International Conference on Engineering and Science for Research and Development (ICESReD)

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PROCEEDING

ICESReD 2016
BANDA ACEH
INTERNATIONAL CONFERENCE ON ENGINEERING
AND SCIENCE FOR RESEARCH AND DEVELOPMENT

Theme

"Enhancing the **quality** of science and engineering through **sustainable research** and development to face **ASEAN** Economic Community challenges."

BANDA ACEH - INDONESIA
October 25-26, 2016

Organized by:

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Conference in Brief

Faculty of Engineering Syiah Kuala University was founded in 1963. The existence Engineering Faculty in Syiah Kuala University was driven by the needs of skilled manpower in the field of engineering to fill the human resource development in the province of Aceh. Then, with the discovery of natural gas which is abundant in the area of North Aceh district. And now the Faculty of Engineering has been managing 11 study programs consist of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, Architecture, Geophysics, Geology, Industrial Engineering, Mining Engineering, Urban and Regional Planning, and Computer Engineering. Engineering Faculty of Syiah Kuala University has vision to be the leading education and research institution that is capable to compete in national and global levels.

As its founding background and vision, the FT Unsyiah is required to play an important role in ASEAN Economic Community Trade Area, particularly to produce qualified graduates who highly honour moral and ethical values. The International Conference on Engineering and Science for Research and Development (ICESReD) is a part of various efforts to achieve this goal. This conference will be carried out biannually by Faculty of Engineering Syiah Kuala University.

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Welcome Speech from the Dean

Assalammualaikum Wa Rahmatullahi Wa Barakatuh,

In the Name of Allah, the Most Beneficent, the Most Merciful

May the peace, the mercy, and the blessings of Allah be upon us.

Distinguished Participants, Honorable Speakers, Ladies and Gentlemen,

On behalf of Faculty Engineering, Syiah Kuala University, I would like to welcome all of you to the first International Conference on Engineering and Science for Research and Development in conjunction with Annual Meeting of Cooperation Agency–Public Universities (BKS PTN) West Region, Engineering Section.

The Prophet Muhammad (peace be upon him) said *'Acquire knowledge and impart it to the people.'* (Al–Tirmidhi). The quest for knowledge has been from the beginning of time but knowledge only becomes valuable when it is disseminated and applied to benefit humankind. I sincerely hope this conference is inspiring and also the one to be anticipated in the next years to come. It is pleasing to note that the agenda of this conference covers a wide range of interesting topics related to engineering and sciences. Enhancing the quality of science and engineering through sustainable research and development to face ASEAN Economic Community challenges is theme of this conference and it is an issue that has been implemented since 1st January 2016. Therefore, the focal drive of this conference is to exchange ideas, and by participating in this exchange, it is hoped that all parties who may benefit from the conference can apply it in managing activities in their areas.

It is hoped that ICESRed 2016 will be a platform to gather and disseminate the latest knowledge in engineering, architecture and urban planning. Academicians, Scientist, Researchers and practitioners of engineering, architecture and urban planning will be able to share and discuss new findings and applications of engineering and architecture and design. It is envisaged that the intellectual discourse will result in future collaborations between universities, research institutions and industry both locally and internationally.

Last but not the least, my deepest gratitude goes to the Organizing Committee, institutions, and companies who have directly and indirectly supported the well–running of this conference. The committee has organized a vibrant scientific program and is working hard to present highly respected and internationally well–known speakers to lead it. Although we have attempted to professionally all the services for the implementation of this conference, on behalf of the Faculty of Engineering, Syiah Kuala University, please accept our sincere apologies should there be inconveniences that occur before, during, or after the event.

I wish you a very productive conference with exciting and encouraging discussions and exchange of knowledge so that together we can anticipate a future of groundbreaking sciences, technologies and education. May God bless us all with good health to make this event a successful and enjoyable one!

Thank you.

Dr. Ir. Mirza Irwansyah, MBA., MLA
Dean of Faculty Engineering, Syiah Kuala University

Message from the Chairman

Assalamualaikum Wr. Wb.

Dear Ladies and Gentleman,

First, I would take the privilege to warmly welcome our Keynote Speaker, Presenters, and Participants who have come from all over Indonesia and abroad to our conference today. We are indeed honored to have you here with us.

The International Conference of Engineering and Science for Research and Development (ICESReD) is a forum for shearing idea and scientific discussion of research development on engineering and science fields. This conference is the first international conference on engineering and science for research and development organized Faculty of Engineering Syiah Kuala University and will be carried out regularly every two years. The theme of this conference is Enhancing the quality of science and engineering through sustainable research and development to face ASEAN Economic Community challenges.

Furthermore, in this year The ICESReD is organized in conjunction with Annual Meeting of West Region Public University Cooperation (BKS–PTN Wilayah Barat) in Engineering Field. Accordingly, about 60 papers will be presented in this event, including those in the fields of Engineering and Sciences, with very interest topic such as transportation, innovative design, renewable energy, urban planning, etc. Therefore, I would like to thank you for your valuable contributions to this conference.

I am very happy to inform that the committee is fortunate to have keynote Prof. Dr. Bambang Brojonegoro, the Minister of National Development Planning/Chair of National Development Planning, who will explain to us the opportunity and challenge of higher education, especially Engineering and Science filed in ASEAN Economic Community era which begun in December 15, 2015. And we also have three invited speakers from Austria, Japan and Malaysia, who have supported us from the very beginning with their capabilities to personally come and meet all of you here at the conference.

At this juncture, I would like to take the opportunity to thank everyone who has made this event happen. It is a great pleasure for me to be a part of the organizing committee to coordinate such a remarkable conference. It does not only function to bring us to organize the conference, but it also bridge us to further networking in sharing our idea and research experiences that we build from this conference.

Finally, I hope that all participants will have memorable moments through this conference, since we also will guide all you to sightseeing visit monument created by tsunami several years ago and another historical place around Banda Aceh and Sabang, Weh Island. So, we hope that you enjoy your stay in Banda Aceh.

Warm regards,

Dr. Edi Munawar
Chairman of Committee

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The Contribution of (European) Universities to Research and Innovation

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Abstract

The European Union has set itself the target to become the globally leading region in science and innovation until 2020. Thereto the national expenses for research and development should be increased to 3% of the Gross Domestic Product GDP, whereby a significant share should be invested into universities. So far only a few member states comply with this goal. In average only slightly above 2% of EU´s GDP has been spent on research in 2013. In the frame of the presentation the status and role of universities in the European Union with regards to society´s innovation is analyzed. Besides the input (public funding) into universities, the outputs in terms of graduates and knowledge generation are evaluated. The results of this analysis clearly indicate that countries spending more money on their universities do not only generate more outcome in terms of quantity (e.g., number of graduates or number of publications in peer–reviewed scientific journals), but also in term of quality (number of publications top cited or patents utilized by industry). Furthermore, it is shown that in the long run expenses on fundamental (basic) research pay off more when it comes to innovation (e.g. number of patents) in comparison to applied research. This finding is in clear contradiction to the research funding policy of many EU countries, including Austria. Thus, not only the amount of money spent on research determines the output of universities and the degree of innovation of a society, a country or a region like the European Union, but also where it is spent on. Therefore, a well balance between basic and applied research funds is recommended from the author´s perspective.

Keywords : research and innovation, graduate and knowledge, publication.

