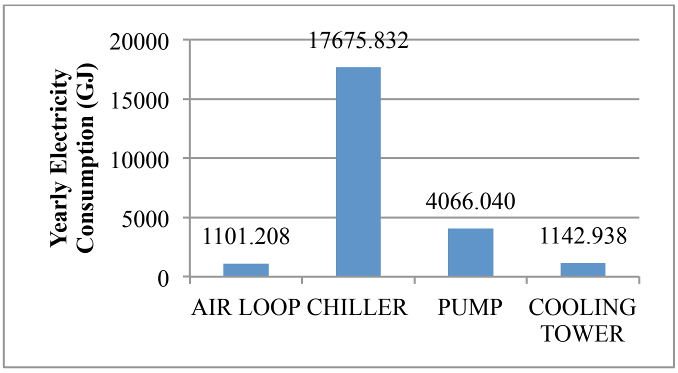


Figure 2. Yearly electricity consumption of HVAC system components.

Lighting System Electricity Consumption

Electricity consumption simulation of lighting system is divided based on thermal zone. Lighting system of Commercial First Floor East zone consumed electricity most among other zones, with 302.566 GJ of electricity consumed per year. Conversely, the lighting system of Meeting Point zone is the least, with 158.108 GJ of electricity consumed per year.

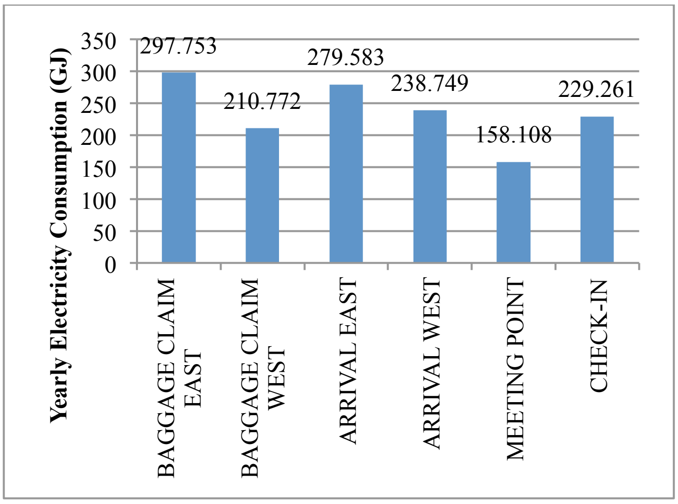


Figure 3.Yearly electricity consumption of lighting system of zone located at the ground floor.

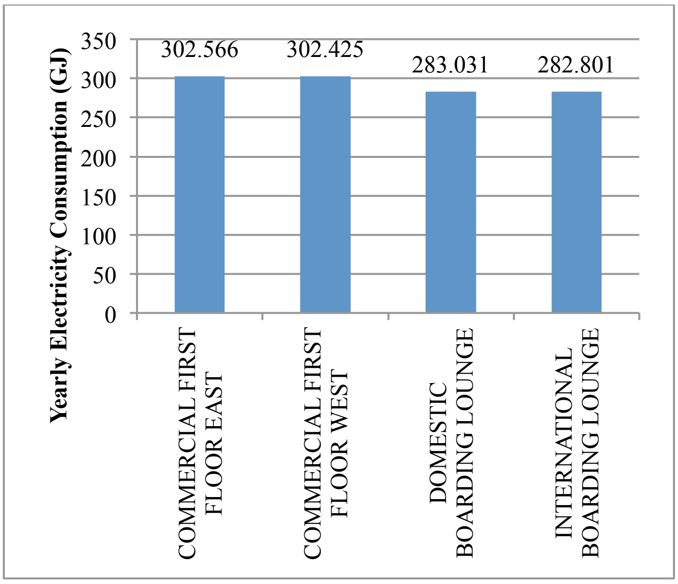


Figure 4. Yearly electricity consumption of lighting system of zone located at the first floor.

Transportation System Electricity Consumption

Simulation of transportation system electricity consumption is divided based on unit of the system. There are five escalators and four lifts that are located at three zones. Electricity consumption of transportation systemdepends on number of passenger carried.

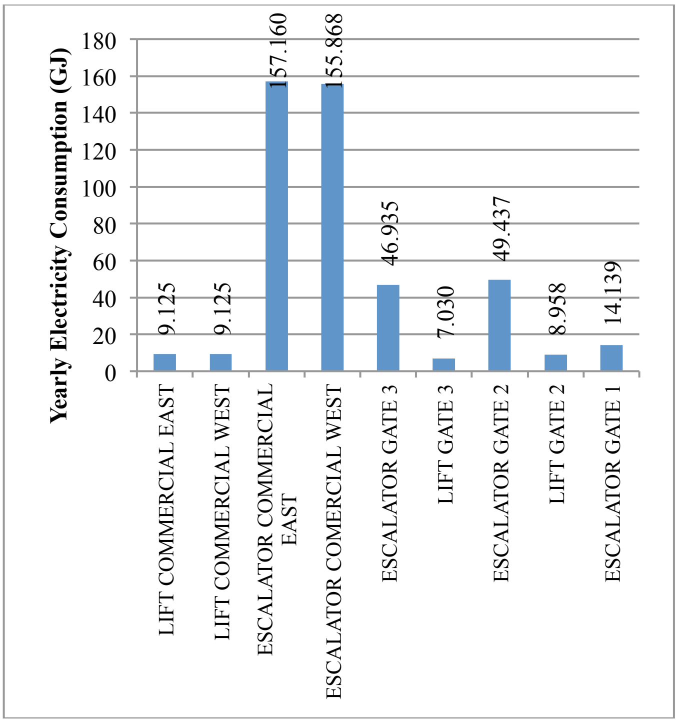


Figure 5.Yearly electricity consumption of transportation system.

Transportation system, which consumes largest is escalator connecting Meeting Point and Commercial First Floor East zone with 157.160 GJ of electricity consumed per year. Escalator connecting Meeting Point and First Floor West zone comes in second place with 143.812 GJ of electricity consumed per year. Two of these systems consume energy larger than other transportation system because they carries much more passengers than other systems. Transportation system which consumes smallest is Lift Gate 3 which connects Domestic Boarding Lounge zone with Gate 3, with 7.030 GJ of electricity consumed per year. This system also carries least passenger.

Electric equipment electricity consumption.

Electricity consumption simulation of electric equipment divided based on thermal zone. Each zone has certain number and specific types of equipment, therefore it is possible to get different amount of energy consumption. All of the ten zones are simulated, except Baggage Claim West zone, because no commercial activity and electric equipment are installed there.

Electric equipment installed at International Boarding Lounge zone consumes most among the others, with 170.834 GJ of electricity consumed per year, whereas electric equipment installed at Arrival West zone consumes least with 10.220 GJ of electricity consumed per year.

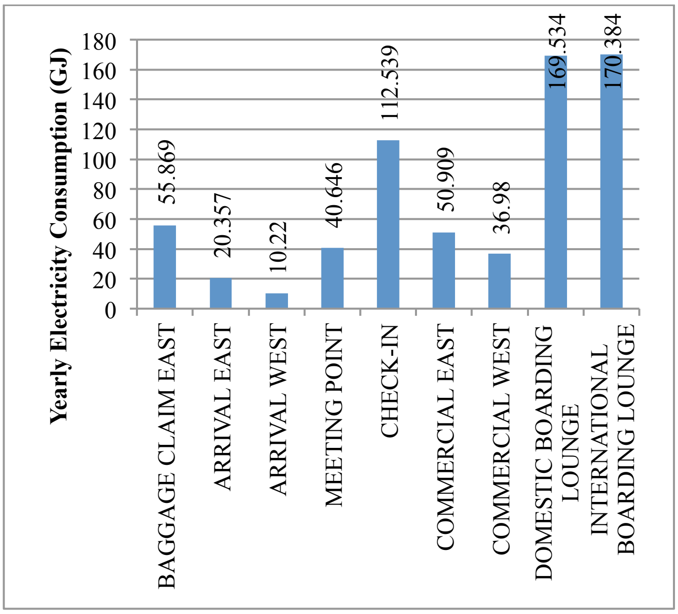


Figure 6.Yearly electricity consumption of electric equipment.

Overall Building Electricity Consumption

Overall electricity consumption of Terminal 3 is 27700.107 GJ per year or 7694474.183 kWh per year. HVAC system dominates the overall electricity consumption with 23986.018 GJ of electricity consumed per year or 86.59% of overall electricity consumption. Meanwhile, lighting system comes second with 2585.048 GJ of electricity consumed per year or 9.33% of overall electricity consumption, followed by electric equipment (667.434 GJ per year, 2.41%) and transportation system (461.606 GJ per year, 1.67%). With overall area of 27699.258 m^2(combination of ground floor and first floor area), the energy consumption intensity of Terminal 3 according to simulation result is 277.786 kWh/m^2/year.

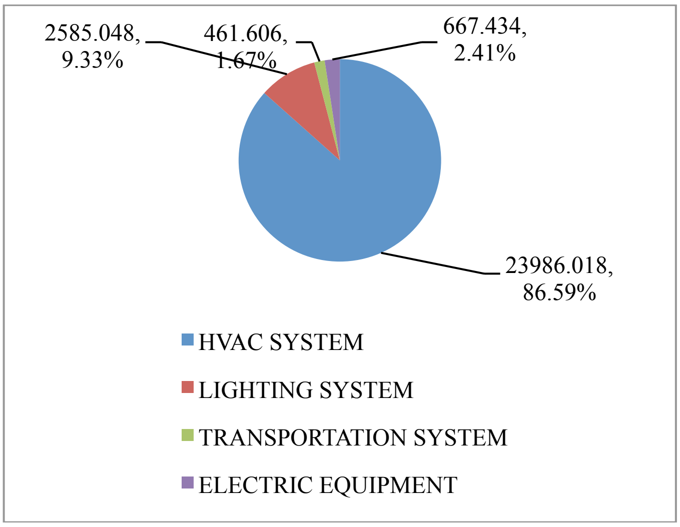


Figure 7.Breakdown of overall electricity consumption.

Building Performance Evaluation and Energy Conservation Opportunities

The term of building performancein this research is limited to thermal and visual comfort. Both thermal and visual comfort evaluation conducted by comparing the value obtained by simulation with respective standard. This evaluation is conducted in order to find energy conservation opportunities.

The thermal comfort of the building is evaluated by comparing the temperature and humidity of certain zone with the Indonesian National Standard (*StandarNasional Indonesia*) 03-6572-2001[8]on procedure of the design of building ventilation and air conditioning. The visual comfort of the building is evaluated by comparing the illuminance level with the regulation issued by Directorate General of Civil Aviation number SKEP/VI/77/2005 [9]ontechnical requirements of airport technical facility operation and by comparing the glare index with the maximum allowable glare index [7].

Building performance evaluation gives three energy conservation opportunities, i.e. increment of setpoint temperature, AHU (air handling unit) rescheduling, and window film replacement.

Energy Conservation Effort by Increasing HVAC Setpoint Temperature

According to SNI 03-6572-2001, temperature value fit in the comfort zone for tropical climate such as Indonesia is between 20.5°C and 27.1°C. Range between 20.5°C and 22.8°C is called 'comfortable cool', while range between 22.8°C and 25.8°C is called 'optimally comfortable', and range between 25.8°C and 27.1°C is called 'comfortable warm' [8].

Setpoint temperature of the existing building (baseline) is set at 23.5°C. To achieve the level of optimally comfortable, the setpoint temperature can be increased until 25.8°C. However, the new setpoint temperature proposed in this research is at 24.5°C. The upper limit value not chosen in order to minimize the occurrence of temperature exceeds the limit of optimally comfortable level. The value 24.5°C is chosen because middle value between existing setpoint (23.5) and upper limit of optimally comfortable level (25.8) is 24.45, or can be rounded up to 24.5°C.

Energy Conservation Effort by Rescheduling AHU Operation

Simulation result shows that some AHUs keep operating at low-occupation hours when there is no departure or arrival. This makes the temperature of the zone served by those AHU falls below comfortable limit (20.5°C) and at the same time, the electricity consumed by the AHU is useless. Therefore AHU rescheduling can be done to specific zone in order to get electricity consumption reduction.

Energy Conservation Effort by Replacing Window Film

According to simulation result, glare occurs at zones located at the first floor. The glare index measured at those zones is over 22, whereas 22 is the maximum allowable glare index for office [7]. High glare index can causes visual discomfort. Therefore replacement of windows film in order to reduce glare is done. At the same time, this can reduce solar heat gain and hence can reduce electricity consumed by HVAC system.

Formulation of Energy Conservation Scenarios

Energy conservation efforts mentioned above are formulated to become three energy conservation scenarios. They are Scenario 1, Scenario 2, and Scenario 3. Scenario 1 consists of setpoint temperature increment. Scenario 2 consists of setpoint temperature increment combined with AHU rescheduling. Scenario 3 consists of setpoint temperature increment and AHU rescheduling combined with window film replacement.

Result of Energy Conservation Scenarios Implementation

	Electricity Consumed (GJ)	Saving		EUI(kWh/m^2)
		GJ	%	
Base Case	27700.107	-	-	277.786
Scenario 1	26482.144	1217.963	4.40	265.572
Scenario 2	26287.844	1412.263	5.10	263.624
Scenario 3	226271.312	1428.795	5.16	263.458

Conclusion

1) Simulation based on assumptions predicts that overall electricity consumption of Terminal 3 Soekarno-Hatta International Airport is 27700.107 GJ or 7.694 MWh per year.
2) HVAC system consumed the largest portion (86.59%) of overall building electricity demand, with 23986.018 GJ per year. Comes in second place is lighting system, accounted for 9.33% of overall annual building electricity consumption, equivalent to 2585.048 GJ, followed by electric equipment (2.41%, 667.434 GJ), and transportation system (461.606 GJ per year, 1.67%) comes last.
3) According to that simulation, The Energy Use Index (EUI) of Terminal 3 Soekarno-Hatta International Airport is 277.786 kWh/m^2/year.
4) Three energy conservation efforts are proposed, they are increment of temperature setpoint, AHU rescheduling, and window film replacement.
5) Implementation of Scenario 1 could reduce overall building electricity consumption 1217.963 GJ (4.40%) per year, whereas implementation of Scenario 2 could decrease building electricity consumption 1412.263 GJ (5.10%) and Scenario 3 could reduce building electricity consumption 1428.795 GJ (5.16%).

References

RahmiAndarini, H. Schranzhofer, W. Streicher, and A.K. Pratiwi. "Thermal Simulation and Cooling Energy Sensitivity Analysis of a Typical Shophouse in Jakarta, Indonesia". *Building Simulation 2009*, *Eleventh International IBPSA Conference*, page 1887 – 1893, Glasgow, Scotland, 27 – 30 July 2009.

Fatma Tuba Ceyhan Zeren. *Energy Performance Analysis of Adnan Menderes International Airport (ADM)*. Thesis, Graduate School of Engineering and Sciences, İzmir Institute of Technology, İzmir, Turkey, 2010.

Yimin Zhu. "Applying computer-based simulation to energy auditing: A case study". *Energy and Buildings*, 38: 421–428, 2006.

ASHRAE. *2009 ASHRAE Handbook – Fundamentals (SI)*. American Society of Heating, Refrigeration, and Air Conditioning Engineers Inc., Atlanta, Georgia, U.S., 2009.

Drury B. Crawley, Linda K. Lawrie, Frederick C. Winkelmann, W.F. Buhl, Y. Joe Huang, Curtis O. Pedersen, Richard K. Strand, Richard J. Liesen,Daniel E. Fisher, Michael J. Witte, and Jason Glazer. "EnergyPlus: creating a new-generation building energy simulation program". *Energy and Buildings*, 33:319–311, 2001.

ErinaAhyudanariandUpaliVandebona. "Simplified Model for Estimation of Airport Check-In Facilities". *Journal of the Eastern Asia Society for Transportation Studies*, 6 : 724 – 735, 2005.

EnergyPlus Input-Output Reference. Technical document, University of Illinois, Urbana, Illinois, and Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California, U.S., 2011.

Tata Cara Perancangan Sistem Ventilasi dan Pengkondisian Udar apada Bangunan Gedung. Standar Nasional Indonesia (SNI) 03-6572-2001. Badan Standardisasi Nasional, Jakarta, 2001.

Persyaratan Teknis Pengoperasian Fasilitas Teknik Bandar Udara. Peraturan Direktur Jenderal Perhubungan Udara Nomor SKEP/77/VI/2005, Direktorat Jenderal Perhubungan Udara, Kementerian Perhubungan Republik Indonesia, Jakarta, 2005.

Using the Ecomix Additive for the Base Layer Stability in the Road Structure (A Case of Study on Road Structure in the Coal Mining Area, Banjarmasin, South Kalimantan)

Edy Purwanto

Civil Engineering Department, Faculty of Civil Engineering and Planning
Islamic University of Indonesia

Email: eddypps@yahoo.com

Abstract

Bearing capacity of soft soil is the most often problems founded in the site. Soil stabilization, with the use of ecomix additive material, has proven to solve this problem. The result of research shows that the more ecomix amount is added, the value of CBR and soil bearing capacity show significant rising. For example, the value of CBR original soil increases from 7, 20% becomes 100% with 10% added of ecomix in the 14 up to 28 days of hatching time, so does for the bearing capacity for the original soil after it is stabilized that is from 1,80 kg/cm² becomes 32,10 kg/cm².

Keywords: stabilization, first coat, road structure, ecomix, CBR, soil bearing capacity

Background

In the road development planning, one of the considered factors is the availability of the appropriate materials. The appropriate materials are so limited in the certain areas and it must be come from others area. On road structure developing in Tanjung coal mining location, Banjarmasin South Kalimantan needs so many rocks that are from outside Kalimantan Island those are from Java Island and Sulawesi Island. This will need big transportation cost and longer time than usual; therefore, the total of construction cost will be so high. Besides that, the road condition in the coal mining location is so important to support the productivity or activities in the coal mining location. With the coal mining location is more than 5000 ha width, therefore, the soil condition is variety enough and the experts that responsible toward the road have tried with their maximal power to care and maintain the condition of existing road keep in good condition, such as need to open new mining area location and it will be needed new road, for that, it is needed to hold diversification of using new materials that can be responsible not only technically but also economically. On the certain area, that is station km 11,7, it is still found the unstable condition of soil or soft soil (PT Adaro Indonesia, 2009).