5G Ultra–dense Femtocell Networks Access: Issues and Challenges

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Abstract

Due to the popularity of data–hungry devices, like smart phones and tablets, the mobile operators towards the Fifth Generation (5G) are driven not only to increase their network capacity but also to boost the life of such battery operated wireless smart devices. One of the most feasible solutions to cope with this is the evolution from traditional macro–cell deployments to network densification. Small cells are seen as the best match for network densification, as they can be opportunistically deployed in the highly irregular way in hot spots. In consequence, the deployment of dense femtocell networks (DFNs) can be seen as an efficient spectrum utilization using new spectrum bands but subjected to inter–cell interference coordination particularly to cell–edge macro–users. Moreover, the decentralized architecture of the femtocell networks and the uncertainty in terms of the number and location of femtocell base stations increases the complexity of power control technique. This presentation will discuss inter–femtocell interference scenarios in a typical femtocell cluster together with an overview of some of the available interference management techniques. An interference mitigation schemes in indoor LTE–A femtocell network using a new simple fractional path–loss compensation power control technique utilizing local HeNBs information while maintaining QoS been proposed. Since densification of femtocells in an uncoordinated manner can lead to severe inter–femtocell interference, especially when they share the same channel and operate in Closed Subscriber Group (CSG) mode, a new Semi–virtual Clustering Scheme (SVCS) has been investigated. This scheme exploits users' status to categorize femtocells into the victim, aggressor or neutral and each victim femtocell is then partitioned into two virtual cells. Moreover, the scheme adapts dynamically to the status of each femtocell in the cluster, being either a victim or a safe femtocell and smartly estimates the proper partitioning (time or frequency) of resources within the defined clusters.

Keywords : femtocell, interference, 5G, power control, spectrum utilization.

Effect of Secondary Chamber on Gas Yields by Pre–vacuum ChamberPyrolysis of Rubber Wood –From Science to Engineering and from Engineering to Technology

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Abstract

In this paper, relation between science, engineering, and technology is first discussed. Many industrial developments have been achieved from scientific findings, engineering application, and development of mass production system. However, scientific findings do not always come first. Engineering or experiences developed some technologies without science findings. For one example, wood pyrolysis is explained. Wood or coal pyrolysis is a technology developed in early 1800s for iron industry. .However, we do not completely understand chemical reactions involved in wood pyrolysis. Recently, several advanced pyrolysis technologies have been developed to mitigate global warming. Global warming awareness criticizes further usage of fossil fuels and insists promotion of renewable energy usage. Additionally, many people in rural areas of developing countries cannot access electricity. To solve this sort of energy crisis including global warming, current authors developed a proto–type of a pyrolysis plant equipped with a pre–vacuum chamber, which can be used to produce combustible gases for an engine generator in rural areas where people cannot access electricity. The plant is simple and easily maintained in consideration of special conditions that a rural area can receive very few maintenance service, technical assistance, and supply of spare parts. Due to piloting a new idea, gas yield from the plant was not optimized yet, around 20 wt% of feedstock. This research work aims to examine possibility of gas yield enhancement using a simple technique of secondary tar cracking. Two tar cracking methods are examined. In the homogeneous tar cracking, pyrolysis gases must be heated up to 650 to 700°C and in the heterogeneous tar cracking, wood char is used as catalysis, because wood char is byproduct of pyrolysis. It is concluded that the homogeneous tar cracking is quite unlikely in the secondary chamber, while heterogeneous tar cracking using wood char can produce 30 wt% of gas yield.

Keywords: science revolution, industrial revolution, pyrolysis, pre–vacuum chamber, secondary chamber, secondary tar cracking

Introduction

It is well known that Science is academic field to pursue truth and to try to find out a new law or a new phenomenon in physics, chemistry, biology, and so on, and then, Engineering tries to design concepts of products and systems using and applying scientific finds for practical ends based on human demands and desires while Technology materializes concepts, systems, processes designed by Engineering as products.

First, we consider chronological development of modern science and engineering or technology. There were scientific revolution and industrial revolution. As shown in Figure 1, scientific revolution started 1508 and ended 1830. Nicolaus Copernicus advocated that sun is located at the center of cosmos and earth rotates around the sun. Then, R. Boyle, I. Newton, R. Hooke, D. Bernouli, L. Euler, C. Navier and S. Carnot established foundation of current thermodynamics, hydrodynamics, beam theory, solid mechanics, fluid

dynamics. Now a day, we learn those subjects as engineering science in university. It should be noted that science has been established since 1700s.

On the other hand, how did engineering or technology take development path? We should obtain an answer in relation with the science revolution as shown in Figure 2. Industrial revolution broke out since 1760s in Britain, and it was around 200 years later the scientific revolution. In industrial revolution, several new technologies were established or invented. They are:

1. A spinning machine using flying shuttle, John Kay.
2. A locomotive steam engine, James Watt. Double action.
3. Iron smelter using coke, Clement Clarke.

- 1508 Nicolaus Copernicus
  - » Heliocentrism (Sun centered cosmos)
- 1662 Robert Boy1e
  - » Thermodynamics, PV= cont
- 1665 Isaac Newton
  - » Law of motion, F=ma, Gravitation F=mg
- 1678 Robert Hooke
  - » Strength of materials, Hooke's law, x=F/k
- 1725 Daniel Bernoulli
  - » Hydrodynamics, Beam theory (Jacob)
- 1744 Leonard Euler-Daniel Bernoulli
  - » Strength of Materials, Beam theory
- 1822 Claude Navier
  - » Fluid Dynamics
- 1829 Sadi Carnot
  - » Thermodynamics, Carnot engine

Figure 1. Scientific revolution (Chronological Table)

Figure 2.Scientific revolution to industrial revolution

We look at steam engine and thermodynamics. Theoretical background of steam engine, thermodynamics was established by Sadi Carnot in 1829, while a steam engine was invented by James Watt in 1781. This means that engineering, or technology was developed without science. There are many such examples, for instance, internal combustion engine, herbal medicines, gears, pyrolysis technology, and so on.

United Nations Framework on Climate Change, 21st Conference of Parties (COP21) declared the statement that the global common and long term target is to suppress average temperature raise under 2 degree, even 1.5 degree from the average temperature before industrial revolution era (UNFCC/CP/2015/L.9, 2015). All the participant countries must definitely declare their concrete targets. They must make serious efforts to reduce carbon dioxide emission resulting global warming. On the other hand, International Energy Agency (IEA) reports that emission amount of carbon dioxide gas in 2015 was 32.1 gigaton, the same as that in 2014, even though three percent of economic growth in the world was achieved in 2015 and a main contributor to the suppression of carbon dioxide gas emission is considered utilization of renewable energy

for new electric power plants (Press Release, IEA, 2016). In developing countries, supply of electricity does not match with the demand. They still use fossil fuel like coal for power generation plants, for instance China and Indonesia. The study by IAE also indicated that more than one billion people in the world cannot access electricity (International Energy Agency, 2015). Such people live in rural areas and are not usually covered by grids of power supply.

Off grid of power supply is a feasible way to enhance electrification in the rural areas. There are several technologies for the off–grid power supply, such as micro–hydraulic power, solar photovoltaic cell, and biomass pyrolysis or gasification. They have, however, advantages and substantial disadvantages. For example, the micro–hydraulic power and solar photovoltaic cell panels need expressive initial investment cost, and biomass gasification needs briskets of fuel and feedstock biomass. For instance, a micro–hydraulic power plant costs around 30,000 US$ for 2 kW, and solar photovoltaic cell costs 10,000 US$ for 2 kW. Rural area people, who cannot have enough money for initial investment, and frequent maintenance service, need low cost and less maintenance equipment for power generation. Pyrolysis is rather old technique, but rather simple and of less maintenance.

Considering economy of rural area people, the current authors developed a proto–type of plant to produce pyrolysis gas that can be used for fuel of an engine generator and reported its basic performance (Homma, *et al.*, 2013, Homma, *et al.*, 2014). Gas production of this plant was less than 30 % of feedstock. Usually, plant performance degrades gradually as usage period. Slow pyrolysis process undergoing in this plant produces gas yield as much as 10% to 35% of feedstock (Mohammad, et al 2012). Gas yield from wood pyrolysis increases when pyrolysis temperature increases from 500°C to 900°C (Fagbemi, *et al.*, 2001). The gas yield was obtained as much as 50 wt% of the feedstock at 900°C. On the other hand, other researchers obtained gas yield as much as more than 65 wt% of the feedstock at pyrolysis reactor temperature beyond 800°C (Dufour, *et al.*, 2009). The increase of gas yield is considered as a result from secondary tar cracking.

Several researches on secondary tar cracking in wood pyrolysis have been carried out (Rath and Staudinger, 2001, Morf, *et al.*, 2002, Milne, *et al.*, 1998, Vreugdenhil and Zwart, 2009, Elfasakhany, 2012, Nordreen, *et al.*, 2005, Laosiripojana, *et al.*, 2014, James, *et al.*, 2014, Huang, *et al.*, 2011, Mihalek, *et al.*, 2011, Klinghotter, 2013). There are two types of secondary tar cracking, namely homogeneous and heterogeneous cracking. Only temperature takes part in the homogeneous tar cracking, while temperature and catalyst take part in the heterogeneous tar cracking.

In homogeneous tar cracking, secondary tar cracking is initiated at temperature of more than 600°C, and the cracking reaction is promoted with the temperature rise (Milne, *et al.*, 1998). Then, the primary tar from wood pyrolysis is completely converted to secondary tar, light molecular tar and gases. Fast pyrolysis utilizes homogeneous tar cracking to produce high volume of gases.

On the other hand, in heterogeneous tar cracking, not only temperature, but also catalyst takes part in tar cracking. The cracking reaction takes place near catalyst and it is called heterogeneous one in contrast to homogeneous one, which takes place in whole reactor. Many researches on catalyst effectiveness were carried out for Fe based catalyst (Nordreen, *et al.*, 2005); Ni based catalyst (Laosiripojana, *et al.*, 2014, James, *et al.*, 2014), Pd (Huang, *et al.*, 2011), zeolite (Mihalek, *et al.*, 2011), and char (Klinghotter, 2013). The main purpose of catalyst is promotion of tar cracking reaction to remove tar from syngas completely. Another effect of catalyst is to down temperature for tar cracking. In homogeneous tar cracking (Milne T.A., et al 1998), the primary tar cracking was initiated above 600°C. If palladium was used for tar cracking catalyst (Huang, *et al.*, 2011), primary tar conversion reached around 50 % at 500°C of catalyst temperature, 80 % at 600°C, and 92% at 700°C. In this experiment, syngas was heated at 300°C. As mentioned in the research (Klinghotter, 2013), char can be surely used for a catalyst of tar cracking, and it is cheaper than other commercial catalysts. In addition, catalytic temperature of char is around 100°C lower than that of metallic catalysts, such as Platinum, Pt and Alumina, Al_2O_3.

This work aims at gas yield enhancement in the proto–type plant of pre–vacuum chamber pyrolysis, which has been developed to supply electricity to people living in isolated rural areas. Therefore, feasibility on two ways of secondary tar cracking, homogeneous one and catalytic one is examined. Catalyst to be used is char, because char is cheap and continuously produced by pyrolysis of wood, namely self–supplied. In the previous experiment (Homma, *et al.*, 2013), temperature at top of pre–vacuum chamber where small rubber wood pieces undergo thermochemical reaction, was around 400°C. In this work, a secondary chamber is designed and constructed for secondary tar cracking after the pre–vacuum chamber and pyrolysis gas including tar vapor is heated more than 600 ºC. In the proto–type plant, a wood stove is used for a furnace. Precise temperature control in the secondary chamber is substantially impossible. In such situation, this work attempts secondary tar cracking under less controlled temperature, namely large fluctuation of temperature, and effectiveness of the secondary chamber is discussed.

Experimental Procedure for Enhancement of Gas Yield

To increase combustible gas yield, a secondary tar cracking reaction is introduced to the proto–type plant equipped with a pre–vacuum chamber for rubber wood pyrolysis, which has been developed for self–supply of electricity to rural people (Homma, *et al.*, 2013). In this work, the secondary tar cracking undergoes in the secondary chamber heated by exhaust gas from the furnace.

Apparatus

A secondary chamber is designed and constructed to heat pyrolysis gas from the pre–vacuum chamber up to more than 600°C and placed between the pre–vacuum chamber and the tar trap. A schematic diagram of the experimental apparatus is shown in Figure 3. Except the secondary chamber, the apparatus is the same as one used in the previous experiment (Homma, *et al.*, 2013). Pyrolysis gas flow is also indicated by arrows in the figure.
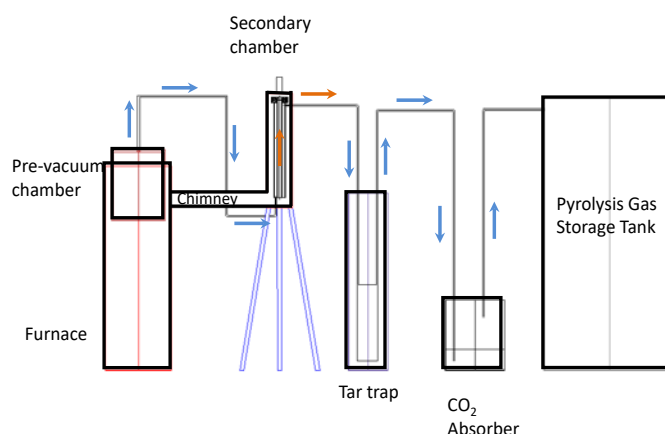
Figure 3. Schematic diagram of experimental apparatus

Rubber wood pieces are decomposed to pyrolysis gas including tar vapor in the pre–vacuum chamber and the pyrolysis gas flows out there and enter a secondary chamber from the bottom. The secondary chamber consists of a steel triple tube. The outermost tube is made of a steel pipe, 195 mm in outer diameter, 5mm in wall thickness, and 845 mm in height. The middle tube is made of a stainless pipe of JIS 10k–80A. The center tube is also made of a stainless pipe, 40mm in outer diameter, and 2 mm in wall thickness. The exhaust gas flows in the center tube and the outermost tube, and the pyrolysis gas flows in the middle tube. The center and outermost tubes are heated by exhaust gas, namely combustion gas of fuel wood pieces. Temperature of exhaust gas is monitored by a thermo–couple at a position 50 mm before the secondary chamber inlet. The end of the thermo–couple is positioned at the center of the chimney. Char is used for catalyst of secondary tar cracking. When the catalyst is used in experiments, char is put in the basket and placed at the middle height in the middle tube. Char is broken into small pieces, around 10 mm cubic. Total mass of the char is 80 g. Outermost surface of the secondary chamber is covered with thermal insulating band to prevent exhaust gas temperature from drop.