To overcome this problem, it has been long time developing a method what is so called as soil stabilisation, that is a method to increase or repair the characteristics and strength of the local soil become materials that fulfil the requirements, whether it is for sub grade, sub base, or base layer (PT Ecomix™ Indonesia, 2002).

One of industry products that can be used as an alternative soil stabilisation material is ecomix. This stabilized material can be added with Portland cement to repair unstable soil become stable soil. This can be created because the ecomix additive material repairs the characteristics and the strength of soil that contains clay in it. For the use of ecomix in Indonesia, it is needed to be done research or trial, whether it is in the laboratory or in the field. It is intended to get the concrete condition, at least in laboratory scale. The main parameter needed is the strength obtained from UCS and CBR test (PT Ecomix™ Indonesia, 2002).

Figure 1. Location of road works that use ecomix material

Soil Stabilization

One of the ways to stabilize the soil is mixing the additive materials with certain percentage, so it will produce optimum strength for the soil endurance. The goals of adding the additive material in general are

1. Reducing the permeability
2. Increasing the sliding strength
3. Volume stability
4. Reducing the deformability

Ingels and Metcalf (1972) argued that there are some methods that can be used in the soil stabilization implementing, namely:

a.Mechanical stabilization

This method is done to repair the grain size distribution (gradation) and it is done through adding or mixing the available materials in the location with the other materials from another location, such as mixing the fine material that is in the location with coarse grained material from another area or vice versa. This method will causes problems, especially in repairing the distribution of the size of coarse grained size whereas the added material is fine grained material that has more plastic characteristics and sensitive toward water content which is able to causes the reduction of stability.

b.Physical / thermal stabilization

Physical stability is a method to change the soil characteristics through using the soil reactions, for example using the electric current for heating and cooling. One of the most used physical stabilization is heating.

c. Chemical stabilization

This method is often used to stabilize the cement, lime, bitumen or others chemicals materials. The research result shows that there is significant repairing. However, there are existing weaknesses and it supports the industry societies to seek the alternate materials that can be used as stabilization materials. One of new founded products is ecomix and it can be a material to stabilize the unstable soil with adding of cement. That material is designed to repair the strength and characteristics of clay or soil which content clay. To use the ecomix material, it is necessary to be done research or trying, whether in the laboratory or in the field. Although in the laboratory scale, the main needed parameter is power, which is got as the result of from UCS and CBR investigation.

2.1 Ecomix Stabilization

Ecomix is not only a stabilization material but also ground compaction and additive material to maintain the soil function, especially its fertility. This product is in the form of fine grained or powder which is consist of metal composition and salt or mineral an organic, such as sodium chloride, potassium chloride, magnesium chloride, calcium chloride, phosphate calcium, sodium sulphate and many others that are from sea and safe for the living things and environmental friendly.

Based on PT Ecomix™ Indonesia (2002), it is stated that the compositions of an organic mineral which are in the ecomix are NaCl (15%-25%), KCl (20%-35%), CaCI2 (15%-25%), MgCI2 (5%-15%), Ca3 (PO4) 2 (1%-5%), Ca2SO4 (1%-10%) and C8H8O7H2O (1%-5%) and others elements (5%).

2.2. The Function of Ecomix

If the particle of soil is seen microscopically, there is thin water layer on the soil surface, the thick of the water layer is about 0, 5 υm. This layer has extraordinary strength is about 2000 kg for each 1 cm2. Moreover, to move this water layer, the big amount of energy is needed. The character of the sticked water is a bit different with the ordinary water that is known by people. For normal water, 1 cc is 1 gr in the 4 degrees Celsius of temperature, but this water is 1, 4 gram for 1 cubic centimetres. This water can move in horizontal direction but it cannot move vertically. This water is blocked the cement and changes it become hard. The humus formation is though dissolving death plants into the sticked water on the surface of soil. This humid acid / RCOOH block the happening of contact between cation calcium (Ca++) on the cement and anion (-) from the soil particles. On the time when using ecomix, we have to dissolving it into the water on ten percent solubility (molarities).

The variety of ecomix component causes the weakening of the negative function from the humus and will reducing the level of humus itself. Moreover, cation calcium (Ca++) in the cement can stick on directly in the soil surface. Ecomix is dissolving humid acid in the soil and banning the effect of blocking the ion grouping, so the soil particles become easier to contain negative ion (anion), so the cation calcium can tight directly to the soil particles easily. Ecomix helps in supplying more replacing ion and form acid compound silica aluminium so it can form bee nest 3D structure among the soil particles. If the mixing between soil and cement that contains sulphur (SO_3) does not involve ecomix, as a result when it is mixed with soil water or touch with rain water, it will produce sulphuric acid that causes the crack condition, whereas the chemical reaction is $SO_3+H_2O=H_2SO_4$. This matter will be different if it is added with ecomix, whereas when cement tighten on soil particles and dry because or dehydration reaction, it will form crystals that appear among the cement mixing that tight soil particles, those crystals is similar with needles, the amount will intensively adding and being bigger that will form micron space that absorb water (porosity).

The Indonesia centre of research and development department of public works (2006) has done research about soil stabilisation with ecomix. The research uses three types of soil that are taken from three locations; those are lateritic soil, brown / red clay soil, grey soil. The result of research shows the characteristics changing and strength of soil endurance. Plasticity index (IP) has passed decrease changing. It is caused by the decreasing amount of fine grained as a result for adding cement. Meanwhile, the soil endurance shows increasing not only from CBR test but also from unconfined compressive strength test. The additive ecomix material is getting more used to repair the stability of soft soil and to thrift the construction cost, especially for above lands work. However, there are plenty of geo technicians do not know the benefits of using ecomix material and how to plan and mark the work of it.

Methodology

The method used in this research is preceded by taking the sample of the soil directly from the location and after that it is done laboratory test. Based on the result of laboratory test, the implementation in the field is done later. Laboratory test is carried out through the use of various percentage of ecomix additive material. The testing is based on existing Indonesia national standard. The soil composition with ecomix additive material has determined as much as 5 % and 10 % toward the weight of cement, meanwhile the use of cement is determined the percentage that are 2%, 3%, 4%, 5%, 6% and 7 % of cement toward the weight or dry soil. The testing is done through the examined material is hatched as long as 7 days, 14 days and 28 days. The type of examining that is done is CBR test (California Bearing Ratio) and UCS test (Unconfined Compressive Strength). The used method is descriptive method; it is a way to compare between the result of laboratory test and the composition of adding additive ecomix material toward the original soil. In the process of data analyzing, it is done some adjustments that can be logically accountable, with limited research problems to get the representative value.

Discussion and Findings

The testing result of soil grain distribution analyzing and compaction testing of proctor standard for the original soil that is taken from the location is in the following: soil in the form of yellowish sand tends to clay. The compositions of the soil consist of clay (18.20%), silt (12.30%), sand (64.86%), and gravel (4.65%). The maximum dried weight volume is 1.68 gr /cm³. Optimum water content (wopt) is 26.39 %, meanwhile the testing result of soil mechanical characteristics through using CBR and UCS testing is described on the Table 1, 2, 3 as follows.

Table 1. The result of mechanical characteristics original soil testing

No.	The source of soil	Types of testing	The result of laboratory testing						
			Original soil	Soil + cement			Soil + cement + 10% ecomix		
				2 %	4%	6 %	2%	4%	6%
1	PT ADARO	Specific gravity	2.54						
		Atterberg limit							
		Liquid limit	56 %	51	46	41	56	54	51
		Plastic limit	18 %	28	24	22	26	27	26
		Plastic index	38 %	23	22	19	30	27	25

Tabel 2. The Resume of CBR Testing Result

No.	Level of cement	Soaked	CBR (%) (soil+cement)		CBR (%) (soil+cement+ecomix 10 %)	
	(%)	(days)	Soak	Unsoaked	Soak	Unsoaked
1	Original soil		7.20			
2	2	7	28.20	30.30	31.60	34.50
	4		40.20	40.20	44.90	55.20
	6		46.60	52.40	64.10	68.30
3	2	14	31.30	46.40	56.10	64.50
	4		43.00	53.20	78.20	92.50
	6		54.60	72.70	88.20	100
4	2	28	44.10	66.20	98.30	100
	4		51.70	82.40	100	100
	6		66.30	88.60	100	100

Table 3. The Resume of Unconfined Compression Strength Test Result

No.	Level of cement	Hatching	UCS	Level of Ecomix	UCS
	(%)	(days)	Qu (kg/cm²)	(%)	Qu (kg/cm²)
1	Original soil		3.60 kg/cm²		
2	2	7	7.5	10	7.10
	4		10.20		10.10
	6		15.90		16.80
3	2	14	11.60	10	14.60
	4		17.80		22.40
	6		24.40		29.30
4	2	28	21.40	10	24.60
	4		24.90		28.50
	6		29.60		32.10

Table 1 shows that the mechanical characteristics of the original soil, original soil plus cement, and original soil plus cement plus ecomix ten percent. The adding of additive ecomix material as much as ten percent from the dried soil weight is caused by the maximal result in the soil will be got through adding ecomix ten percent and it is proved with laboratory tested through adding additive ecomix as much as 2%, 5%, 10%, 12% and 14%. The Original soil has 2,54 specific gravity and 56 % original soil liquid limit after it is added with ecomix and cement that will show the value inclining decrease. It is caused cement ad ecomix tight soil grains into the bigger grains or clump. It is said so for the PI value that show inclining decreasing and that problem is caused by the changing of grain from the fine grained become coarse grained so its plasticity characteristics is reducing. The adding of ecomix results the value of IP is a bit inclining if it is compared with the IP value of the soil which is mixed with cement only.

Table 2 shows the result of CBR original soil testing and CBR soaked / unsoaked value to influence the adding of 2%, 4%, 6% and ecomix 10% with the hatching time as long as 7 days, 14 days, and 28 days. The value of soaked CBR that is resulted is relative smaller if it is compared with unsoaked CBR value. It is caused by the influence of water soaked on the soil sample. If it is compared between CBR of original soil with CBR of original soil that has been added with cement and ecomix, it shows the significant increasing. Nevertheless, the increasing of soil CBR value that is added with cement and ecomix if it is compared with CBR of original soil that is added with cement shows that there is preference increasing although there is not significant increasing.

Table 3 shows the result of adding 2%, 4%, 6% and ecomix 10 % influencing with hatching period as long as 7 days, 14 days, and 28 days toward the Unconfined Compressive Strength (UCS). If it is compared between original soil strength powers with the original soil strength power that has been added with cement and ecomix show the significant increasing. However the increasing of added soil strength power with cement and ecomix if it is compared with original soil strength power that is added cement shows that preference an increasing although the increasing is not significant.

Field Practice

Based on the above laboratory testing, the application in the field is done in the location, exactly in Km 11, 7 km for the 500 meter length of road with the width of the road 16.00 meter. Meanwhile, the road structure that use ecomix as additive material consist of mixing layer between soil, 6 % of cement, and ecomix additive material 10 % with the 80 cm thickness and it is done in order to replace the conventional road structure (LPA and LPB). Upper coat, which is functioned as cover, is spread by hot mix asphalt 5 cm thickness. Based on laboratory test, it shows that the road structure that use ecomix additive material is stronger and more elastics with the power capacity more than 100 ton/ m² depends on the layer thickness. The figure of conventional road structure and road structure that use ecomix additive material is represented in the Figure 2 bellows.

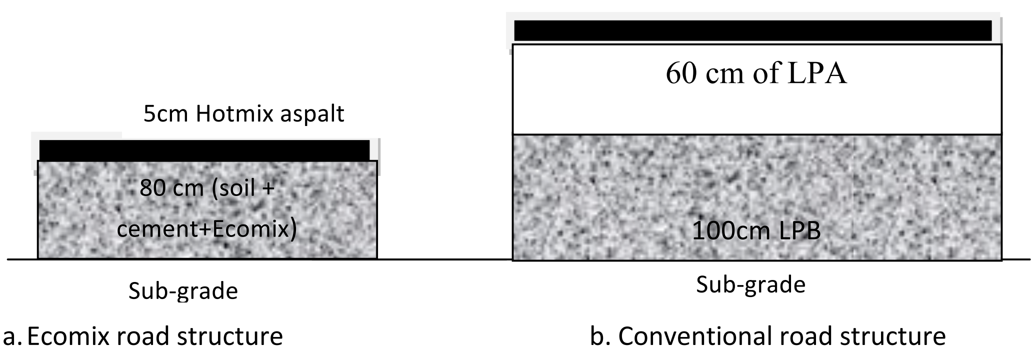


Figure 2. Cross section on conventional road and road structure that use ecomix additive material.

To grasp the optimal result in developing realisation on road structure in the field, therefore, the realisation should follow the procedure of realisation standard (PT Ecomix™ Indonesia, 2002). The procedure of realisation standard of road structure work through using ecomix additive can be explained as follows.

Step 1: road body loosing
Excavating the sub grade as thick as more or less 80cm, the width of the road is 16 m, the length of the road is 500 m, through using motor grader.

Step 2: cement distributing
Spread the cement out smoothly on the layer of the road or on the above road body loosing. Spreading the cement can be done manually or using machine, such as bulldozer.

Step 3: cement and original soil mixing
Mix the cement with the original soil in the location of road making so smoothly mixing through using rotary tractor or excavator.

Step 4: watering the road body surface with ecomix liquid
Dissolve the additive ecomix into the water and then spray it to the surface of road through using sprayer or watering car.

Step 5: soil, cement and ecomix liquid mixing
Mixing among the soil, cement and additive ecomix material is done in the field through using the rotary tractor as mixer or excavator so it can spread evenly or homogeny.

Step 6: making the road body more intensive with tire rolling
For the beginning of making intensive the road, it can be done one time of crushing through using tire roller.

Step 7: surface of the soil levelling
Manage the height of intensive making process with the appropriate needs and the sizes are 80 cm thickness, 16 widths, and 500 m length through using bulldozer or motor grader.

Step 8: making the road body more intensive through using vibro
Making intensive both side roads is done through doing intensive making in the road body minimal 4 times crushing through using macadam roller or Stoom Walls.

Step 9: road body final cramming
Cramming the road body for the last time as much as six times crushing or depend on the needs. The machine that should be used is macadam roller or Stoom Walls.

Step 10: hot mix asphalt spreading as final result
Let the road becomes hard as long as 24 hours, or 48 hours with maximum period is 7 days if the weather is in bad. Close the surface of the road with vinyl if it is rain and if the road has changed into hard condition, use the hot mix asphalt to cover the surface of the road with more or less 5 cm width. It is suggested to use hot mix because it has better water absorption capacity than common out pouring

asphalt that is merged with ecomix formula. For further explanation, it can be seen in Figure 3.

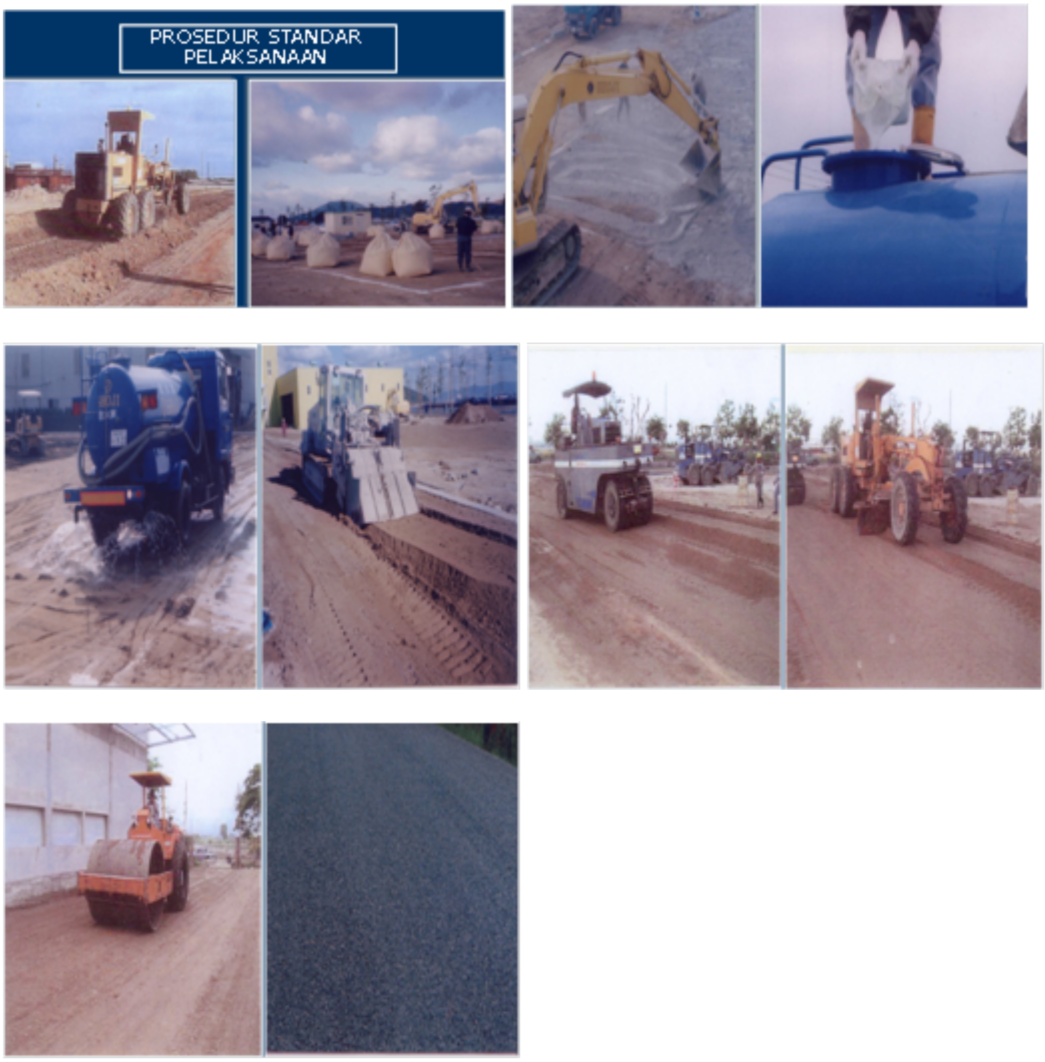


Figure 3. Construction Standard Procedures (Source: PT.Ecomix 2002)

The obtained benefits from road structure that use ecomix additive material compare to the conventional road structure are as follows:

1. The road using ecomix creates micro poly cavity layers give not only elasticity but also give good capacity to absorb the water.
2. Make the underground water can freely flow in the road base, so it will not stagnate and disturb or erosion above asphalt construction.
3. Reducing the bad influence from water absorption on LPA + LPB road because the construction of ecomix is becoming stronger in stagnant water.
4. Prevent disintegrated of the based road (LPA + LPB road) or prevent erode because of its elasticity character.
5. Free maintenance damage in the base road (LPA+LPB) and the surface of the asphalt layer can survive longer.
6. Sub base layer of the road is no need to conciseness
7. Local dig soil can be used to make foundation after it is given ecomix
8. It is no need to add soil and gravel to make the base of road
9. It is no need to add soil and gravel on the sub base layer

10. Hot mix asphalt will stick on well and perfect with road material structure that is done with ecomix.
11. The needed time is shorter and easy, therefore it needs cheaper costs if it is compared with road conventional structure.