Table 1 Experimental Conditions

Experimental Description	No Tar Cracking	Homogeneous Tar Cracking	Heterogeneous Tar Cracking
Feedstock (kg)	1.0	1.0	1.0
Char (g)	0.0	0.0	40.0
Pressure (MPa)	0.3	0.3	0.3

Feedstock and char of catalyst

Three kinds of experiments are carried out to examine effectiveness of the secondary chamber for homogeneous and heterogeneous, catalytic, tar cracking. The experimental conditions are summarized in Table 1. In experiment of no tar cracking, the secondary chamber is removed from the experimental apparatus to obtain the reference data. Feedstock is rubber wood pieces that are wood wastes supplied by a furniture company in Medan Indonesia. To keep humidity of feedstock constant, wood pieces are placed in a dry box having humidity absorbent, calcium chloride for one week before experiment. Two kg of wood pieces are kept in the dry box having 270g of calcium chloride. Calcium chloride can absorb water twice as

heavy as weight of calcium chloride. The wood pieces are dried to around 10 % of humidity. Tar is recovered as liquid matter in the tar trap. If the feedstock contains much humidity, liquid matter, namely tar is recovered reflecting the humidity. Therefore, humidity of feedstock must be kept constant as accurately as possible to discuss experimental results reasonably.

Feedstock loaded in the pre–vacuum chamber is 1 kg for all the experimental conditions as shown in Table 1. In the experiment for heterogeneous tar cracking, 80g of char is used for catalyst, which is produced by the previous experiment and to which any special treatment is not applied.

Secondary tar cracking

When feedstock undergoes pyrolysis process, gases including tar vapor are emitted from the feedstock and fill the pre–vacuum chamber and the secondary chamber that are initially evacuated to vacuum. As the pyrolysis process progresses and gases fill the chambers, pressure in the chambers increases. Because valve is fit to piping before the tar trap and shut, gas flow is stationary in the chambers until the valve is opened. The valve is opened when the pressure reaches 0.3 MPa. Therefore, pyrolysis gases including tar vapor are heated up in the secondary chamber. Although precise temperature control is almost impossible, a conventional wood stove is used for a furnace, because the stove is one of the most popular and suitable furnaces in rural area where maintenance service is not frequently available. Nevertheless, possibility of gas yield enhancement by means of secondary tar cracking should be investigated for rural area people, who cannot access electricity. One key skill is to keep exhaust gas up to 700°C. Several feeding ways of fuel wood pieces with the stove were tried and the best way is found. It is to keep solid burning of wood as long as possible. However, when a stove charge port is opened at every feeding time, the exhaust gas temperature is down.

When the pressure reaches 0.3 MPa, the valve is opened and valve opening is adjusted to keep the pressure constant, 0.3 MPa. This operation is taken so that gas yield including tar vapor stay in the secondary chamber as long as possible.

Result and Discussion

Temperatures at bottom of pre–vacuum chamber and exhaust gas

During experiments, temperatures at bottom of pre–vacuum chamber and exhaust gas are monitored using sheathe type of thermos–couples. The measured results are plotted as a function of time in Figure 4. Experiments were carried out three times every condition. In the figure, average temperature is plotted. As mentioned above, averaged temperature of exhaust gas is still fluctuated with time. Nevertheless, temperature at the pre–vacuum chamber bottom is rather smooth as compared with exhaust gas temperature. In Figure 4(a), temperature–time histories at the pre–vacuum chamber are plotted for three experimental conditions, namely, reference experiment without a secondary chamber, experiment of homogeneous tar cracking with a secondary chamber, and experiment of heterogeneous tar cracking with a secondary chamber equipped with a char box filled with 80 g of char. No significant difference between them is seen. The temperature smoothly increases with time to 20 minutes. In experiment 1 and 2, temperature fluctuates and increases with time. The fluctuation may result from pyrolysis progress in the pre–vacuum chamber.

Primary decomposition of lignin and xylan (hemicellulose) starts at 200°C, and 230°C, respectively, while primary cellulose decomposition takes place in a narrow temperature range between 330°C and 400°C (Giudiciammi, *et al.*, 2013). Pyrolysis process is well known as an endothermal reaction. Therefore, pyrolysis reaction causes temperature drop. The first temperature fluctuation at 150°C to 200°C may correspond to hemicellulose and lignin decomposition. The pyrolysis completion is defined as the condition where the pressure in the pre–vacuum chamber does not lift beyond 0.3 MPa for more than 5 minutes. According to this definition, for all the experimental conditions, pyrolysis of 1kg rubber wood pieces terminates in 60 to 70 minutes. It should be noted that temperature at bottom of pre–vacuum chamber has a similar time history for three experimental conditions. On the other hand, temperature of exhaust gas from a wood stove steeply increase to 300°C and then moderately increases to 500°C taking 20 to 30 minutes. In experiments of homogeneous tar cracking and heterogeneous tar cracking, exhaust gas temperature reaches 600°C after 40 minutes and then, keep more than 600°C for 10 to 20 minutes. It can be expected that secondary tar cracking surely takes place in the secondary chamber, if pyrolysis gases are effectively heated by this hot exhaust gas. Large fluctuation in temperature of exhaust gas results from cold air suction into the wood stove at the time of fuel feeding.
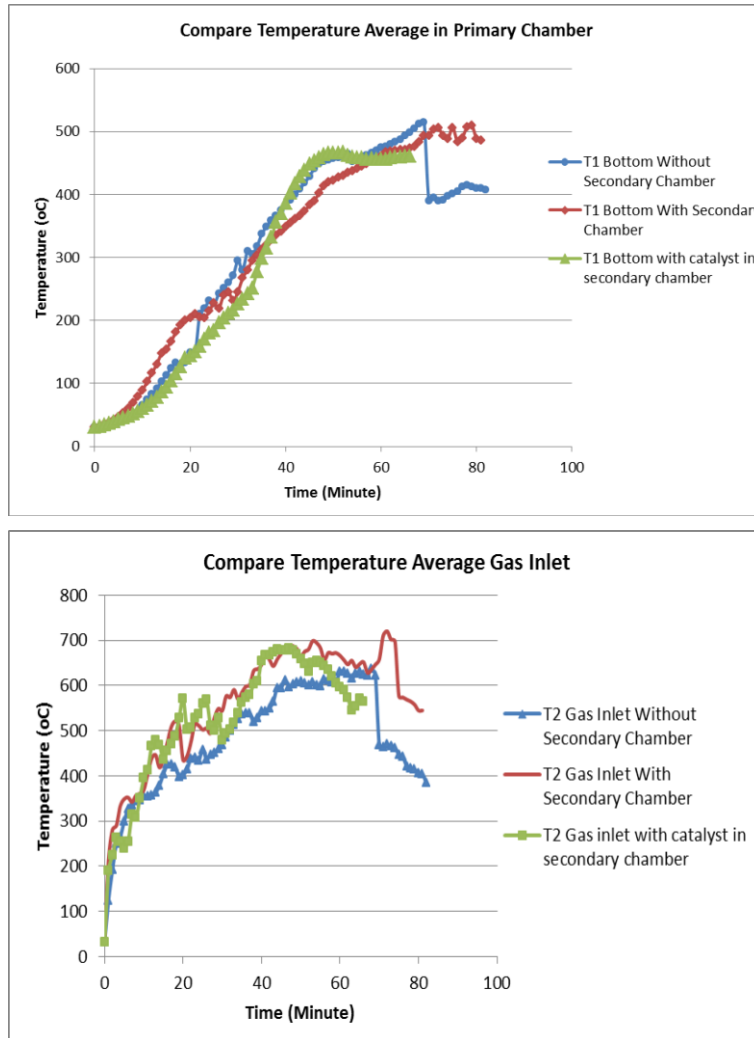
Figure 4. Temperature–time histories for three experimental conditions. Temperature–time histories before inlet of secondary (top), and temperature–time histories at bottom of pre–vacuum chamber (bottom).
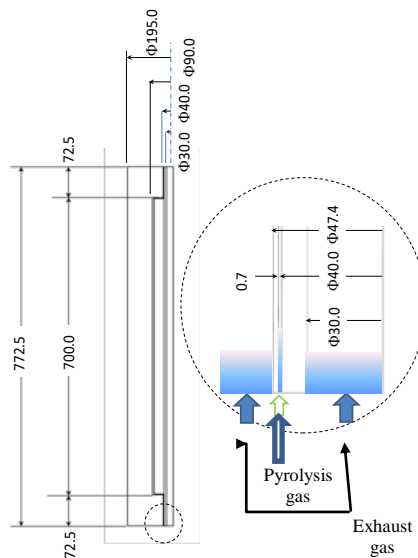
Figure 5. Numerical analysis model of secondary chamber