CONCLUSION

The conclusions of the research are bellows:

1. Adding of ecomix additive causes significant rising in CBR value (soaked and unsoaked) and soil bearing capacity,
2. The value of CBR original soil is increasing from 7.20% become 100% after it is stabilized with 10% Ecomix in the 14-28 days of hatching time, so does the bearing capacity for the original soil after it is stabilized, that is from 1,80 kg/cm² becomes 32,10 kg/cm².
3. The length of period is shorter and the cost of infrastructure is lower compare to the structure of conventional road.

References

Anonym. 2002. Prinsip dan Aplikasi, ECOMIX™ Sistem Konstruksi Masa Depan (*Principle and application, ECOMIX™ Future Construction System*). Japan: PT Ecomix Indonesia with Eco Avanca, Co.

Anonym. 2006. Laporan Hasil Pengujian Stabilitas Tanah dengan Ecomix. Bandung: Public works department of Indonesian Republic, research and developing agency on the central road and bridges research and development.

C.D.F. Rogers, S. Glendinning and Dixon. 1996. Lime Stabilization. London: Thomas Telford.

Nelson, John D and Debora J Miller. 1982. Expansive Soils. New York: John Wiley and Sons, Inc.

Braja M. Das. 1993. Principles of Geotechnical Engineering. Third Edition. Boston: PWS Publishing Company.

Kezdi. 1979. Stabilized Earth Roads. New York: Elsvier Scientific Publishing Company.

O.G. Ingles and J.B. Metcalf. 1972. Soils Stabilization Principle and Practice. Sidney: Butterworth.

Oto Julfitri A. 2009. "Stabilisasi Tanah Lempung dengan Zat Additif Ecomix untuk Badan Jalan". Yogyakarta: Islamic University of Indonesia.

PT Ecomix Indonesia. 2002. Ecomix™ Sistem Konstruksi Masa Depan. Japan: Eco Avance, Co. Ltd.

Collaborative Design in Construction: Past, Present, and Future Research

Yani Rahmawati, Christiono Utomo, Nadjadji Anwar

Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

yanirahmawati2012@gmail.com

Abstract

Recently, development in construction industry is involving complexity of engineering systems. It is becoming more complex when faced with consideration to sustainability build environment. Lots of aspects and factors need to be considered and implemented in design, and it needs multiple expertises to deal with it. Collaborative design is conducted in order to facilitate collaboration of experts with different backgrounds, expertise, and experiences, with purposes to produce design and to solve problems. Experts are distributed to work together at same or different time and place. Many problems appeared in design process related to coordinate multiple expertises. These problems are used as a background for researchers to develop research in collaborative design area, with main purpose to find solution in reducing, managing and facing the problems in facilitating collaborative design process. This paper discusses a review of collaborative design researches from past, present through prediction of future research development. Method used in this research is literature study with focus on theoretical, contextual, and methodological mapping, which will be organized chronologically. Outcomes resulted from this research is a conceptual theoretical framework, which is a prediction of future research in the area of collaborative design. This research is the beginning process of research in doctoral program, and will be used for dissertation's conceptual definition.

Keywords: collaborative design, multi-discipline design, literature review

Introduction

Development in construction industry is involving complexities in engineering systems, which is need various disciplines to complete the construction works. Development of architecture and building design, structure, utility systems, building facilities, and also environment consideration are led to the involvement of experts to collaborate in producing architectural and building design. Unwell design production caused problems in construction process of the building itself, and it influenced the built environment socially, economically, and environmentally. Hosseini et al (2011) and Holub et al (2011) concluded that environmental consideration is important to be implemented in building design, because it can supported the sustainability of built environment. Successful collaborative design process can be conducted to achieve sustainability built environment through optimum design and best solution.

Collaborative design is one of the important processes in construction's life cycle projects, where experts with different backgrounds are met to produce design, which will be used as guidance in construction projects implementation. Liu et al (2004) explained that collaborative design is a process which placed in early stage of construction project that involving a variety of experts to produce design in order to achieve solutions from integration of various complexity disciplines. According to Favela et al (1994), collaboration is a very important aspect at design process, it is because decision-making process in design is not linear and it requires a collaboration process. Kvan (2000) stated that collaboration by involving various experts and foreign consultants is one of approach that need to be implemented in solving problems and decision making, related to the need of data and information collected from experts in accordance with required disciplines in order to formulate and produce design. According to Sebastian and Prins (2009), the need of collaboration in design process was caused by global organization development, which was applied with purpose to do job effectively and efficiently in accordance with data and information obtained from experts in solving the problem.

Main goal of conducting collaborative design process is to produce optimal solution, which reflected on high quality shared design. It can be achieved by integrating experts in solving problems at design process. Because of the involvement of experts with different backgrounds, it is necessary to create system in managing them in order to avoid any misunderstandings or to solve problems related to participant's time and place availabilities. In addressing these problems researchers within the areas of collaborative design are considering information technology and communications infrastructure development in facilitating collaborative design process. Other important thing in conducting successful collaborative design process is to facilitate negotiation and decision making process (Utomo et al 2008; Utomo and Idrus 2011).

Methodology

There are some literature study-based researches, which conducted with purpose to conceptualize the direction of future research (Kilgour and Hipel 2005; Barry 2007). Buelens et al (2008) conducted literature study-based research with focus on methodological issues in negotiation research. This paper presents a literature review of collaborative design research. The review identifies methods and approaches that have been done in collaborative design research, then synthesize and analyze each methods in order to structure the direction of collaborative design research development and to make prediction of collaborative design future research. This literature study-based research is a qualitative research, in which authors synthesize and analyze primary data collected from journals and conferences without using statistical analysis. In doing the research, authors have a neutral view, as well as results of the research are treated as fact. Organizational system used in this review is historical and chronological.

There are four groups of methodologies which are used to map and classify the collaborative design research. The groups or classifications are literature review, case study, modeling, and applied Information Technology (IT). The paper classified with main focus on methodology in order to deeply understand methods that have been used in the collaborative design process and research. Main purpose of conducting this research is to raise concept and prediction of collaborative design future research. Rahmawati et al (2011) stated that researches in the area of collaborative design are mainly about inventing solution in facilitating collaborative design process with purpose to face, eliminate, and avoid the appearance of problems related to different perspectives and also time and place availabilities.

Synthesize and Analysis

Data collected will be synthesized by mapping it into four categories, which are focused on the methodology used. The categories are literature review, case study, modeling, and applied IT. The conceptual figure of literature review process is presented on Figure 1. Each category will be analyzed by comparing, combining, and identifying the research path development. Outcomes resulted from this process is a description about methods used in collaborative design research and its development. Main purpose of this process is to identify what has been done in collaborative design research and what need to be done in the next research.

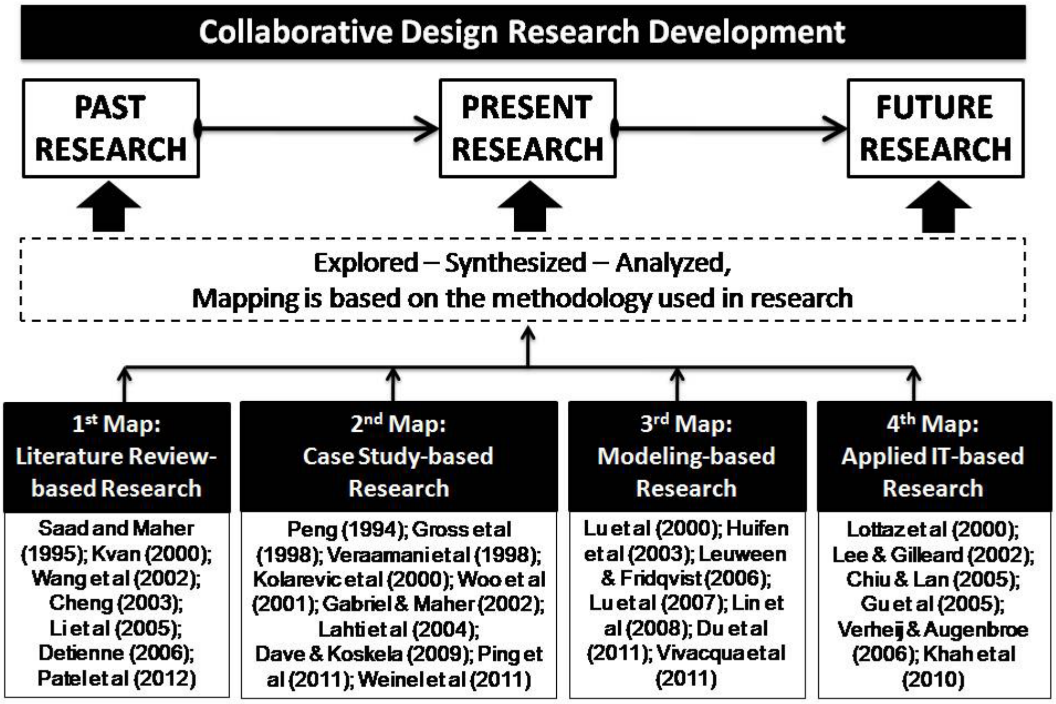


Figure 1. Conceptual Figure of Literature Review Process

First Map: Literature Study-based Research

According to Fink (2010), literature review is a systematic, explicit, and can be reproduced with purpose to evaluate and synthesis an overview about scope of the research, supported by exact and correct data. Literature study methodology used in collaborative design research was mainly conducted with purpose to explore methods and factors which are leading to successful collaborative design process.

There are two different approach used in collaborative design research with literature study-based methodology. Some of papers are mainly discussed and considered topic which related to the tools and system used to support collaborative design process, and the rest are mainly discussed about organization and participants. The emerging of information technologies and communication infra-structures took part in this research.

Researchers whom concerned to technical factors are inventing tools and system which can be used to facilitate the collaboration process. Kvan (2000) explored computer functions to support collaborative works, it is found that computer system and tools are able to handle and facilitate the problems of group size, and also time and place availability of participants involved. Computer technologies are used with main purpose to create shared understanding environment (Saad and Maher 1995). The tools and system used are emerging to the use of internet and web applications (Wang et al 2002); and the use of CAD as a collaboration media in conducting effective collaborative design (Li et al 2005). Meanwhile, there are some researchers whom concerned to social factors. Cheng

(2003) explored the affects of approaches used to teamwork. Teamwork was also considered by Detienne (2006) whom explored the task coordination and interdependencies in forming teamwork. Social factors are considered also by Patel et al (2012) whom explored factors that need to be considered in conducting successful collaborative design which related to human factors.

Based on the reviews, it can be seen that there are two different paths in collaborative design research development. Some researchers thought that the important thing in collaborative design is technical factors, and others are social factors. Researches with technical factors based are mostly considering the collaboration of design project, by using tools and systems which integrated with information technology and communication infrastructures development. Meanwhile, researches with social factors based are mostly considering to human factors, by constructing and developing model in organizing participants in achieving better interaction.

Second Map: Case Study-based Research

Case study research is an exploratory research which is conducted in order to reveal facts from the field by using real case. The research are mainly about taking deep understanding about tools or systems capabilities in supporting collaborative design process. Some other case studies are conducted to compile data and then construct it into model, weather it is conceptual or computer model. Mostly, data collected from observation and recorded data, and some are gotten from interviews with participants. This research methodology is used to test the capability of invented tools and systems in facilitating the collaborative design process. This research is also used to explore data which will be compiled and analyzed to build conceptual model that can lead to successful and effective collaborative design.

There are two categories of case study-based collaborative design research which divided by its purpose. First category is a case study which conducted to explore the capabilities of tools or system in facilitating the collaborative design process. Research categorized on this is mostly considering technical factors of collaborative design. And the second category is concerned about exploring behavior of participants at collaborative design. Second category is mostly focusing on social factors that affected successful and effective collaborative design process.

One of research categorized on first category is conducted by Gross et al (1998), who explored the advantages and disadvantages of supported equipments in conducting collaborative design especially in virtual environment. Result found that its need to consider multi media and equipments to avoid disadvantages caused by the use of single equipments. Research are developing to invent supported tools and system, which was influenced by the emerging of IT and communication infrastructure development. The limited time and place availabilities of participants were also took part in the research development. This condition supports the use of virtual environment in conducting collaborative design process. From case study research conducted by Woo et al (2001), it can be concluded that collaborative design process can be conducted successfully by using shared workspace, where participants worked together in one media.

There are two different statement and result related to the use of virtual environment. Kolarevic et al (2000) found that it is possible to conduct research based on virtual design studio facilities, but it is only capable to facilitate the design project collaboration, a collaboration process which is only focused on the object, but cannot facilitate the collaboration of participants involved. Meanwhile, Gabriel and Maher (2002) found that in conducting collaborative design process it was no need to consider the participants, because the interaction can be stored textually, which made participants much easier in tracking back the design process, so the misunderstanding caused by different perspectives can be avoided. Misunderstanding can also be caused by different perception of knowledge or data. One problem appeared in conducting collaborative design virtually is managing data or knowledge to support better communication, especially in negotiation and decision making process. Veeramani et al (1998) conclude that knowledge management is needed to facilitate decision making, especially in achieving design constraint. In line with this statement, Dave and Koskela (2009) also concluded that it is important to manage data in order to support successful collaborative design process through problem solving and decision making process.

Some of researches reviewed are categorized on social factors based research. One of case study-based research with main focused on social factors is conducted by Peng (1994), whom found that designer behaviors in the design process affected the communication process. It is need to be considered in conducting effective and successful collaborative design process, because it may takes time for designer to be adapted with other participants in collaboration works. Another research is conducted by Lahti et al (2004), whom found that in conducting collaborative design process using Virtual Design Studio need to consider social infrastructure through organization between participants which can be achieved through organization. From this finding it can be seen that social factors are also need to be considered in conducting collaborative design, not only the technical factors. This conclusion is support result found by Kolarevic et al (2000), that Virtual Design Studio are not made to collaborate people but made to collaborate design object, so the problem won't be solved if only concern to technical factors. Social infrastructure through organization can be implemented by organizing the participants into work teams or work groups (Robbins 2003). According to Ping et al (2011), successful collaborative design can be achieved through integrated teamwork. It is important to organize participants into teamwork to finish the task. Some social factors can influence the teamwork performance, i.e. personality; behavior; motivation; satisfaction; etc. Weinel et al (2011) found that social presence influenced the attitudes of participants in doing and finishing the task, in which it influenced the successful and effective collaborative design process as well.

Based from review to case study-based collaborative design research, it can be concluded that there is a destructive development path in the research. Research began with developing tools and systems to facilitate collaborative design process. The tools and systems were made with purpose to collaborate the design project, or mainly concerned to the object. Then it was developing by concerning the social factors. Social factors are needed to avoid or reduce problems related to the participants. Collaborative design process is not only a process to achieve goal by focused only to the object, but it has to achieve optimum goal by concerning the source, including the participants. Best or optimum solution can be achieved by collaborating best knowledge revealed from multiple expertises.

Third Map: Modeling-based Research

There are three classification of modeling-based research. Egger and Carpi (2008) defined the modeling method by dividing the method into three groups, namely physical modeling; conceptual model; and computer modeling. Physical modeling used to create a mini version or copy of real situation in order to investigate phenomena within the object of interest. Conceptual modeling used to construct concept, which usually used to solve problem related to the interaction or connection between involved factors. Computer modeling is used to create program that will be applied to computer. There are five steps that need to be accomplished in building a model. The first step is defining the model by choosing form of the model, it is physical; conceptual; or computer model. Then it continues to make assumption if there are too many variables included in the research. The next step is to create the model. The model that has been created need to be tested in the next step. And the final step is iterative process, which needed to simplify the model and to find fitness with the problem and goal to be achieved. Each journal extracted by classifying into two classifications, which consist of defining systems and testing model case. Physical, conceptual, and computer model are part of system definition. There are two types of test case used in testing the model, by comparing the model to other related model or matching the model with real situation. Sometimes, iteration process is needed in modeling-based research with purpose to simplify the model and fit it with the purpose of the research.

Most of case study research required test case process by matching it with the actual condition. Du et al (2011) used test case process to compare model with other similar model and different model with same purpose in order to maximize the structured model. Meanwhile, Leuween and Fridqvist (2006) combined both of the test case process, tested the structured model by comparing it with other similar model and then matching it with the actual condition. Modeling research method used in the study reviewed is conceptual and computer modeling. Each research stated constructive position in the collaborative design research area, where the research position supported other research finding and contributed to the development of the collaborative design research.

Some models were built or proposed to support collaborative design process. Lu et al (2000) proposed model of Socio-Technical Framework that can be used to analyze the collaborative design process, especially related with social relations among participants in which the causal of conflict can be seen, other purpose of the model is to understand the interaction between conflict and design process in order to increase productivity in collaborative design process. This concept was then developed by Lu et al (2007), by exploring some approach in facilitating the collaborative design, and continued by build socio-technical approach model which implemented and validated in the collaborative engineering process at truck industrial. In addition to the importance of understanding the elements of social interaction among participants, which were influential for collaborative design process outcome, the behavior of participants in decision making process also plays an important role for the outcomes. Which is like study conducted by Vivacqua et al (2011), whom developed an ontology to describe participants' behavior at collaborative design meeting especially in decision making process, the description correlated behavior in decision making activities by analyzing agreement or acceptance of participants which is affecting the final outcome of a product. In facilitating the process of achieving collaborative design optimal result, Huifen et al (2003) build a computer model based on the feature of collaborative design process in editing or producing drawings, the model called Feature-based Collaborative Design. The purpose of the model is to facilitate the collaborative design process where participants located in different place and conducted at different time, it can help design producing and drawings editing process easier, it also can facilitate the problem solving process faster.

The involvement of participants with different backgrounds led to the importance of managing and storing design process development. Du et al (2011) created S-DTPM models which combined the concept of design rationale and design annotation that can be used to graph design process and to create shared understanding between participants. The model validated experimentally by applying model to teammind software, the application can combine graphic model from products and design documents. Leeuwen and Fridqvist (2006) build a conceptual model that supported data integration process on collaborative design by providing access for end users as well as providing flexibility for participants to participate in the design development process. Shared understanding and data integration are needed to facilitate better communication process between participants. Lin et al (2008) build conceptual communication model which can be used to conduct effective collaborative design through building relationship and team's cohesiveness.

There are three different background of approach used in modeling-based collaborative design. Some research concerns to facilitate technical factors in conducting collaborative design, some other concern to the social factors, and the other concern to combine the social and technical factors. Research with technical factors based mainly focus on facilitating the design process, which is achieved by creating shared understanding environment and shared workspace. Meanwhile, social factors based research is mainly concern to communication between participants, where can be influenced by participants' behavior, attitude, motivation, etc. There is some effort to combine technical and social factors to be considered in facilitating collaborative design process.

Based from review, it can be concluded that the development of modeling-based collaborative research is a destructive, whereas there are some contra in determining and identifying important factors that need to be considered in conducting collaborative design process.

Fourth Map: Applied IT-based Research

Applied IT-based research methodology is a method, which is used to integrate systems and computer equipments with considering the development of information and communication technology in order to support and facilitate collaborative design process. Utomo (2009) described that computer system which can be used in integrating information technology divided into two categories; they are conventional programming and artificial intelligence (AI). Conventional programming is a simple system in making or writing computer programs using traditional computer language procedure. Some examples of conventional programming are database, spreadsheet, C++, internet, windows, operating system, foxpro windows, web-based application (html), pascal, cobol, and fortran.

Several studies, which based on conventional programming, support collaborative design process in managing participants and data. Verheij and Augenbroe (2006) developed model in order to facilitate problems appeared related to geographical location of participants and to facilitate mediation process between them by integrating Project Planning Process Model (PPPM) with web-enabled B2B facility. The integration is used to build virtual workspace with purpose to manage participants with different time and place availability. In addition to the need in managing participants involved, collaborative design process also required management of generated data. Chiu and Lan (2005) build an approach using data mining technique to show information pattern which can be used to manage captured or appeared information during the collaborative design process held. In line with Chiu and Lan (2005), Gu et al (2005) developed WordNet by building Ontology Description Language (FLO-DL) and introducing it to explain Global Ontology Library (GOL) which can be used to reduce semantic conflicts that often arise caused by the inconsistency data (word).

According to Jones (2009), AI can simply be defined as property or equipment in mind, which has ability to plan, solve or resolve problems, and give some reasons. Main capabilities of AI is ability in making right decision on some inputs (given inputs) and a variety of possible actions that can be used or applied in solving problem. Some examples of AI applications are database search engines, expert systems, knowledge-based system, AHP, builder information, and Delphi.

AI is used as a method in collaborative design research with main purpose to facilitate the process in managing participants and data. Lee and Gilleard (2002) developed a Hypermedia system in form of virtual discussion tables that can be used for facilitating activities in exposing data or information from participants. Khah et al (2010) developed Intelligent System for Interaction Analysis in Design (ISIAD), which is integrated with Boolean Algebra and Dynamic Optimization Operation, a kind of agent systems that can be used to facilitate in analyzing participant dynamic interactions during collaboration design progress. The appearance of data during idea representation activity caused problems in collaborative design process. This condition made researcher paid attention to the process of managing inconsistent and ambiguous data, just like system which was developed by Lottaz et al (2000), a system that can facilitate negotiation in collaborative design process based on the appearance of inconsistency data problems during communication activities.

From the literature study of several journals related to the use of information technology applications in collaborative design process, it can be concluded that several studies developed conventional programming, and some developed AI. All research studied by authors stated constructive, with main goal to support and strengthen research in collaborative design with mainly concern to build system and program in facilitating collaborative design process, especially in managing data or information during the process.

Result and Discussion

Conclusion and description of each classified collaborative design research which based on its methodology were made to identify and discover methods and techniques development. This result will be integrated and analyzed to identify development of the research and to discover new line of inquiry and future research direction in collaborative design research. Conceptual figure of the analysis process is presented on Figure. 2.

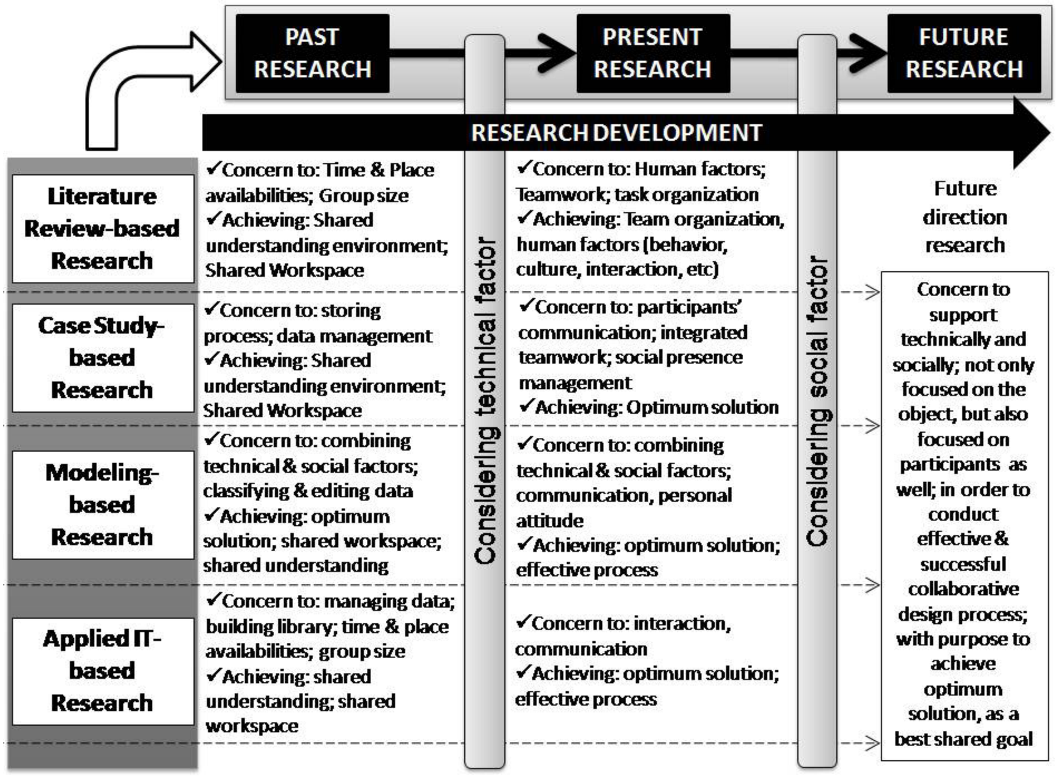


Figure 2. Conceptual Figure of Literature Review Result

Based from Fig. 2, it can be seen that collaborative design research began with discovering and inventing tools and systems that can be use to functionally facilitate the collaboration process with concern to collaborating the object (design). Main problems appeared in conducting collaborative design process were the group size and also participant's time and place availability. Based from these problems, researchers invented tools and systems which implemented to computer in conducting collaboration process at different time and place. By the development of information technology and communication infrastructure, research in the area of collaborative design then develop to facilitate collaboration process virtually.

Some problems appeared in conducting virtual design studio to facilitate the collaborative design process. Some research was conducted with purpose to create shared understanding and shared workspace through data/knowledge management and recorded design process. At this point, there were two different thoughts, some researchers stated that the important thing is facilitate collaboration functionally (Saad and Maher 1995; Kvan 2000; Woo et al 2001; Gabriel and Maher 2002), but others stated that it was need to consider the participants as well (Kolarevic et al 2000; Cheng 2003; Ping 2011; Patel et al 2012), because functional facilities can only collaborate objects but not the participants. Some researchers had found that social presence related to participants influenced the result (Lahti et al 2004; Detienne 2006; Lin et al 2008; Vivacqua et al 2011; Weinel et al 2011), where optimum solution or best design could not be achieved. Collaborative design research was then developing with social factors consideration. Some researchers were trying to combine technical and social factors to be considered in the research (Lu et al 2000; Lu et al 2007). According to Vreede and Vogel (2003), there are three elements of organizational systems that can support collaborative design; the elements are human elements, technical elements, and informational elements. It is found that to conduct successful collaborative design process has to consider two important aspects, which consist of both social and technical factors.

Conclusion

Based from literature review to collaborative design research, it can be concluded that future direction of this research area is concerning both technical and social factors of collaboration, which are design as an object and experts as participants. In facilitating successful and effective collaborative design process, it is not only need to focus on the object, but also need to focus on participants as well. Technical factors need to be considered to support the data integration, and social factors need to be considered in revealing and integrating best solutions which are collected from participants. This consideration is purposed in order to achieve optimum solution, as a best shared goal from participants.

References

Barry B (2007) Negotiator effect: the state of the art (and the science). Journal of group decision and negotiation 17:97-105. 11

Buelens M, Woestyne MVD, Mestdagh S, Bouckenooghe D (2008) Methodological issues in negotiation research: a state of the art review. Journal of group decision and negotiation 17:321-345.

Cheng NY (2003) Review: Approaches to design collaboration research. Journal of Automation in Construction 12:715-723.

Chiu ML, Lan JH (2005) Information and in-formation, information mining for supporting collaborative design. Journal of automation in construction 14:197-205.

Dave B, Koskela L (2009) Collaborative knowledge management - a construction case study. Journal of automation in construction 18:894-902.

Detienne F (2006) Collaborative design: managing task interdependencies and multiple perspective. Journal of interacting with computer 18: 1-20.

Du J, Jing S, Liu J (2011) Creating shared design thinking process for collaborative design. Journal of network and applications.

Egger AE, Carpi A (2008) Research methods: modeling. Visionlearning Vol. POS-1 (8). http://www.visionlearning.com/library/module_viewer.php?mid=153. Accessed 11 November 2011.

Favela J, Imai K, Connor JJ (1994) Hypermedia support for collaborative design. Journal of design studies 15(1):45-58.

Fink A (2010) Conducting research literature reviews from the internet to paper, 3rd edn. Sage Publications, USA.

Gabriel GC, Maher ML (2002) Coding and modelling communication in architectural collaborative design. Journal of automation in construction 11:199-211.

Gross MD et al (1998) Collaboration and coordination in architectural design: approaches to computer mediated teamwork. Journal of automation in construction 7:465-473.

Gu N, Xu J, Wu X, Yang J, Ye W (2005) Ontology based semantic conflicts resolution in collaborative editing of design documents. Journal Of Advanced Engineering Informatics 19:103-111.

Holub M, Suda J, Fuchs S (2011) Mountain hazards: reducing vulnerability by adapted building design. Journal of environmental earth sciences.

Hosseini SB, Faizi M, Maleki SN, Azari ARK (2011) Impact evaluation of rural development plans for renovating and retrofitting of rural settlement, case study: rural districts of taresh in iran. Journal of environmental earth sciences.

Huifen W, Youliang Z, Jian C, Lee SF, Kwong WC (2003) Feature-based collaborative design. Journal of materials processing technology 139:613-618.

Jones MT (2009) Artificial intelligence: a system approach. Jones and barlett publisher, America.
Khah RM, Ostrosi E, Garro O (2010) Analysis of interaction dynamics in collaborative and distributed design process. Journal of Computer in Industry 61:2-14. 12

Kilgour DM, Hipel KW (2005) The graph model for conflict resolution: past, present and future. Journal of group decision and negotiation 14:441-460.

Kolarevic B, Schmitt G, Hirschberg U, Kurmann D (2000) An Experiment in Design Collaboration. Journal of automation in construction 9:73-81.

Kvan T, (2000) Collaborative design: what is it. Journal of automation in construction 9:409-415.
Lahti H, Hakkarainen PS, Hakkarainen K (2004) Collaboration patterns in computer supported collaborative designing. Journal of design studies 25:351-371.

Lee YC, Gilleard JD (2002) Collaborative design : a process model for refurbishment. Journal of automation in construction 11:535-544.

Leeuwen JPV, Fridqvist S (2006) An information model for collaboration in the construction industry. Journal of computers in industry 57:809-816.

Li WD, Lu WF, Fuh JYH, Wong YS (2005) Collaborative computer aided design – research and development status. Journal of computer aided design 37:931-940.

Lin C, Standing C, Liu YC (2008) A model to develop effective virtual teams. Journal of decision support systems 45:1031-1045.

Liu H, Tang M, Frazer JH (2004) Supporting dynamic management in a multi-agent collaborative design system. Journal of advance in engineering software 35 493-502.

Lottaz C, Smith IFC, Nicoud YR, Faltings BV (2000) Constraint-based support for negotiation in collaborative design. Journal of artificial intelligent in engineering 14:261-280.

Lu SCY, Cai J, Burkett W, Udwadia F (2000) A methodology for collaborative design process and conflict analysis. Journal of annals of the CIRP 49(1):69-73.

Lu SCY, Elmaraghy W, Schuh G, Wilhelm R (2007) A scientific foundation of collaborative engineering. Journal of annals of the CIRP 56(2):605-634.

Patel H, Pettitt M, Wilson JR (2012) Factors of collaborative working: a framework for a collaboration model. Journal of applied ergonomics 43:1-26.

Peng C (1994) Exploring communication in collaborative design : co-operative architectural modelling. Journal of design studies 15(1): 19-44.

Ping CS, Keung CNY, Ramanathan M (2011) Integrated team design process – successful stories of Hong Kong MTR corporation projects. Journal of procedia engineering 14:1190-1196.

Rahmawati Y, Anwar N, Utomo C (2011) Kolaborasi desain proyek konstruksi : tinjauan pada riset terdahulu, kontemporer, dan masa datang. Konferensi nasional pascasarjana teknik sipil 2011.
Robbins SP (2003) Organizational Behavior. Prentice Hall, New Jersey.

Saad M, Maher ML (1995) Shared understanding in computer-supported collaborative design. Journal Of Computer Aided Design 28(3):183-192.

Sebastian R, Prins M (2009) Collaborative architectural design management. In Emmit et al (ed) Architectural management international research and practice. Willey-Blackwell, UK. 13.

Utomo C, Idrus A, Napiah M (2008) Methodology for multi criteria group decision and negotiation support on value-based decision. International conference on advanced computer control. Singapore, January 22-24 2009.

Utomo C, Idrus A, Napiah M (2008) Methodology for multi criteria group decision and negotiation support on value-based decision. International conference on advanced computer control. Singapore, January 22-24 2009.

Utomo C (2009) Development of a negotiation support model for value management in construction. Unpublished Dissertation, Universiti Teknologi Petronas.

Utomo C, Idrus A (2011) A concept toward negotiation support for value management on sustainable construction. Journal of sustainable development 4(6):56-66.

Veeramani D, Tseng HP, Russel JS (1998) Computer-integrated collaborative design and opertaion in the construction industry. Journal of automation in construction 7:485-492.

Verheij H, Augenbroe G (2006) Collaborative planning of AEC projects and partnership. Journal of automation in construction 15:428-437.

Vivacqua AS, Garcia ACB, Gomes A (2011) BOO : Behavior-Oriented Ontology to describe participant dynamic in collocated design meetings. Journal of expert system with application 38:1139-1147.

Vreede GJD, Vogel DR (2000) Group support systems for the collaborative design of organizational systems: introduction to the special issue. Journal of group decision and negotiations 9:93-96.

Wang L, Shen W, Xie H, Neelamkavil J, Pardasani A (2002) Collaborative conceptual design - state of the art and future trends. Journal of computer-aided design 34:981-996.

Weinel M, Bannert M, Zumbach J, Hoppe HU, Malzahn N (2011) A closer look on social presence as a causing factor in computer-mediated collaboration. Journal of computers in human behavior 27:513-521.

Woo S, Lee E, Sasada T (2001) The multiuser workspace as the medium for communication in collaborative design. Journal of automation in construction 10:303-308.

Energy Consumption and Thermal Comfort in Residential Building in Pakistan

Iftikhar A Raja, Amir H Malik and Waqar Ahmed

Department of Environmental Sciences

COMSATS Institute of information Technology

Abbottabad, Pakistan

iaraja@ciit.net.pk, iaraja47@hotmail.com

Abstract

Pakistan with a shortfall of over 4000MW per day in electricity supply and shortage in gas supply is presently facing a serious energy crisis. The scarcity of energy is having a severe impact on industry, commerce and daily life. All possible measures are thus needed to conserve energy at all levels, from efficient use to utilize all available sources to enhance energy production and conserve it. Built environment (buildings) are among sectors, where energy usage is substantial. Households are responsible for over 20% of the nation's total energy, a major proportion of which is used to maintain acceptable thermal environment. ASHRAE 55 or other international standards for indoor thermal comfort are generally followed. These standards lay down a controlled range (21 ^{0}C - 26 ^{0}C) and comfort level is maintained by extensive use of energy. Indoor thermal comfort has thus become synonymous with consumption of energy. Strict control of indoor temperatures recommended by international comfort standard such as ASHRAE 55 leaves a very little opportunity for energy conservation. This paper presents thermal comfort (temperature range) acceptable in residential buildings in Pakistan and energy consumption in to maintain the comfort level indoors.