Measurement of pyrolysis gas temperature in the secondary chamber is technically difficult. The secondary chamber is placed in a large chimney and is initially evacuated into vacuum, and then, the secondary chamber is taken out of the chimney after experiment for char charging. If a sheathe type of thermo–couple is used to monitor pyrolysis gas temperature in the secondary chamber, to keep sealing for vacuum and to disassemble the secondary chamber fitted with the thermocouple requires a lot of patience and skill. Therefore, to avoid such patience and experimental skill, numerical analysis is used to monitor the pyrolysis gas temperature in the secondary chamber.

Numerical analysis on temperature of pyrolysis gas in secondary chamber

Using temperature data measured by experiments, heat and mass analysis is carried out using ANSYS Fluent ver.13. A numerical model is shown in Figure 5. The numerical model simulates an actual secondary chamber as exactly as possible, while inlets and outlets of the secondary chamber for exhaust gas and pyrolysis gas are modified to axi–symmetric configuration for simple numerical calculation. As shown in Figure 5, pyrolysis gases and exhaust gas inlets are shown by arrows. Those gases flow into the secondary chamber from the bottom through cylindrical inlets for an axi–symmetric problem.

This simplification for the axi–symmetry will not bring about significant error in numerical result. The exhaust gas temperature at the inlet is specified by the result measured in the experiment shown in Figure 4(b). The pyrolysis gas temperature at the inlet is given by the result measured in the previous experiment (Nordreen, *et al.*, 2005). Outermost surface of the secondary chamber is wrapped by rock wool tape for thermal insulation. Numerical analysis treats the thermal insulation as follows:

(1) Perfect thermal insulation. Namely, the outermost surface of the secondary chamber is thermally insulated.

(2) Insulation performance of the rock wool tape is not perfect, thus, heat is released from the outer surface. The heat flux density $\dot{q}$ is defined as:

$$\dot{q} = K\left(T_{of} - T_{air}\right) \tag{1}$$

$$\frac{1}{K} = \frac{\delta_{is}}{\lambda} + \frac{1}{h_{air}} = \frac{0.005}{0.04} + \frac{1}{5} = 0.325 \tag{2}$$

where K is heat transmission coefficient, δ_{is} is insulation tape thickness, λ is thermal conduction coefficient, and h_{air} is heat transfer coefficient of air.

Temperature distribution inside the secondary chamber is shown for the time of 1552 sec in Figure 6. The exhaust gas and the pyrolysis gas enter the inlets located at the left hand side and exit the outlets at the right hand side in the figure. In Figure 6 (a), the result is shown for case where the outermost wall is thermally insulated, and in Figure 6 (b), the result is shown for case where heat flux is allowed from the outermost wall to ambient air according to Equations (1) and (2). It is seen from the figure that the temperature of the pyrolysis gas is lower in case of heat flux allowance than one in case of thermal insulation. Heat flux allowed from the outermost wall can be considered more realistic as compared with complete thermal insulation. Therefore, pyrolysis gas temperature in case of heat flux allowance is examined in detail. In Figure 7, pyrolysis gas temperatures near inner wall and at the center of the middle tube, pyrolysis gas pass are plotted as a function of time. In the figure, exhaust gas temperature is also plotted for the reference. The exhaust gas temperature rises to 430°C (700 K) steeply in first 10 minutes, while pyrolysis gas is not heated up remarkably and the temperature of the pyrolysis gas remains at low level. Pyrolysis gas is heated gradually in the pre–vacuum chamber and is led to the secondary chamber. The exhaust gas is also heated up to 660°C (930 K) at time of 30 minutes.
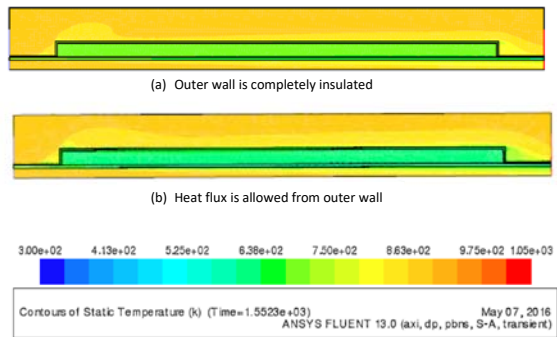
Figure 6. Comparison of temperature distributions for different boundary conditions at the outermost.
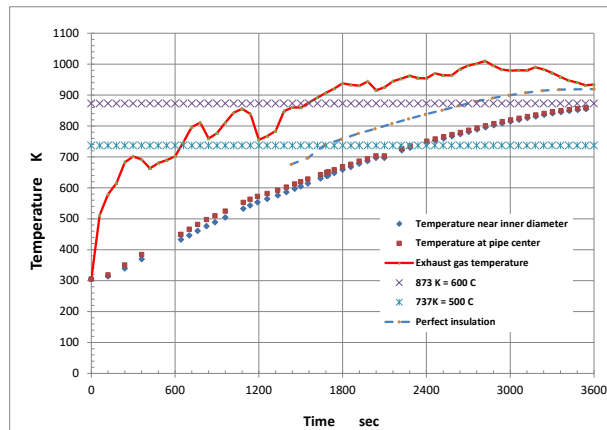
Figure 7. Temperature–time history of the pyrolysis gas in the secondary chamber.

Pressure of the secondary chamber reaches 0.3 MPa at 27 to 30 minutes. Then, the pressure is kept 0.3 MPa by adjusting open angle of the valve until the end of the experiment. Then, the pyrolysis gas flows out from the secondary chamber to the tar trap. When the valve opens and the pyrolysis gas flows out from the secondary chamber, the pyrolysis gas temperature reaches 670 K (400°C) and rises up to 870 K (600°C) at the end of the experiment, 3600 sec. There is no significant difference between temperatures of the pyrolysis gas at two positions, and it is in range of 5 and 10 K. The pyrolysis gas temperature smoothly rises over the experimental period, while the exhaust gas temperature fluctuates remarkably.