Keywords: Built environment, thermal comfort, energy consumption

Introduction

Pakistan is energy deficit country presently facing serious energy crisis. The gap between energy demand and supply is increasing with every passing day. A shortfall of about 80% a day in electricity supply and massive shortage in gas supply are badly affecting industry, commerce and daily life of people. All possible measures are needed to be considered and adopted to conserve energy at all levels. Built environment is among the sectors, where energy usage is substantial. Households are responsible for over 20% of the nation's total energy usage; furthermore energy demand is increasing rapidly in housing sector. Electricity and gas contributes a major proportion to household energy demand (46% and 17%). Electricity mainly being used for cooling and gas for heating and cooking.

On the average a person spends most of his time indoors, whether it is work related or family life. Studies show that in the US people spend about 87% of their time indoors, of which 69% in residence and 18% in other indoor locations (Klepeis ety.al. 2001). Thus an indoor environment plays a major role in our daily life style and importantly linked to both our quality of life and health. It is essential to provide suitable living conditions, particularly within an indoor thermal environment. Thermal comfort standards are designed for this purpose to ensure that occupants are comfortable. To maintain such an environment in buildings a range of international standards such as ASHRAE 55-2004 or other international standards are followed.

However in a developing country like Pakistan very few buildings actually meet these standards. For example, thermal comfort studies in Pakistan have shown that the majority of buildings, even if mechanically controlled had temperatures outside the acceptable range of the ASHRAE 55 standard, but indoor thermal conditions were still acceptable to occupants [Nicol at.el 1994, 1997a]. This suggests that people are comfortable, or that the thermal environment of the building is acceptable to them at the temperature ranges well outside of the ASHRAE 55 standard. Field studies such as those undertaken and reported on by Nicol *et al.* [1999] and Humphreys 1994] support this view. The studies show that people of different cultures manage and social set up maintain very different indoor conditions, spreading over a wide range of temperatures.

A field study on thermal comfort and building energy has been carried out in Abbottabad, Pakistan. The objective of this study was to determine the thermal comfort (i.e. temperature range) acceptable to the population. Also the amount of energy spent on heating the homes during winter to maintain indoor thermal environment within acceptable temperature range. This study had combined the primary data collected through fields and secondary data on energy. The environment variables examined were the air temperature (ºC) and relative humidity (%) indoors involving 83 occupants in 19 buildings in Abbottabad. This paper reports the procedure, data and results obtained from this study.

Energy and Comfort

Indoor thermal conditions vary with outdoor temperatures and buildings that are not heated during cold winters or cooled in warm summers will have indoor temperatures that may not be acceptable to occupants. Thus energy is needed to bring the indoor thermal environment with in comfortable temperatures range. On the other hand energy prices keep rising and are likely to go even increase in the future. Therefore households look to keep energy bills as low as possible whilst still maintaining sufficient levels of comfort. Maintaining adequate levels of thermal comfort in buildings is also becoming a challenge, particularly in the light of global climate change - global warming predictions etc. Thus the building sector is under pressure from the impact of high energy prices and growing international obligations to reduce CO_2 emissions associated with energy use.

Thermal comfort standards are designed to ensure that buildings occupants are comfortable whilst indoors. This is important since a person can spend up to 90% of their time indoors. Thermal comfort standards, such as ASHRAE and ISO standards etc; specify that the combinations of indoor thermal environmental factors and personal factors will produce thermal environmental conditions which are acceptable to a majority of the occupants within that particular space. Environmental factors include temperature, thermal radiation, humidity and air speed, while personal factors include activity and clothing. ASHRAE 55-2004 is based on climatic chamber studies and lay down a controlled range of temperature that generally limits the occupants' freedom over the use of available controls i.e. windows, doors and physical factors i.e. clothing and activities.

However, if indoor temperatures are not significantly different from the "usual" temperature for the given population, people can learn to adapt to these indoor temperatures. Simply by providing the opportunity to occupants to alter the indoor climate to suit themselves. the building can play a part in this process. This variation of the temperature which people find comfortable has been demonstrated in the analysis of comfort temperature in naturally ventilated, free-running buildings (Humphreys 1976, deDear at. el 1997).

Generally prevailing climate determines energy consumption patterns in buildings. Hot summers and cold winter conditions make the thermal environment of the buildings uncomfortable. Energy is required for heating and cooling to maintain thermal conditions within an acceptable range of temperatures. Global concern over the environment and increased consumption of scarce energy resources, it has become essential to look into the relationship between comfort practices in built environments and building energy use.

Climntic Profile of Abbottabad

Abbottabad city is located in the Hazara division of the Khyber Pakhtunkhwa province of Pakistan. The city is situated at an altitude of 1,260 meters (4,134 ft). Abbottabad has a humid subtropical climate, with mild to warm temperatures during the months of spring and autumn, humid temperatures during June and July and cool temperatures during the winter. The temperature can rise as high as 35°C (97°F) during the mid-summer months and drop below 0°C (32°F) during the winter months. Snowfall can be observed during January and February, though it is sparse, while most rainfall occurs during the monsoon season stretching from July to September. The average maximum and minimum temperature recorded in the months of June and January is 33 °C and 2°C respectively. The maximum rainfall up to 247 mm occurs in the months of July and August while minimum rainfall 31 mm is recorded in the month of November. Mean maximum and minimum temperature and rainfall is given in Table 1.

Table 1: Temperature and Rainfall in Abbottabad.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
T_{max} °C	12	14	18	23	28	33	30	28	28	25	20	15	22
T_{min} °C	2	4	8	12	16	20	20	19	17	13	8	4	11
Precipitation mm	73	103)	123	104	73	77	247	244	96	51	31	47	1,269

Present Study

The primary purpose of the present study was to investigate the occupants' thermal comfort in residential buildings, use of energy consumption for Heating, Ventilating, and Air Conditioning (HVAC) systems, to achieve an acceptable level of thermal environment. The study was divided in two parts – peak winter (the heating season) and peak summer (the cooling season). In the first part, a field survey was conducted to investigate its occupants' thermal sensations and an acceptable temperature range indoors (residential buildings) during winter and use of energy to maintain that range. Field survey was conduct in 19 buildings, a mix of new and old buildings including flats, detached, semi detached and terrace homes involving 83 occupants in Abbottabad.

Energy Consumption

Energy consumed by households represents a considerable percentage of the energy consumed in the country. Patterns of domestic energy consumption are closely linked to local weather and socio-economic conditions e.g. living standards, family size etc. In order to calculate the amount of energy consumed for heating and cooling purpose, a study was carried out in Abbottabad covering households from different socio-economic groups. The survey was conducted in 19 buildings with the help of a questionnaire. Utility bills of electricity and natural gas for twelve months were also collected for each building.

Thermal Comfort Survey

A longitudinal thermal comfort survey was conducted during winter months [December-March] in 19 buildings located in various parts of Abbottabad. Subjects 83 in total , both males and females, of varying ages, (as given in Table 1) were questioned. The subjective responses of thermal comfort, of the households were taken using seven-point Bedford scale.

Table 2.4: Age Profile of Subjects

Age Group	Male	Female	Total
1 to 10	1	7	8
11 to 20	8	17	25
21 to 30	2	8	10
31 to 40	3	7	10
41 to 50	6	9	15
51 to 60	7	4	11
61 to 70	4	0	4
Total	***31***	***52***	***83***

The purpose, meaning, relationships and evaluation methods of the questionnaires were explained in to the subjects in order to improve the accuracy of the responses. Thermal sensations were taken by approaching the subjects individually, recording the response and measuring the thermal environment, temperature and humidity. Last 15 minutes activities were of the individual subject was also recorded. Various controls like door/windows open/close, heater on/off in real time were entered accordingly. Clothing insulation values were calculated based on the clo values used by Fergus Nicol and his team for thermal comfort survey in Pakistan [Nicol, 1994]. Outdoor temperature and relative humidity data for investigation period [December–March] was obtained from local Meteorological office located in Kakul, 5 Kilometres northeast of Abbottabad city.

Result and Discussion

Energy Consumption Pattern
Electricity and natural gas are used for cooling and heating purposes. The heating season starts from December-March while cooling season May-September. Natural gas and electricity used during these months is shown in Fig.1 and Fig. 2.

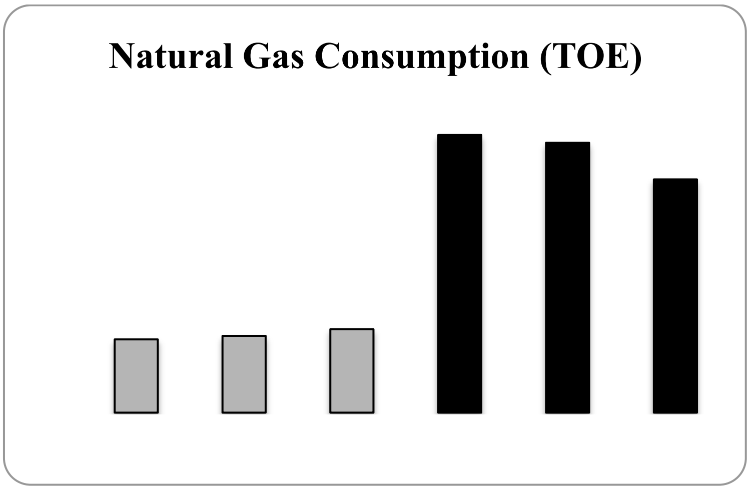


Fig. 1: Natural Gas Consumption (TOE) during summer and winter months

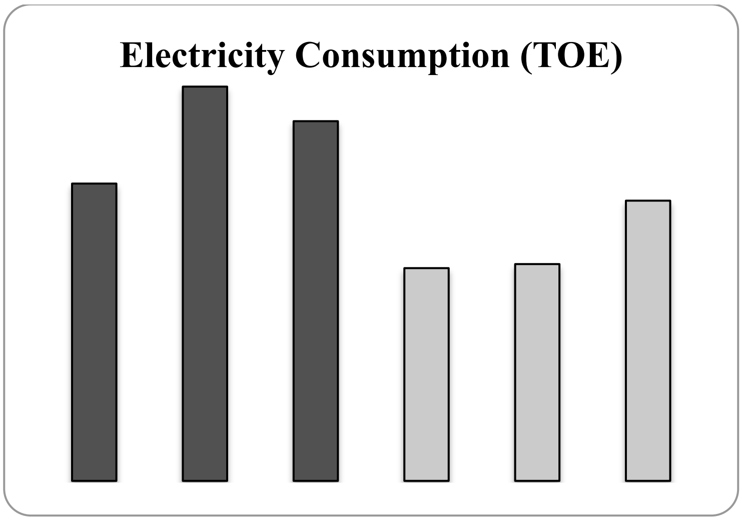


Fig. 2: Electricity Consumption (TOE) during summer and winter months

Results from the building and thermal comfort surveys showed that the households use natural gas for heating (gas heater) during winter and electricity for cooling (for running fans, air-conditioners, room coolers etc.) during summer. In terms of energy consumption, natural gas is more consumed than the electricity during the year. The share of natural gas and electricity is 70% and 30% respectively in total energy consumption. Natural gas consumption is 54% more than the summer season and it is assumed that this additional amount is used for heating to maintain thermal comfort indoors in winter. Electricity consumption in summer season is 19% more than the winter season. This extra amount of energy is used for cooling in summer. Electricity consumption for cooling is far less than the natural gas consumption for heating. The main reason being Abbottabad's mild summers; resulting in lower energy consumption required for cooling whilst winter are severe requiring greater energy to maintain indoor comfort levels.

Thermal Comfort

The statistical analysis of principal variables of the study is given in table xx, below.

Table xx: Principal Variables

Variable	Number	Minimum	Maximum	Mean	SD
Comfort Vote	2075(votes)	-3	2	-0.32	0.97
Preference Vote	2075 (votes)	-1	+2	0.37	0.66
Clo Value	2075 (votes)	0.58	2.45	1.67	0.44
Temp[indoor] (^{0}C)	25 (days)	11.24	28.41	15.94	4.10
Temp[outdoor] Instantaneous(^{0}C)	25 (days)	10.35	27.73	15.61	4.61
Outdoor Temp (^{0}C)	25 (days)	2.8	15.40	7.22	3.16
Comfort Temp (^{0}C)	25 (days)	12.03	23.89	16.92	3.71

The mean outdoor temperature during the surveyed period was 7.2 °C (44.96 °F) while the indoor mean recoded temperature was 15.94°C (60.69°F). Mean comfort temperature according to Griffith equation [Nicol & Raja, 1996] was found 16.92°C (62.46°F). Under these weather conditions 86.6 % of the comfort votes (61.5% without the use of heating facility and 25.1% with heating facility) were found in comfort zone i.e. from -1 comfortably cool to +1-comfortably warm and only 13% comfort votes were not found in the comfort zone. The mean of comfort votes was found -0.328 and standard deviation was 0.97. Preference vote also showed that majority of the subjects were comfortable with thermal condition under the aforementioned climatic conditions, as 56.48% were not in favour of any change while 32.96% votes were for a bit warmer and 5.4% were for a bit cooler environment. The mean of preference votes was found 0.376 and standard deviation was 0.66.

Comfort and preference votes are plotted in Fig 3. The patterns of comfort and preference votes showed that subjects are well adapted to the climatic conditions of the area and were found comfortable at 15.94°C (60.69°F) to 20.9°C (69.62°F) which is below the ASHRAE indoor design temperature (21°C/ 69.80°F) standard for winter season. The amount of energy consumed to maintain the indoor temperature at 21°C (69.80°F) can be saved if the indoor design temperature for the buildings (in the study area) are set at 16°C (60.80°F) , i.e. lower than ASHRAE recommended 21°C (69.80°F). Adapting climatically determined indoor temperatures with adjustment in clothing will help reduce energy consumption and the passive use of heating. Studies show that lowering comfort temperature to 19 °C (66.20°F) has the potential energy saving of 80% [Milne & Boardman 2000]. Studies in Netherlands found that habits were changed to adapt the behaviour to suit the new circumstances [Boerakker & Jeeninga 2005] with some adjust in clothing and use of available control [Raja at.el. 1998, and 2001). People are better off even at much lower temperatures by dressing appropriately.

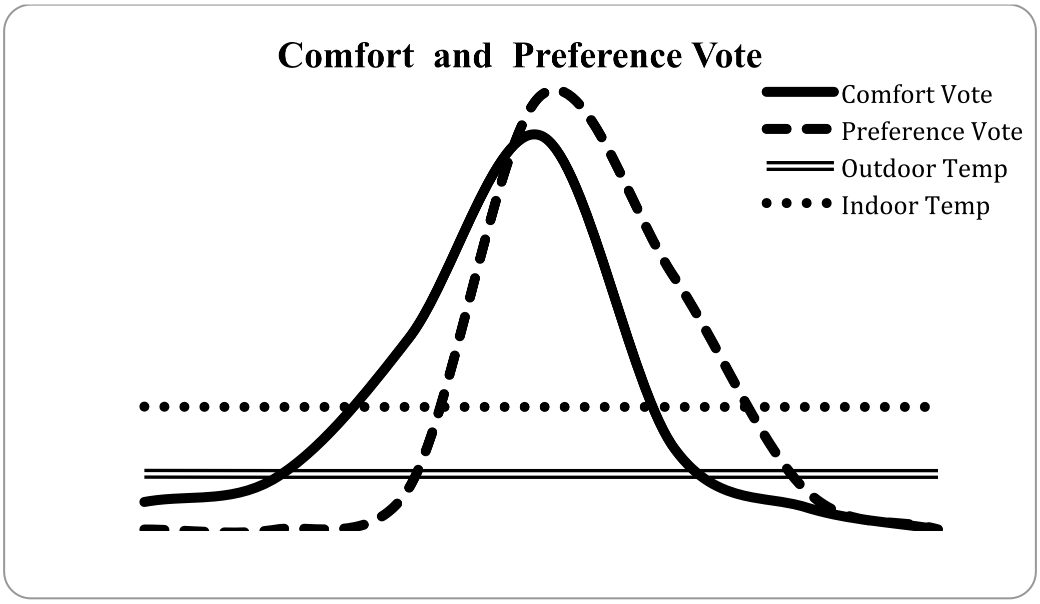


Fig. 3: Comfort and Preference Votes

CONCLUSION

Thermal comfort standards are designed to ensure that buildings occupants are comfortable while indoors. Prevailing ASHRAE standard presents a tightly controlled range. Although in Pakistan ASHRAE 55 standard should be applied to buildings, however in reality a very few buildings actually meet or observe these standards. The study found that most of buildings had temperatures outside the acceptable ASHRAE 55 range and that most occupants seemed satisfied with their thermal environment. Over 87% reported that the thermal comfort conditions were acceptable. This suggests that people in Pakistan are comfortable, or at least satisfied with temperature ranges well outside of the ASHRAE 55 standard. The present study suggests that Pakistan should formulate its own thermal comfort standards that provides the flexibility to effectively reflect the prevailing thermal environment indoors. As proposed in the earlier studies based on adaptive approach, the benefits would appear in the form of energy saving in the building sector and play an important role in helping Pakistan to overcome its Energy Crisis.

REFERENCES

Boerarkkar Y and Jeening H, (2005), The influence of behavior on the effectiveness of more stringent standards. Proceedings European Council for an Energy efficient Economy, 2-101.

R.J. de Dear, G.S. Brager, D. Cooper, (1997): Developing an adaptive model of thermal comfort and preference (ASHRAE RP-884), Sydney, NSW 2109 Australia: Macquarie Research Ltd., Macquarie University, Sydney, NSW 2109 Australia and Centre for Environmental Design Research, University of California, Berkeley, CA 94720, USA.

Humphreys M.A; (1976): Field studies of thermal comfort compared and applied, Building Services Engineer, 44.

Humphreys, M. (1994) Field studies and climate chamber experiments in thermal comfort research, in Oseland, N. and Humphreys, M. (Eds): Thermal Comfort: Past, Present and Future, Building Research Establishment, Watford, pp.52–69.

Klepeis, N.E., W.C. Nelson, W.R. Ott, J.P. Robinson, A.M. Tsang, P. Switzer, J.V. Behar, S.C. Hern and W.H. Engelmann, (2001): The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. J. Exposure Analysis and Environmental Epidemiology 11: 231-252.

Milne G and Boardman B, (2000): Making cold homes warmer: the effect of energy efficiency improvements in low-income homes. A report to the EAGA Charitable Trust. Energy Policy, 28(6/7): 411-424.

Nicol, J.F., Jamy, G.N,Sykes, O.,Humphreys, M.,Roaf, S.,Hancock, M. (1994): A survey of Thermal Comfort in Pakistan - Toward New Indoor Temperature Standards, Oxford Brookes University, Oxford.

Nicol, J.F; Raja I A; and Allaudin A: (1997a): Thermal Comfort in Pakistan II - Toward New Indoor Temperature Standards, Oxford Brookes University, Oxford UK.

Nicol JF; Raja IA; Allauddin A and Jamy GN, (1999): Climatic variations in comfortable temperature: The Pakistan projects: Energy and Building, 30, 261-279.

Raja IA, Nicol JF and McCartney KJ;(1998): Natural ventilated buildings: use of controls for changing indoor climate, Renewable Energy, 15(1-4), pp(391-394)1998.

Raja IA, Nicol JF, McCartney KJ & Humphreys MA: Thermal comfort: Use of Controls in natural ventilated buildings, Energy and Buildings, 33(3), (235-244)2001.

Daylighting Quality of Students' Livable Space

Sugini

Department of Architecture, Faculty of Civil Engineering and Planning Universitas Islam Indonesia

Email: sugini@uii.ac.id

Abstract

Creation of space for a better life must begin with knowledge of how good the quality of existing space has been able to sustain life. Although the issue of environmental degradation has been presented, but it is need to know a measurable clarity about how much space quality degradation has occurred so that the step of diagnosis can be established.

Indonesia is a country with an abundant wealth of natural light. In such conditions, the quality of daylighting space should certainly be no problem. The advantage of daylighting is reduction of energy consumsion for lighting that will encourage the sustainable development. But unfurtunatly, space development in this moment are more concerned with instant economic benefits aspects therefore the strategy election to the achievement of quality space is less wise.

This paper is the result of research aimed at identifying student living room dayligting quality and look for factors that contribute to the quality of those student living room daylighting. Case study of this research is UII Architecture student in Yogyakarta.

The methods of data collecting in this study are observation and DF data modeling. DF factor is measured using a mathematical simulation of the Sky factors. The raw data contains Height and Width of opening that effectively can catch the sky dome and the depths of room. Quality indicator standard is based on SNI standards on daylighting. This research is expected can conclude the quality of daylighting student livable space and recommendations for improvement the students' liveable space especially to achieve a standardized day lighting quality.

Keywords: Livable space, Student, Daylighting

Background

Environmental degradation has occurred in the world. Rising global temperatures causes changes in the habitat quality and futhermore give an impact on reducing the environmental carrying capacity, the health of the environment and economic activity. Therefore developing the ways to preserve environment is important to do.

How to prevent an increase in temperature of the earth is by control global warming. Based on the Climate Institute, 2010, global warming arises because of the ozone holes. Activity of human civilization on earth produces many gases that cause O3 break down into a more stable O2. To reduce the gas emission therefore reduction activities related to the productivity of the gases should be done. One strategy to reduce the ozone hole is by reducing the use of electricity, which is based on fossil fuels and return to natural resources. Back to natural lighting or daylighting in daily activities is one methode in use of natural resources. This is according to a statement from Ferron, Pattini, Lara, 2010 and Kozlowski, David, 2006.

The use of daylight activity is not only significant in pushing for energy conservation, but also will affect the aspects of health and productivity of occupants (Mudit Saxena, 2008). Samuhatananon, Chirarattananon, 2011 stating that the use of daylighting in the equator is feaseable.Therefore This option becomes very appropriate in Indonesia because Indonesia is a country located on the equator with high altitude. High Altitude conditions led to Indonesia with abundant sunlight. Daylighting design approach should be a popular choice for architects in creating livable space. According to Ullah, Liaw Wee Lin, 2003, Daylight not only generate adequate lighting but also provides a color rendering quality and more satisfaction for men. Daylighting study on livable space becomes very significant when focused on the function of the activity with the demands of high lighting comfort. Livable space with high lighting comfort demands are generally inhabited spaces of the student. Thus, with daylighting studies relating to the student becomes very important. Therefore this study aimed to answer very basic question is how comfortable daylighting quality of livable space for the student.

Yogyakarta is a city which is said to be very popular student city. Both privat and state universities there is a lot there and there are thousands of students scattered in this city. One of the oldest universities in Indonesia is the University of Islamic Indonesia (UII). UII has more than seventeen thousand students from various parts of Indonesia. Therefore, this study will focus on livable space for UII student.

Research Questions

This study is part of a more complete study. The question to be answered in this phase of the research is whether or not the quality of livable space for daylight student meets the Indonesia National Standar (*Standar Nasional Indonesia* SNI).

Research Objectives

This paper reports the results of initial research was aimed to look for quality daylight in student. In subsequent studies will be developed on the search factors that affect the quality of daylight the space.

Review of references

Parameters of daylighting

Daylighting is lighting that based on natural resources. Light that are included to the source of natural light are the direct sunshine and sky dome, the reflected light of the sun or sky dome by external elements and the natural light reflected by the element of space inside. The Parameters to measure the daylighting space is daylight factor (DF). DF illustrates the comparison of natural illumination in the room compared to the illumination outside the chamber or open field (BSNI, 2001; Li, Cheung, 2006; Mudit Saxena,2008; Nabil, Mardaljevic, 2005). DF can be measured in two ways, namely empirical or simulation.

The *Indonesia National Standard* SNI measure DF of a room by adding the value of the sky factor (fl), the outer space reflectivity factor (frl) and the indoor reflectivity factor (frd).

Sky factor is the factor that indicates how much the dome sky light can be inserted into the room. In principle it is determined by the effective aperture area of space in capturing the sky dome. Formula to find fl are as follows[1]:

$$1)\quad fl = \frac{1}{2\pi}\left\{\arctan \frac{L}{D} - \frac{1}{\sqrt{1+(H/D)^2}}\arctan\frac{L/D}{\sqrt{1+(H/D)^2}}\right\} \text{ .... (1)}$$

L is the effective width of the effective openings which can capture the sky dome. D is the distance of work plane. H is the height of the effective opening.

Outer space Reflectivity factor (fl) shows the amount of natural light received from the reflectivity field compared with the celestial sphere exterior light. The formula is as follows[2]:

$$2)\quad frl = (fl)_p \times L_{rata\text{-}rata} \text{ .... (2)}$$

Fl (p) is the factor of the sky when space is in the free condition, L $_{rata\text{-}rata}$ or $L_{average}$ is the ratio between the exterior field reflected luminance with sky luminance.

Reflectivity factor in the space (frd) shows the comparison between amount of natural light that comes from the reflectivity in the room with natural light from the sky dome. The formula is as follows[3]:

$$3)\quad frd = \frac{\tau_{kaca}}{A.(1-R)} \times (C.R_{fw} + 5.R_{c\,w}) \text{ ....(3)}$$

T_{Glass} is the transmission factor of light from openings glass depending on the data from glass manufacturers; A is the surface area in space; R is the average reflectivity factor of the entire room; W light exposure area; R_{cw} is average reflectivity factor ceiling and upper wall of the chamber (from the middle hole of light) and does not include the wall opening where and C is a coeficient based on the angle of the barrier.

The comparison between the natural light from dome sky and or the sun with the reflected natural light is very contrast In Indonesia. This is due to bright sky in Indonesia is very high. In such conditions, the SNI explain that to a common anatomical space where the space can still catch the sky dome therefore the FRL and FRD are ignored. So to measure the DF space with anatomical space in general in Indonesia we use the formula 1).

Determining building daylighting components

As described previously, the DF as a parameter of quality daylighting defined by three things. First by a factor of sky that shows the ability of capturing light celestial space. The second is the reflection factor of outer space that shows how much natural light can be reflected into space. The third is the reflection factor of space in which shows how much interior space can reflect the natural light entering the space.

---

[1] SNI 03-239-2001

[2] ibit

[3] ibit

In this study, the assessment will use a mathematical formula of number one. The collection of data about the width and height effective opening, height and depth of work plane were done by measurement with appropriate tools (BSNI,2001; Reinhart, Lo Verso, 2010). Based on the data calculation of DF were done by using formula 1. By this simulatif analysis, from this result also can be known the components that play a role in the success of the design space. This is because through the observation of effective opening height, we have observed indirectly eksterior obstacles or the opening eaves / shading. In addition at the same time, we also have observed height and position of openings from the ceiling and the eaves outside. Likewise, when we observe the effective width of the light opening, indirectly we have observed a vertical barrier in outer space or fin / vertical shading and wide openings. Illustration can be seen in the following figure.

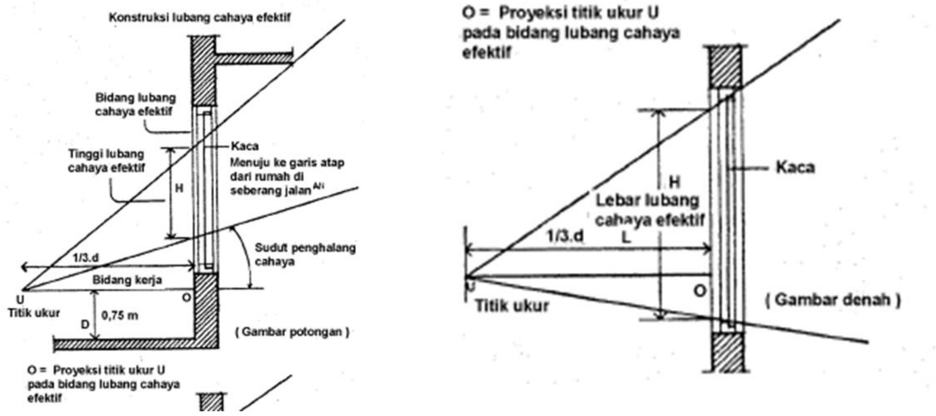


Figure 3: Opening and effective dimensions and other elements that define fl

(Source: BSNI, 2001)

Daylight standards

Based on SNI standards, the natural lighting is determined by several things. The first is determined by its classification. Classification of space is determined by two things: the burden of the job or 'task' and the length of time from the burden. When the job must be charged and constantly careful work it is called is very smooth and the condition is classified on the quality of A. For example drawing detail, engraved, stitched with dark colors. When the work is meticulously charged but not necessarily continuous, then the condition is entered on the quality of B or so-called fine job. Work of reading, writing, assembling small components are examples of this group activity. While the job without concentration included in the quality of C or menial labor. An example is the assembling of the parts, carpentry and the like. The latter is a job that only requires details of the inclusion in the quality of D or menial work. An example is the activity of walking in the hallway, warehouse or place where the objective is to identify the location of objects and the like.

To student livable space, as a consequence of work for the student activity space certainly more than just a classification D, as a rough job. More work being done on the work of writing, reading. However, for students of Architecture Department then needs a detailed drawings for a long time is dominant. Therefore in the scope of the architecture student livable space, The standards that are applied is quality of A. Referring to the Table 1, the SNI standard in this study is 0.45 d. In this case d is the depth of the observed space. Thus, the standard of each chamber was observed to be relatively dependent on the depth of space.

Table 1: fl standard for general building (Source: BSNI,2001)

Clasification	Fl_{min} TUU
A	0,45. d
B	0,35. d
C	0,25. d
D	0,15. d

Analysis and Discussion

The analysis of this study was based on a sample spread from 0.1 km to 30 km from the campus architecture UII. But most of the range is 1 km from campus.

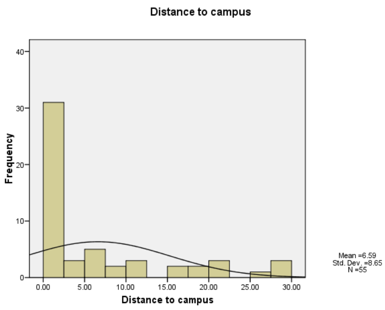


Figure 1: Distribution of sample position to Campus

DF's performance based on space and high value as the determining variable effective aperture, effective aperture width is illustrative shown in figure 1 below. The average of depth variable (d) is 3.32 m. While the average of effective aperture height (H) is 0.9 m and average height of working area is 0.54 m.

The mean of difference DF is 4.5. To see the significance of the difference between riel DF with standard test is performed using paired samples t test. From the analysis it can be concluded that the quality of space daylight was significantly different to the SNI standards. The mean of difference DF is positive. This positive value indicates that the DF riel conditions far above the standard. Although this condition indicates the adequacy of light, but there are things to watch out for the glare effect. This is because the quality of lighting comfort is not only determined by the adequacy of light but is determined also by the glare. Especially for Indonesia with excessive strong illumination with high light of the sky are actually brought to the detriment of glare.

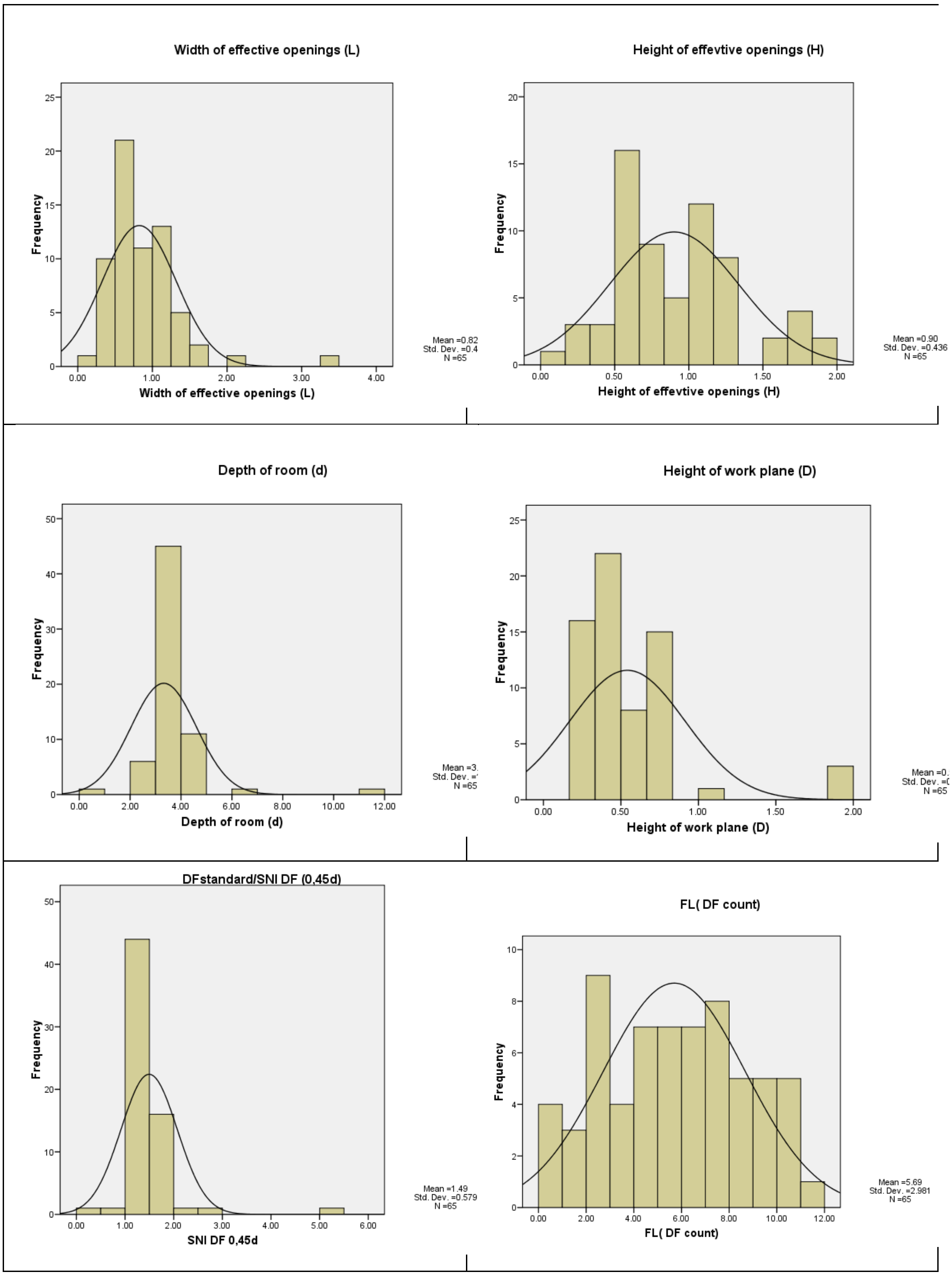


Figure 2: Distribution of data on the height and width of the effective opening, the distance / height and depth of work plane

The next question is how do we can renovate student livable space so close to the quality standard of living. To be able to renovate the space so that space is close to the standard is by manipulating the factors that determine the Df difference. Method to find the determining factor is by find the existence of correlations between factors are suspected with the DF difference.

Effective openings width.

Based on correlation analysis of effective width of openings can be concluded that the effective opening width significantly correlated with DF differences. Based on regression analysis can be seen (Figure 3) that effective opening width can be described as a cubic equation.

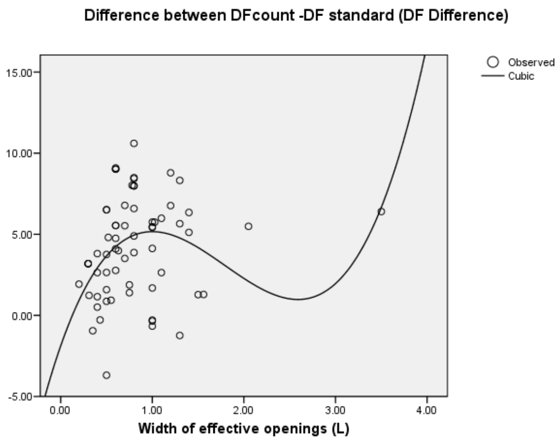


Figure 3: Association between effective width of aperture with difference DF.

Height of effective opening

From the correlation analysis can be seen that the correlation between the DF difference with the effective opening height was greater than the correlation between the DF difference with the effective opening width. Curve estimate based on regression analysis also produced a stronger model than the association model of effective opening width.