In Figure 7, for reference, pyrolysis gas temperature in case of perfect insulation of outermost wall is also shown with a dotted line. Pyrolysis gas temperature is around 100 K higher in the perfect insulation case than in case of heat flux allowance.

Pyrolysis yields and compositions of gas yield

For three experimental conditions, pyrolysis yields are measured after experiments and measured results are summarized in Table 2. Experiment without a secondary chamber produced tar of 0.44 kg, char of 0.29 kg and gas of 0.23 kg as shown in the first row. Results of experiment aiming at homogeneous tar cracking are shown in the second row. Comparison between the two results indicates no significant difference between them and suggests that there is no clear evidence of secondary tar cracking.

Table 2 Pyrolysis yields obtained by three experimental.

Experiments	Feedstock	Tar		Char		Gas	
	kg	kg	%	kg	%	kg	%
Without secondary chamber	0.98	0.44	45.5	0.29	30.4	0.23	24.1
With secondary chamber	0.97	0.41	42.3	0.30	31.7	0.25	26.0
With secondary chamber + char	0.96	0.37	38.9	0.30	31.4	0.28	29.7

Table 3 Gas component wt %.

Gas component	Without char	With char
H	26.4	28.5
CH4	10.7	18.4
CO	20	21.4
CO2	43	31.6

According to numerical analysis result on temperature–time history in the secondary chamber, if the wall surface of the secondary chamber is perfectly insulated thermally to the ambient air, pyrolysis gas is heated up to more than 900 K (627°C). Therefore, the secondary tar cracking likely takes place. However, the pyrolysis yields provide negative evidence for the homogeneous secondary tar cracking. On the other hand, if heat flux from the outermost wall of the secondary chamber is allowed instead of the perfect thermal insulation, the pyrolysis gas temperature can reach 600°C at the end of the experiment. It is quite unlikely that homogeneous secondary tar cracking takes place in the secondary chamber.When 80g of char was inserted in the secondary chamber, tar yield was decreased from 0.44 g to 0.37 g. This may suggest that secondary tar cracking took place in the secondary chamber. It is likely that char can function as a catalyst for secondary tar cracking and the secondary tar cracking takes place under temperature of lower than 600°C, like 500°C. Analysis results of pyrolysis gas component by gas chromatography are shown in Table 3. The table compares results for pyrolysis gas produced by the secondary chamber without catalyst, char and pyrolysis gas produced by the secondary chamber with catalyst, char. Existence of char increases H, CH_4, CO components and decreases CO_2 component. As mentioned by the previous researcher (Klinghotter N., 2013), char surely functions as a catalyst, and cracking temperature of primary tar can be downed by around 100°C. The results shown in Tables 2 and 3 provide evidences of secondary tar cracking. However, amount of secondary tar cracking is not large as expected.

Conclusions

In order to enhance efficiency of a simple and less maintained proto–type plant of biomass pyrolysis that can be used for a family living in rural areas where they cannot access electricity, concept of secondary tar cracking is introduced into the proto–type plant. A secondary chamber for the secondary tar cracking is designed and installed with the proto–type plant. The secondary chamber aims to heat up pyrolysis gas to

temperature for the secondary tar cracking with and without a catalyst, char. The conclusions obtained from the experiments and numerical analysis of heat and mass transfer are as follows:

1. Pyrolysis gas produced in pre–vacuum chamber is surely heated up to the temperature for the homogeneous tar cracking in the secondary chamber. However, tar yield does not decrease significantly as compared with the reference result without the secondary chamber.

2. Numerical analysis of heat and mass transfer in the secondary chamber shows that the pyrolysis gas is heated up to more than 600°C, under which the secondary tar cracking can take place. It suggests that the secondary tar cracking may take place at higher temperature than one reached by the experiment.

3. The secondary tar cracking surely take place in the secondary chamber when 80g of char is used for a catalyst. It can be understood that the secondary tar cracking take place at low temperature by existence of catalyst, char.

4. Char surely works as a catalyst for secondary tar cracking, but amount of cracked tar is not so large as expected. To obtain higher performance of the proto–type plat, further investigation is necessary.

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The Tensile Behaviour of Concrete with Natural Fiber from Sugar Palm Tree

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Abstract

The ductility of concrete matrix which is strong in term of compressive but weak in term of tensile and flexure could be increased by fiber addition.This research aims to investigate the influence of sugar palm fiber addition toward the tensile strength of concrete. The natural fiber from the sugar palm tree was spread randomly in normal concrete to increase its tensile strength. The splitting tensile strength test was done in accordance with ASTM C496–90. Four different percentages (2.5%, 5%, 7.5%, 10%) of sugar palm fiber were added to normal concrete to discover the tensile behaviour of this type of concrete. The result shows, 10% sugar palm fiber addition increases the tensile strength of concrete up to24% at the age of 28 days, and the increasing rate is getting low at the age of 4 months (7.5%).

Keywords : natural fiber, reinforced concrete, green technology.

Introduction

Protecting the environment becomes mandatory for the researchers before implementing the new technology to ensure no damage or environmentally friendly. Utilization of waste material and renewable resources as alternative building materials have become the popular way to overcome the environmental problem in most developing country (Neville, 1995).

Fiber reinforced concrete (steel fiber or natural fiber) is gaining more attention in construction industry. Adding the short fiber reinforcement in low volumes (less than 2–3%) can increase the fracture toughness of concrete that will help to control the width of crack that form due to the volume changes in concrete (Raoufi and Weiss, 2011).

Organic fibers can be produced from a number of solid wastes such as bamboo, coconut, date palm, oil palm, sugarcane, and vegetable wastes. Some of these fibers are chemically more inert than either steel and glass fibers. They are also cheaper and more importantly most of them can be natural (Safiuddin *et al.*, 2010). The tensile strength of concrete is about 9–15% of its compressive strength, and concrete is considered as brittle material. The fiber addition inside the concrete could increase its ductility that makes it suitable to be used in the earthquake prone area. Previous research shows that bamboo fiber addition could increase the tensile strength of concrete (Wahyuni *et al.*, 2014). Torgal and Jalali (2011) said that promoting the use of concrete reinforced with vegetable fibers could be a way to improve concrete durability and also sustainability construction.

When concrete cracks, fibers help to bridge a crack and transfer load across the crack. Fiber reinforcement will limit the extent of restrained shrinkage cracking by limiting the width of the crack that forms in concrete element (Shah *et al.*, 1995).

Sugar palm fiber is obtained as a by–product of the sugar palm tree (Arenga Pinnata). This durable fiber is extracted from the trunk and leaf–bases of sugar palm plant. Sugar palm fiber offers good tensile and flexural properties in polymeric composites due to a better bonding with the matrix (Bachtiar *et al.*,2010).The most crucial structural component of the natural fiber is its cellulose in comparison with the other chemical constituents. The amount of cellulose in their cell walls will determine the mechanical properties, cost of production and various potential applications of fibers (Sanyang *et al.*,2016).

It is encouraged to use the renewable materials for sustainable pattern of consumption of building materials. The focus of this research is utilizing the fiber from sugar palm tree in concrete. Sugar palm tree grows very well in Bengkulu Province.