To illustrate the pattern of association can be seen in Figure 4. The Association is most appropriate to describe the relationship of effective opening height with DF defference are quadratic and cubic regression.

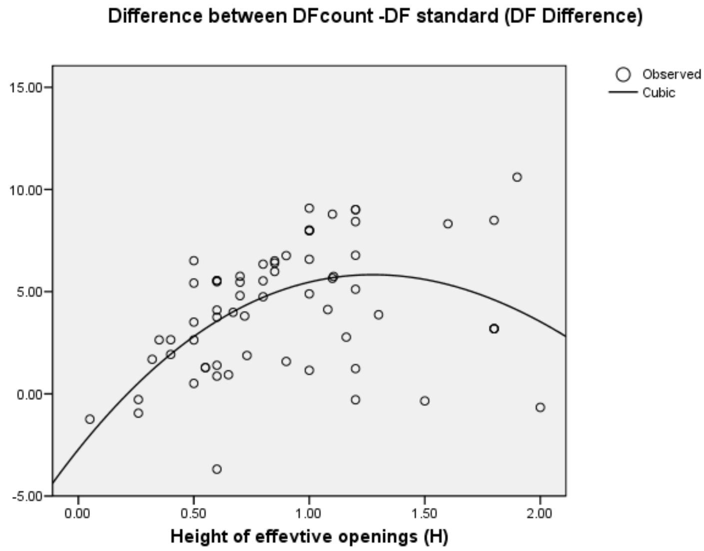


Figure 4: Association between effective opening height with a difference DF

The work plane

Based on correlation analysis of height of work plane was significantly correlated with DF difference. The correlation result of regression analysis is better than the two previous variables. The regresi model can clearly be seen in Figure 5 the following illustration:

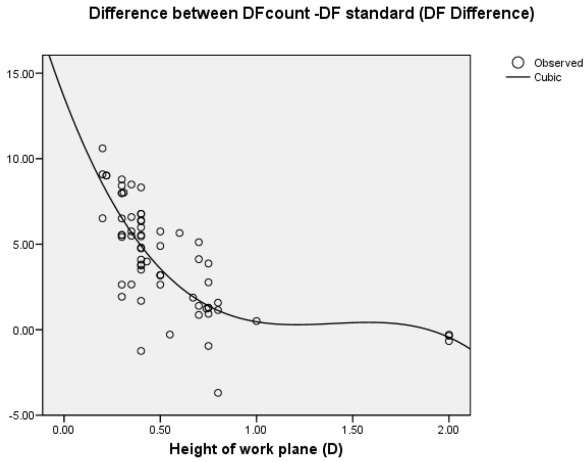


Figure 5: Association between work plane height with the DF difference

From the analysis of variable of ratio effective opening width, effective opening height with work plane height inferred the existence of a strong correlation with the DF difference than when these variables were analyzed individually. For the deepening of the analysis was carried out following the combination of a single variable.

The Effective opening area

Analysis of correlation between the effective opening area (multiplication of effective opening height with the effective opening width) with difference DF produce a significant correlation. Regression analysis can also generate a significant pattern of association. The pattern of association is the cubic regression. The cubic regression model can be seen in Figure 6.

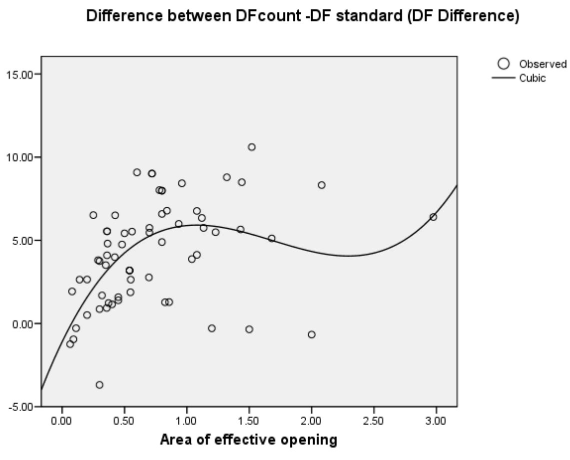


Figure 6: Association between area of effective opening with a DF difference

The ratio between width of effective openings with a height of work plane (L / D)

Correlation analysis of the ratio of effective opening width to the height of the working area (L / D) with DF difference was significant. Based on regression analysis, the model was found significant cubic regression relationship with R value of 0.570. In an illustrative depicted in Figure 7.

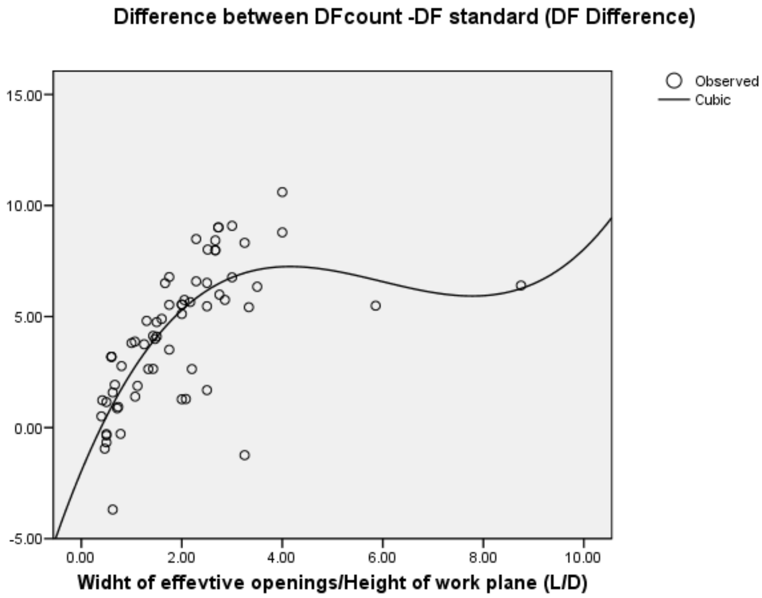


Figure 7: Association between L / D with a difference DF

The ratio between the effective opening height to the height of the work plane

Based on correlation analysis of the ratio between the high opening and high effective work plane with DF difference can be generated a significant correlation. Based on the regression of the association, also found a cubic regression model with a larger R value 0.798. illustration can be seen in Figure 8 below.

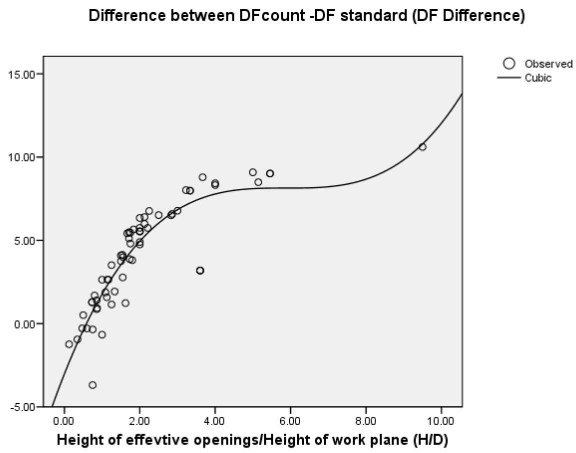


Figure 8: Association between the H / D with a difference DF

The ratio between Effective opening area with the height of the working field

When the variation of the ratio between variable widened by comparing the effective aperture area of work with high-field measuring point then the analysis produces a significant correlation as well. Regression analysis of yield curve also estimate the association better cubic regression. However, the resulting model is still lower than the cubic regression model the association of a high ratio of effective aperture. R values of the model is 0.795. Illustration cubic association is shown in Figure 9 below.

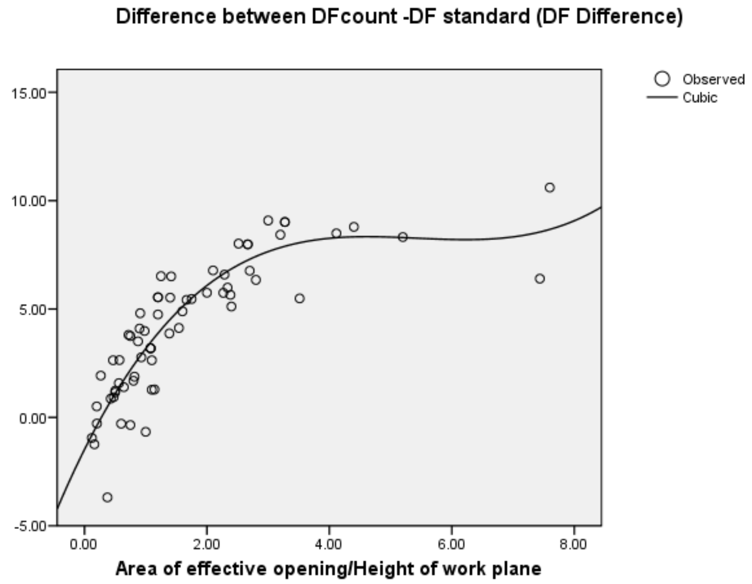


Figure 9: Association of the ratio between the effective aperture area to the work plane height with the difference DF

Square of the ratio between the effective opening height to the work plane height

Analysis of the square of the ratio between the height of the high effective aperture area of work produces a significant correlation. Regression analysis of yield curve also estimate the association cubic regression better than the association of other variables. However, the resulting model of the association is still lower than the cubic regression. R values of the model is 0.682. Illustration cubic association is shown in Figure 10 below.

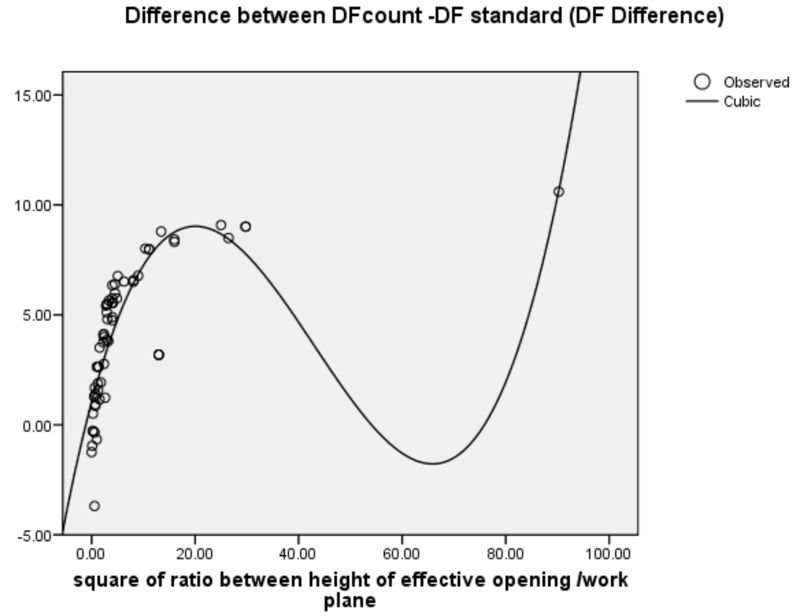


Figure 9: Cubic regresion model of association between of square of ratio between height of effective opening with the works plane height

From the analysis and discussion as the above can be seen that the most effective way to achieve a consistent standard is to consider four factors. These factors consist of a single variable and the combination of three factors. These are (from weak to strong):

1. The ratio between the effective opening width to the work plane height with the value of R is 0.570.
2. The height of work plane. Value of R in the cubic regression model is 0.595.
3. Square of the ratio between the height effective opening and the area of work plane. Regression value of R in association cubic amounted to 0.682.
4. The ratio between effective opening area the height of work plane (L/D). Value of R in the cubic regression model is of 0.795
5. The ratio between the height of effective opening with the of work plane. Value of R in the regression model is of 0.798.

Last two factors, namely the ratio between the effevtive opening area with the height of work plane and the ratio between the height of effective opening with the of work plane has a high R value above 0.7. It shows that the strength of the combination is very high factor in determining the value of differences in DF. So using these two formulas in setting the direction of daylighting design to achieve the appropriate quality standards are very precise.

Based on cubic regression association of L/D formula (formula 4) can be designed \a design guidance. Formula 4 is formulated based on the results of regression analysis according to the Table 2.

Table 2: Results of regression analysis between the cubic L / D with a DF difference

Model Summary and Parameter Estimates

Dependent Variable: Beda antara DF hitung (FL hitung)-DF standar

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Cubic	,795	78,668	3	61	,000	-1,482	5,656	-1,068	,066

The independent variable is Luas bukaan/Tinggi Bidang kerja titik ukur.

$B = -1.482 + 5.656 (L / D) - 1.068 (L / D)^2 + 0.066 (L / D)^3$ ..... (4)

B: The difference between DF riel (FL count)-DF standard
L: effective aperture area
D: High work plane measuring point
Because we want the DF riel value becomes equal to the value of the standard DF B value becomes equal to zero so the equation becomes as follows:
$0 = -1.482 + 5.656 (L / D) - 1.068 (L / D)^2 + 0.066 (L / D)^3$
$L = 0.2761 D$

Based on cubic regression formula of the association between the ratio of effective opening height to the work plane height (hereinafter referred to as H / D), the guideline design can be developed based on the following formula 5. Formula 5 is formulated based on the results of regression analysis in Table 3 below.

Table 3: Regression Analysis of cubic H / D with DF Difference riel with standard

Model Summary and Parameter Estimates

Dependent Variable: Beda antara DF hitung (FL hitung)-DF standar

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Cubic	,798	80,528	3	61	,000	-3,021	5,710	-,974	,055

The independent variable is Tinggi bukaan efektif/Bidang kerja titik ukur.

$B = -3.021 + 5.71 (H / D) - 0.974 (H / D)^2 + 0.055 (H / D)^3$ ..... (5)

If we want a value equal to the value of DF difference then the value of B equal to zero so the equation becomes as follows:

$0 = -3.021 + 5.71 (H / D) - 0.974 (H / D)^2 + 0.055 (H / D)^3$

$H/D = 0.5856$

$H = 0.5856D$

Based on Figure 8 can be understood if the design is intended to approximate the quality standards of DF then this means the ratio between the effective opening height with the work plane height should be getting smaller by nearly 0.5856. When the comparison between the effective opening height with the work plane height is smaller than 0.5856 so this means riel DF is lower than the standard. It is not allowed. Figure 8 can also be understood that when the design of room will be addressed as close to the standard DF then if a effective opening is high, so the height of work plane should be increased as well.

Figure 9 shows that in principle the same as figure 8. To achieve the design of room with the DF close to the standard, it means the ratio between the height of openings with the height of work plane should be small and close to 0.5856. However, this comparison should not be smaller than 0.5856 because when it happens , there fore DF riel lower than the standard value of DF. As well as the relationship in formula 5, then when the design of room is intended to approximate the value of this standard, it means that the higher the effective aperture, the height of work plane should also be increased.

Conclusion

From the analysis and discussion can be concluded as follows:

1. The mean quality of student livable space daylighting in the sample exceeds the standard DF. From the review it means the quality is positive. However, when viewed from a more comprehensive review, this condition is feared it will appear glare. Glare is not favorable for visual comfort.
2. Factors that determine the accuracy of student livable space daylighting in a sequence from strongest to weaker are:
    a. The ratio between the effective opening height with the work plane height.
    b. The ratio between the effective opening area with the work plane height.
    c. The square of the ratio between the effective opening height with the work plane height.
    d. The work plane height.
    e. The ratio between the effective opening width and the work plane height.
3. Student livable space design devoted to the interests of proper daylight standards achieved by two design concepts with the guideline design as follows:
    a. Comparison between the effective opening height to the work plane height area should be close to 0.2761 and should not be lower than that value.
    b. The higher the effective opening, high field of work should also be increased.
    c. Comparison between the effective aperture area with the work plane height should be close to 0.5856 and should not be smaller and lower than that value.
    d. The larger effective opening, The height of work plane should also be increased.

References

BSNI,2001, SNI 03-2396-2001, *Tata Cara Perancangan Sistem Pencahayaan Alami pada Bangunan Gedung*, BSNI. Indonesia Climate Institute, 2010.

Mudit Saxena,2008, A New & Better Way to Calculate Daylight, Buildings, 102,8, p:62, ABI/Inform.

Ferron, Pattini, Lara, 2010, A New Type of daylight Passive Collector: The Shaped Refractor, Lighting Res. Technol;43:309-319, The Chartered Institution of Building Sciences.

Reinhart, Lo Verso, 2010, A Rules of Thumb-Based Design Sequence for Diffuse Daylight, Lighting Res. Technol, 2010;42:7-31, The Chartered Institution of Building Science.

Samuhatananon, Chirarattananon, 2011, An Experimental and Analytival Study of Transmission of Daylight through Circular Light Pipes, Leukos, Vol 07, 2011;P:203-219, The Illuminating Enggineering Society of North America, America.

Li, Cheung, 2006, Average Daylight Factor for The 15 CIE Standard Skies, Lighting Res. Technol, 38,2 (2006) pp.137-152, The Chartered Institution of Building Science.

Ullah, Liaw Wee Lin, 2003, Daylight Distribution in The Living Rooms of Four Types of Public Housing Building in Singapore, Lighting Res. Technol.35,2 (2003) pp.91-100, The Chartered Institution of Building Science.

Kozlowski, David, 2006, Harnessing Daylight for Energy Saving, Building Operating Management; 2006;53,4, pp;15;SBI/Inform

Nabil, Mardaljevic, 2005, Useful Daylight Illuminance: A New paradigm for Assessing Daylight in Buildings, Lighting Res. Technol. 37,1 (2005) pp 41-59, The Chartered Institution of Building Science.

Community Participation In Situ *Pengasinan* Conservation Effort To Create A Green Living Place

Agung Wahyudi, C. Widi Pratiwi

Departement Architecture , University of Gunadarma

E-mail: agung_wyd@staff.gunadarma.ac.id

Abstract

Some *situ* in the Greater Jakarta has experienced a shift of functions, including the change of function as a water catchment reserve and residential functions. So in many cases there have been narrowing and silting Situ land. Without realizing the danger of narrowing of the land becoming increasingly threatening, especially in the rainy season with high rainfall, then flooding will always threaten the lives of citizens. When dry season comes, will be a shortage of clean water due to catchment areas and catchment areas continue to dwindle. As one measure situ conservation districts in the area Situ Pengasinan Sawangan Depok West Java is the participation and awareness of local residents around the lakes to preserve Situ without support from the government of Depok. Efforts are made one of them is to create model villages or housing with the concept of green living. That society as a self-help buy land adjacent to it without building altogether, a new building behind the line of *sempadan* Situ established in accordance with the rules of the local government that is built up only 30%. Land along the demarcation line is only used for green areas such as urban forest, or park that aims to protect water catchment areas is maintained. Purchase of land use rights was not only the status of property rights, but society as a self-conscious, as if to fall into the developer or developers of land would be changed into housing and consequently there will be narrowing and lack of land for water catchment areas.