Material and Methods

Material Used

The sugar palm fiber was from Curup, Bengkulu and available in the hardware shop in Bengkulu city. The palm fiber was cleaned and cut into 2 cm long (Figure 1). The loose bulk density of this fiber is 0.0057. The fiber added to each mix variation was based on the loose weight of fiber toward volume of the cylinder mold (15 cm x 30 cm). Figure 2 shows the ready to use sugar palm fiber into the concrete mixture.
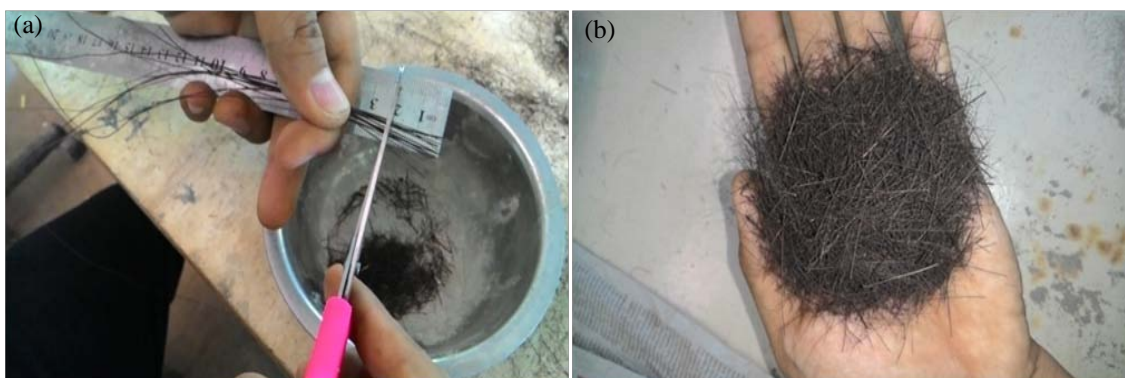
Figure 1. Sugar palm fiber (a) cutting process and (b) ready to use.

Aggregate

The fine aggregate was obtained from Curup Bengkulu, and the coarse aggregate with nominal size of 10 mm and 20 mm was from North Bengkulu. These materials were also available in the hardware shop in Bengkulu city. The physical properties of fine and coarse aggregate are tabulated in Table 1.

Table 1. Physical properties of aggregate

Properties	Fine Aggregate	Coarse Aggregate
Fineness Modulus (FM)	1.76	6.73
Specific Gravity	2.59	2.68
Bulk Density	1.3	1.5

Mix Design

Five mixture proportions were made. Normal concrete was used as the control mix. The water cement ratio was kept at 0.5. The slump value was 60–100 mm. The concrete mix design was prepared in accordance with SK–SNI T–15–1990–03. The type of cement used in this research is PCC which is also available in the hardware store in Bengkulu. It was certain that the cement was in good condition before used in the concrete mixture. The mix proportion for concrete is given in Table 2.

Table 1. Concrete mix design proportion

No.	Materials	Amount kg/m^3
1	Cement	450
2	Fine Aggregate	551.22
3	Coarse Aggregate	1119.15
4	Water	225

The sugar palm fiber were added in 4 different percentages namely 2,5%, 5%, 7,5% and 10% based on its loose bulk density. Four specimens were prepared for each variation. The fiber was distributed evenly inside the concrete mixer to the dry mixture of cement and fine aggregate before adding coarse aggregate and water, so it does not create the weak spot that decrease the strength of the concrete.

The slump test was performed for every 4 specimens made to ensure the workability was within the range of 6–10 cm. The cylinder moulds measuring 150 mm in diameter and 300 mm in height were prepared for indirect tensile strength test. The specimens were cast and demoulded after 24 hours. Each specimen was named before cured in the curing tank until the day of testing.

Results and Discussion

The test of tensile strength of concrete was conducted in accordance with ASTM C496–90 in concrete laboratory, Bengkulu University. The concrete cylinder was tested at the age of 28 days and 4 months. The specimen from the curing tank was air dried one day before tested. The tensile strength of normal concrete was compared to 4 other types of concrete.

The test involved centering the sample in the testing machine. The force applied was at the constant rate until it reached the maximum force. The splitting test set up with the failure cylinder specimen can be seen in Figure 2.

The formula used to calculate the tensile strength of concrete is:

$$T = \frac{2P}{\pi L d}$$

where T is the splitting tensile strength, P is the maximum applied load, l is length and d diameter.

Figure 2. Splitting test set up

Figure 3. shows the result of tensile strength of Normal concrete and 4 variation of concrete at the age of 28 and 120 days. The value of the tensile strength plotted in the graph is the average of 4 specimens from each variation. The tensile strength of concrete is increasing along with the increasing percentage of fiber addition. The 10% fiber addition shows the highest strength both at 28 days and 4 months.
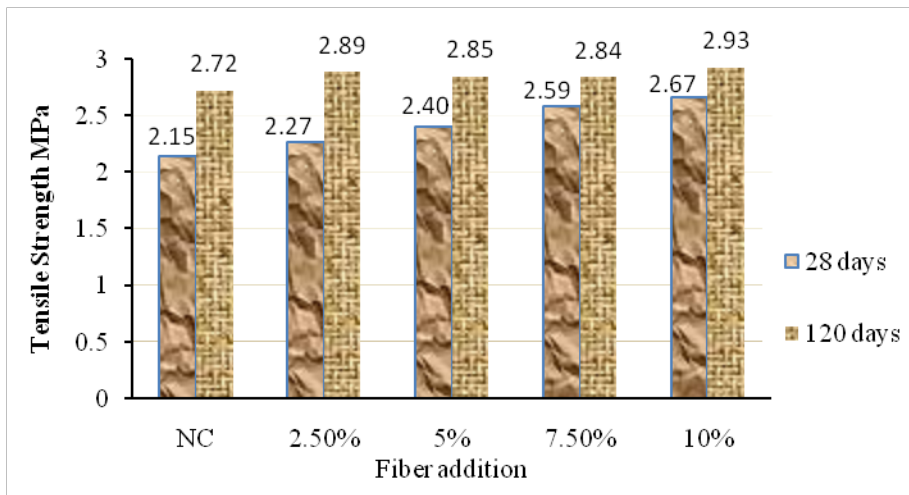
Figure 3. Tensile strength test results

The result shows, 10% palm fiber addition increases the tensile strength of concrete up to 24% at the age of 28 days, and the increasing rate is getting low at the age of 4 months (7.5%). This graph does not show the optimum result yet. The possibility is the tensile strength of this type of concrete will keep increasing with some more percentages of fiber addition. The trend shows the increase of tensile strength at later ages is not significant even though it is still higher than the tensile strength of normal concrete. The fiber inclusion might reduce the compressive strength of concrete as well as increase its ductility. Further research is needed to clarify this finding.

Conclusions

The tensile strength of concrete with sugar palm fiber addition increase with the adding percentage of sugar palm fiber in comparison with normal concrete. The increase of tensile strength test at later ages is not significant. Further research is needed to find the optimum fiber addition toward this type of concrete. The durability of this type concrete is needed to be investigated as this research involved the natural fiber which might react with the alkaline environment.

Acknowledgements

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The Compressive Strength and The Absorbtion of The Clay Brick With The Rice Husk Ash and The Palm Oil Fuel Ash

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Abstract

The Clay brick in Bengkulu Province of Indonesia is usually made of the mix of clay and water till plastic enough to be molded. This research try to obtain the sustainable materials for the brick to settle the shrinkage since the clay quarry is limited. This study used rice husk ash (RHA) and palm oil fuel ash (POFA). Each type of ashes were added to the clay mixture in four different ash variations namely 5%, 10%, 15%, and 20% based on the weight of the clay. The production of the bricks were manufactured according to the method at the factory. The result shows that the bricks compressive strengths decline as the ash percentages increase while the absorption increases as the utilization of ash increases. The compressive strength of RHA bricks are better than the POFA bricks. Both of ashes increase the volume of the bricks but the bricks volume of 10% to 20% POFA is larger than the volume of RHA bricks.

Keywords : clay brick weight, clay brick volume, agricultural waste.

Introduction

The clay bricks as the material of the wall are generally used in Bengkulu–Indonesia due to its reasonable price. The brick manufacturing needs only simple skill and tools. The clay is available in the factory area or can be bought cheaply. Many people take brick manufacturing to be their occupations for those reasons. The clay brick is not the expose one. The brick wall is usually covered by the mortar for protecting propose.

The brick in Bengkulu is made of clay and burnt in the kiln. The brick size is smaller than the code and the absorption is in a range of 25,7% till 26,5%.The main problem of the brick manufactured in Bengkulu is the shrinkage. The volume brick shrinkage is about 42% while the weight shrinkage is bigger (Elhusna, *et al.*, 2014). The shrinkage causes the mold size must be enlarged in order to meet the brick size to the code. The utilization of more clay becomes the consequences of using large mold while the clay quarry is limited and unsustainable (Elhusna, *et al*., 2014).In that case, renewable resources to substitute the clay is needed. Using waste material and renewable resources which is popular as part of "green technology program" (Wahyuni *et al*., 2014) can become one of the solution to cope with the limitation of the clay. Ramezanianpour *et al*. (2009) report that sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural waste components. Recycling of waste components contribute to the energy savings in cement production and the conservation of natural resources in order to protect the environment.

This article reports the study of agricultural wastes utilization in clay brick. Rice husk ash (RHA) and palm oil fuel ash (POFA) which used in this research are sustainable agriculture wastes. The compressive strength and the absorption as the important performance of brick are reported in this article.

Palm oil and paddy production in Bengkulu Province are increased every year. Palm oil production at 2014 in Bengkulu Province and Indonesia are 798.818 tons and 29.278.189 tons (Directorate General of estate Crops, 2014). Paddy production in Bengkulu Province at year 2014 is 593.194 tons (Statistic of Bengkulu Province, 2015). It is known that at least 20% husk or 4% husk ash becomes the waste of the paddy production. In that case, 118.639 tons rice husk or 23.728 tons rice husk ash is available in Bengkulu Province in year 2014 and the waste is increased every year.

Rice husk ash

Rice husk ash (RHA) is the combustion residue of the rice husk which is the shell produced during the dehusking operation of paddy rice. Each ton paddy rice produces about 200kgs of husk which

on combustion, yield approximately 40kg ash (Mehta in Xu, *et al*., 2016) or about 20% of its weight after the incineration (Anwar, *et al.* in Givi *et al.*, 2010). When this husk is burnt in the boilers, about 25% of RHA is generated (Kumar, *et al.*, 2012). Rice husk ash are greatly affected by the burning conditions. When the combustion is incomplete, large amount of un burnt carbon is found in the ash. When the combustion is completed, grey to whitish ash is obtained (Mohan *et al.*, 2012).

The addition of 20% RHA decreased the crushing strength of the bricks to be around 63% of the strength of the control bricks. The water absorption of the bricks increase as a slow rate with the increase up to 20% of RHA (Hossain, *et al.*, 2011). The optimum proportion for bricks was observed as 30% RHA and 70% clay as the bricks exhibited high compressive strength and low brick weight. As the percentage of RHA increased, the water absorption of RHA–clay bricks was also increased (Mohan, *et al.*, 2012). The brick with RHA will expand and cause distortion of the bricks when they are burnt in the kiln, but It is found that there was no definite relationship between the percentage of RHA and the change of the volume (Hossain, *et al.*, 2011).

Palm oil fuel ash

Oil palm fruit production contains 43–45% mill residues in the form of empty fruit bunches (EFB), mesocarp fruit fibers (MF), and palm kernel shells (PKS). MF and PKS wastes are used extensively as fuel for steam production in palm–oil mills in their own low pressure boilers (Abdullah and Sulaiman, 2013). Mesocarp fibers and PKS are ready use as boiler feed (UNEP, 2012) and produce ash called as palm oil fuel ash (POFA). Oil palm waste is a reliable resource because of its availability, continuity and capacity for renewable energy solution (Abdullah and Sulaiman, 2013)

Palm oil fuel ash (POFA) decreased the manufactured bricks compressive strength but increased their dry shrinkage and initial rate of suction (IRS) as a result of increased porosity value. Nonetheless, the incorporations of the ash into a clay brick has improved its thermal conductivity properties and energy efficiency during manufacturing. The ash can be considered for producing lightweight fired clay bricks as they could act as pore formers to improve the thermal properties and energy efficiency in brick firing process (Kadir, *et al.*, 2013).

Material and Methods

The main objective of this research is to find out the influence of the utilization of RHA and POFA to the compressive strength and the absorption of the clay bricks in Bengkulu–Indonesia. The brick volume is also reported since the shrinkage of the local bricks is large as mentioned above. The process of the brick specimens manufacturing is held in the brick factory.

Four different variations of each type of the ashes were added to the clay mixture namely 5%, 10%, 15%, and 20% based on the weight of the clay. RHA and POFA used were taken from the mills. The ashes were dried under the sun to remove the moisture content. Both of the ashes were screened before used. The specific gravity of RHA is bigger than POFA. The physical properties of the clay and the ashes are given in Table 1. The bricks manufacturing process since mixing the materials, molding, drying and burning took about 21 days. The size of the bricks were recorded in order to find out the volume. The water absorption and the compressive strength were tested in the laboratory in accordance to ASTM, C67–07.

The brick absorption is the difference between the soak weight and the dry weight. The bricks were soaked in the water for 24 hours. The brick weight before and after the soak process are recorded. The compressive strength specimens were the bricks covered with mortar at the top and the bottom. The mortar was made of the proportion of cement and sand equal to 1and 3 based on the volume. The brick test at the age of 7 days of mortar shows that every first crack occurred at the brick. The compressive strength value was defined as the value of the first crack that occurred at the brick. The absorption, the compressive strength and the volume that reported are the normalized ones to the control bricks. The control bricks are the bricks without the ashes.

Table 1. Physical properties of clay, rice husk ash and palm oil fuel ash

Properties	Clay	Rice husk ash	Palm oil fuel ash
Specific gravity (kg/cm^3)	2,71	1,72	1,42

Results and Discussion

The compressive strength and the absorption are important performance of the brick. Low compressive strength brick can only be used as filler wall. While the high absorption of the brick is the mainly reason to protect the brick wall from the water. Covering the brick wall with mortar can be a way to protect the brick from absorbing water.

Both of the ash types increase the absorption of the bricks (Figure 1) but the trends are different. RHA causes the bricks absorption increase in slow rate and become the stable value when RHA is more than 15% while POFA causes the bricks absorption increases in higher rate and keep increasing till 20% POFA. The absorption of the 5% RHA brick is higher than the POFA one while RHA brick absorption is less than PAFO one when the bricks contain more ash.

RHA and POFA in clay bricks reduce the compressive strength (Figure 2). The compressive strength of RHA bricks are better than the POFA bricks. The strength of RHA bricks trend is better than the POFA's trend but both of the ashes decrease the strength as the ash in bricks increases.