Keywords: Participation, community, situ, green living.

1. Introduction

Attention of the international community to formally organize the aspects of the global environment has been implemented since the 1970's decade, when the initiative of the United Nations World Environment Conference held the first in Stockholom, Sweden in 1972, where Indonesia is one country that actively participate in the conference. Conference known as the United Nations Conference on Human Environment; which further highlights the environmental aspects of human life. As a follow-up of the above conference, the next 20 years ie in 1992 hadirlah Jenario Rio summit, the approach was different from the first conference, and connotation to the environment and sustainable development (sustainable development). Growing development of construction in Indonesia, on the principles Jenario Rio Summit; contained in the Guidelines of State Policy 1993-1998; with emphasis not only economic benefits, employment and foreign exchange earnings, but more emphasis on two fundamental aspects, namely;

a. Improved environmental sustainability, the physical conservation, water management and soil biota (flora and fauna);
b. Increased participation of communities and local government in policy implementation.

Observing the emphasis as implied in the Guidelines of State Policy, and considering the policies pemeritah through Law. No. 5 of 1990, on ratification of natural resources, and Presidential Decree No. 32 of 1990 on the management of protected areas; saving presence, rescue and optimizing the use of Situ Pengasinan it, mendudukan strategic position for the City of Depok that most of their range (78.2%) is water catchment area.

Situ Pengasinan the importance of saving it, given the increasing threats to the existence there by any of the following;

a. Land conversion (conversion of status); existence is likely due to the rapid population growth luju, which dimbangi by the need for space and land for settlement, to the region where *Situ Pengasinan* the main target;
b. Occupational (squatter) community of Situ Pengasinan it listed 210 families or 816 persons; which gives the tendency increasingly threatened the existence and pelestarianya;
c. Siltation; sludge is one of the major causative factor terdegrasinya situ in-situ, induced the surrounding community; met with domestic waste (household), and enrichment of mineral nutrients, it's often caused flood water during the rainy season, as well as the emergence of odor contamination the less savory;
d. Waste pollution; carried by the flow of water and accumulates it tends to affect the sustainability. As a result it creates, can affect the aquatic biota. Eutrophication process that occurs, causing an abundance of water hyacinth (Eichornia crassipes) in addition to accelerating pendang Kalan, there are also shrinking the amount of water due to high evaporation

2. Purpose, Objectives, Benefits

Community empowerment around Situ Pengasinan, for the purpose of public awareness of the meaning of the importance of service functions situ in-situ, in its essence is the intent and purpose in this paper. The target to be achieved in the developed public awareness to care about the existence, rescue, preservation of Situ Pengasinan away, on an ongoing basis both in the present and future.

Community empowerment benefits, to rescue *Situ Pengasinan*, is expected to stimulate public awareness in matters as follows:

a. Creation of public awareness, so they care to restore the environment in accordance with the conditions where *Situ Pengasinan* before occupation nature, and plays a role as a vehicle for people living nearby;
b. Development of natural resources and marine environment, aiming to realize the harmony between human activities and the environment, to the creation of Depok city beautiful, comfortable, clean and attractive; through community-based activities.
c. Situ Pengasinan away the natural environment in addition to functioning as a water tank are also sources of income for communities and local government, it is given that the environment there-there is a potential that can be used as a vehicle for outdoor recreation, and tourism for the benefit of freshness physical.
d. Increase in Situ Pengasinan away a role other than as a function of the water tank, also can be optimally used both by local people and Government of Depok City, in an integrated manner based sustainable partnerships.

3. Research Methods

This study was made on the basis of qualitative descriptive research method, by performing a series of exploration and field observations on the environment held in Situ Pengasisnan in Depok West Java as a sample of research, literature studies and interviews with several informants.

4. Results and Discussion

Squatter community is basically a community of people living illegally (occupation) in an urban area of the planned allocation, or the role and functions are clearly stipulated in the Act (No. UU.. 5 of 1990 on the ratification of natural resources and biodiversity), and government policy through Presidential Decree No. 32 in 1990, about the management of protected areas.

Looking at the definition above, the approach should be taken based on;

a. Participatory in the sense of looking for a way out so that they remain in optimal circumstances, in accordance with the wishes of the people in a controlled manner;
b. Empowerment in the form of training is geared to spur the public is able to harness the potential of aquatic resources there

4.1 Achieve Conception Independence Community

4.1.1 Conception Independence

To realize the independence of economic development for the community, through the integration of environmental dimensions of development, needed five basic principles of harmony, namely: (a) the balance of the environment, (b) economic empowerment, (c) the distribution of development, (d) integration and (e) the ability sincerity and intentions in synergies

Looking at the five basic principles that interplay with each other, it is not possible in practice be resolved in ways of thinking and acting in a traditional, or conventional. Therefore new ways of thinking that can lead to ways to act rationally. Based on that breakthrough by focusing through the fabric of the relationship between behavioral development (stake holders), including the people in it.

Depok city is an integral part of national development which has a meaning and an important role in realizing the national goal; for the implementation of community-based development seems to be a fundamental consideration in the implementation of empowerment.

Imbalance between the population and the economy, causing various forms of impact include (a) fading attitudes and behavior, (b) increasing poverty, and (c) degradation of environmental quality, such as going around the area where Situ Pengasinan.

Fading attitudes and behavior, reflected in the mastery of demarcation there. Increased border tenure there, due to the lack of attention to stakeholders' propensity to cultivate empowering way of development of society as a "subject of development" that has the capacity as a regional economic bases. In geohidrologi and geomorphology, Depok City Region has a very large functionality to the continuation of the waterworks system both locally and regionally. Regionally, it functions as a reserve of fresh water and flood control, and locally can be allocated for the promotion of business activities and the people pereko-Minister for the Economy as well as fisheries and tourism revenue (local revenue).

Situ utilization, both professionally as a vehicle for conservation, recreation, education (training) and business center, essentially a rational approach to implement the squatter community built

4.1.2 Achieving implementation independence

Situ Pengasinan away the concept of empowerment, there are basically three orders, namely: (a) the development of it, (b) relocation of squatter communities, and (c) encourage community self-reliance, to continue his profession in situ environment Situ Pengasinan.

Situ Pengasinan situ development, will be explored in Section 4.1; while the relocation of squatter communities in this paper is not disclosed; while spurring autonomi public order among other functions performed by the socialization role it and other forms of training.

Form of training that was launched to encourage community self-reliance among others through training, and implemented as a declaration of public activities to fill a variety of economic activities around the area where Situ Pengasinan

4.2 Management and Development of conceptions Situ Pengasinan

4.2.1. In Situ Management of Integrated Management for Sustainable

Situ Pengasinan away the physical condition, based on the history and process of formation, is essentially a basic key consideration in the management approach penanganananya. It is given that the potential capacity of the environment such as soil type situ (original rock), the amount of rainfall, and vegetation cover conditions in the area of catch, a major effect on the physical-chemical properties of water, which is closely related to a potential threat to the sustainability and existence there.

Observing the process of formation there, the conception of knowl-lolaannya approach, should be based on soil and water conservation rules. Pema-situ duserasian the optimum utilization of the efforts (if-power) the preservation of lingkunganya carrying capacity, is an alternative which was considered opportunis.

Building a green area as a buffer area where Situ Pengasinan the water reservoir, in the form of urban forest recreation combination with the development of water tourism, appears to be a strategy to restore it-there presence which is now considered to be very apprehensive.

To that end, the emergence of hope as a principle and policy direction signs for the purpose of rescue, conservation and optimal utilization of community-based organizations will mendudukan strategic position on the achievements reached by the government of Depok in defending its territory as ground water recharge area. This is considering the role that it functions directly affects the downstream section; for it, Rentrada (Regional Development Strategy Plan)

Depok City, in connection with the handling situ-situ in an integrated and sustained, would at least contain the following:

a. Development of natural resources and marine environment, aimed to realize the harmony between human activities and ecosystems that support them; to the purpose of recovery of assets terokupasi Local Government by the people who now can be done in a transparent manner on the basis of public awareness can be realized. This is considering the development of environmentally sound pentingan, through increased culture and aware of the importance of harmony in life.
b. Utilization of water resources there, have the economic and social functions, managed and developed in a coordinated spatial patterns, through the use of the obvious.

Land use and land held the water in an integrated manner, to ensure the preservation of the environment to support the water tank. In order for the goals and objectives and the development of ecosystem management policy-situ tem Situ Pengasinan waters, in an integrated and sustainable can be implemented in a rational way, the main approach that should be addressed:

a. Relocation of squatter communities, at a location relatively close;
b. Recovery of the border there, either through the rehabilitation area, and development role where the function itself.
c. Management in an integrated, programmed. sustainable

4.2.2 Development aspects Situ

Application management and development of aquatic ecosystems is basically done through the preparation of the site plan as a first step in the preparation stage of detailed design concepts engineringnya. In its formulation, formulated as a picture of the allocation and placement (layout) filling the space footprint in an integrated development of the aquatic ecosystem, which includes some elements of a blend between location, physical conditions and environment in the surrounding area, which is closely related to aspects of their utilization.

Based on basic criteria situ management and development of sustainable integrated in-situ, as the previous description by taking into account the physical aspects of the carrying capacity of its territory, for it is in perencanaanya need to consider the following matters:

a. Institutional aspects; situ in-situ in Depok City area ecologically, should be viewed as an integral water tank area which is linked to one another. In this regard, the management should be planned in an integrated manner, involving several related institutions, which include government, private sector and society as a stakeholder.
b. Technical aspects: technical management and development of in-situ it should involve several disciplines, as in pelestarianya include conservation of water resources, soils and ecosystems, which is closely related to the physical condition of each region in situ,
c. Aspects of science and technology; importance of science and technology in the management and development situ-situ, because closely related to efforts to optimum either for recreation and water attractions, budidayaan fisheries, as well as utilization for the benefit of irrigation (irrigation).
d. Aspects of the source of revenue; integrated water resource management sustainable, through the rational management, in addition to increasing

revenues and ensure the surrounding communities, as well as a source of revenue which the professional level and in line with its management.

e. Finally it can be said that the successful management of the situ-situ in an integrated sustainable, as a source of revenue (PAD) and an increase in community income (PPM), based on role function (regulator of the water system, micro-climate, flora and fauna habitat, recreational vehicle, and support environmental harmony), is determined by the level of participation of stakeholders and professional handling.

4.3 Some Aspects of Situ Pengasinan community perception

In addition to occupational populations are closely related to the efforts of conservation areas where Situ Pengasinan, squatter community perception and revelation, showing the level of indifference, the threat of users who are not responsible, and caring and feel to use it, also showed association with the quality of the Situ Pengasinan it.

4.3.1. Against indifference level Situ

Based on the footage of respondents, the level of public indifference to the Situ Pengasinan situ on the basis of perceptions and representations, among others:

a. 26.4% of respondents, claimed to feel like living in the vicinity Situ Pengasinan as close to the city center, terminal and railway station.
b. 3.98% of the respondents, feel comforted that occupied residence inherited from parents.
c. 11.6% of respondents, felt ready to move because he felt himself as a contractor.
d. 9.75% of the respondents, stated that the occupied land is arable land (government land, and if more than 20 years can be taken care of property).
e. 23.7% of respondents, was not guilty of domestic waste from the settlements in there Situ Pengasinan, because the Government does not create a safe sewers.
f. 5.17% of the respondents expressed a lack of government attention in situ care is beneficial

4.3.2. The level of usefulness Situ

Perception and public statements against the benefit of the area along the river, in detail described as follows:

a. 33.72% of respondents, said almost every day, use it as a source of income.
b. 11.2% of respondents, said there Situ Pengasinan when built, will bring many benefits recreational users and tourism.
c. 9.72% of the respondents, stating traditions are endangered and need to be reactivated.

4.3.3. Understanding the Role level Situ

People's understanding of the importance of Situ Pengasinan situ conservation, in detail described as follows:

a. 13.97% of respondents, Situ Pengasinan it useful as flood control, and provide a supply of ground water in the dry season.
b. 18.45% of respondents said there is no place garbage and liquid waste; to need to be preserved.
c. 21.54% of respondents said the community should be responsible and make optimum use of the role of the function there.

4.4.4. Care level Situ

Public awareness of the Situ Pengasinan it, in detail described as follows:

a. 19.23% of respondents said, is ready to participate to participate and take care of it as a vehicle to empower natural recreational waters;
b. 78.3% of respondents, expressed readiness for the relocation of settlements, the origin is placed not too far from the initial location of residence;
c. 90.2% of respondents said although it has been moved, it will return to his profession in situ Situ Pengasinan;

4.4 Aspects of Community criteria and built it

4.4.1. Aspects of Community

Original inhabitants of the area along the river; 69.3% of the respondents came from outside of Depok, and has lived more than 6 years, 10% of respondents (Depok-native Betawi), has been living in the vicinity along the river since his ancestors. Life and profession; 34.2% of respondents said that the profession as a labor and trade; 2.3% of respondents as an employee of the Government; 8.5% of respondents worked in the private sector, 1.8% of respondents claimed to have built a rented house; education community, 26.60% said they generally claim to have attended formal education (schools), and average earnings of not less than USD 1.35 million, -/year; and 75.35% of respondents admitted to the business of producing a rented house> Rp 150.000, - / monthly contract period.

4.4.2. Aspects of Community Development

Squatter community development aspect, dirahkan remain in the profession, with the aim to increase through the following activities;

a. Increased economic empowerment training, conducted by training people to do the breeding of ornamental fish, and the like;
b. Training, for the fulfillment of the service sector, among others, includes technical training paddles, stand-catching and first aid;
c. Training boost for the sale of fishing equipment and similar services;
d. Empowerment training of ornamental plants, and productive hydroponic plants (pot system), and the like.
e. Genuine empowerment of Indigenous cultural training Depok, as one of the preservation of indigenous cultures around there Situ Pengasinan.

Conclusions and Recommendations

Situ Pengasinan it, besides acting as the water tank, has propek bright in relation to the development of natural and recreational vehicle center of economic activities. It is good to plan the development and relocation of squatter communities, appears to be an alternative that should be done. This is because the potential, position, and public awareness about Situ Pengasinan there is a noble desire the creation of authorized capital of the community and the City of Depok. To realize the various efforts to be achieved, it appears that the partnership with stakeholders, it is time for the deceived. Squatter community in order to play an active role in developing it; empowerment (training) people become urgent to be realized immediately.

References

[1] Alkadri., CS., 1999. Technology Management for Regional Development. Policy Directorate of Technological Development Area, BPPT Jakarta.

[2] Anonim, 1999. Peraturan Daerah No. 6 tahun 1999, Tentang Rencana Tata Ruang Wilayah Propinsi Daerah Khusus Ibukota Jakarta tahun 2012.

[3] Bapedalda, 1996. Study of Spatial Regions Based Criterion Slum Village / Urban Poor in Jakarta area. Cooperation Regional Environmental Impact Management Agency with Pusat Pengkajian Geografi Terapan Fakultas MIPA-Universitas Indonesia.

[4] Dinas Tata Kota Propinsi DKI Jakarta, 2001. Formulation of Development Strategy and Plan of Jakarta RTH.

[5] Gunawan dan Waryono,. T., 1987. Assessment and Prediction of Water Infiltration and Runoff Quantities in Around Campus, University of Indonesia. Forest City Development Program Kampus UI Depok.

[6] Hendrawan dan Waryono,. Tarsoen., 1993. Shallow Ground Water Quality Studies in Multiple Locations in Region Strategic Air Resapan Kotatip Depok. Forest City Development Program Kampus UI Depok.

[7] Narwanto dan Waryono,. T., 1994. The amount of water runoff prediction, Infiltration and Evapotranspiration in Around Campus, University of Indonesia. Forest City Development Program Kampus UI Depok.

[8] Soerjani., M,. 1987. Population Natural Resources and Environment in Development. University of Indonesia. Jakarta. UI Press 1087.

[9] Salim., E, 2000. Pembangunan Berwawasan Lingkungan. LP3S. Jakarta.

[10] Wolf,. JCM., 1996. Urban Geomorphology in dry lands, pp. 234-253, Clarendon Prees, Oxford.

[11] Waryono., Tarsoen, 1996. Aspek Lingkungan Fisik Kritis Perkotaan dan Upaya Pengen-daliannya (Studi kasus DKI Jakarta). Diskusi panel Program Pasca Sarjana Biologi Konservasi Universitas Indonesia.

[12] ________________, 1997. Fenomena Kutub-kutub Panas Kota dan Upaya Pengendaliannya (Studi kasus DKIJakarta).Diskusi panel Program Pasca Sarjana Biologi Konservasi Universitas Indonesia.

[13] ________________, 1998. Peranan Fungsi Jasa Bio-Eko-Hidrologis Kawasan Hijau Dalam Kancah Pembangunan Wilayah Perkotaan. Diskusi panel Program Pasca Sarjana Biologi Konservasi Universitas Indonesia.

[14]________________, 2012. Aspek Pengelolaan Wilayah Resapan Berbasis Ramah Lingkungan. Warta Pembangunan Kota Depok. Edisi-1 tahun 2002

CONFERENCE SPONSORS:

werder
ROOFING-SYSTEMS

GRESIK PORTLAND CEMENT
INDONESIA
SEMEN GRESIK
KOKOH TAK TERTANDINGI!

CITRA GADING GROUP

mandiri
syariah

UNIVERSITAS ISLAM INDONESIA
الجامعة الإسلامية الإندونيسية
DPPM UII

PT. PUSER BUMI

mandiri

BANK BUKOPIN

ISBN: 978-602-98397-1-5

Faculty of Civil Engineering and Planning
Universitas Islam Indonesia

In collaboration with: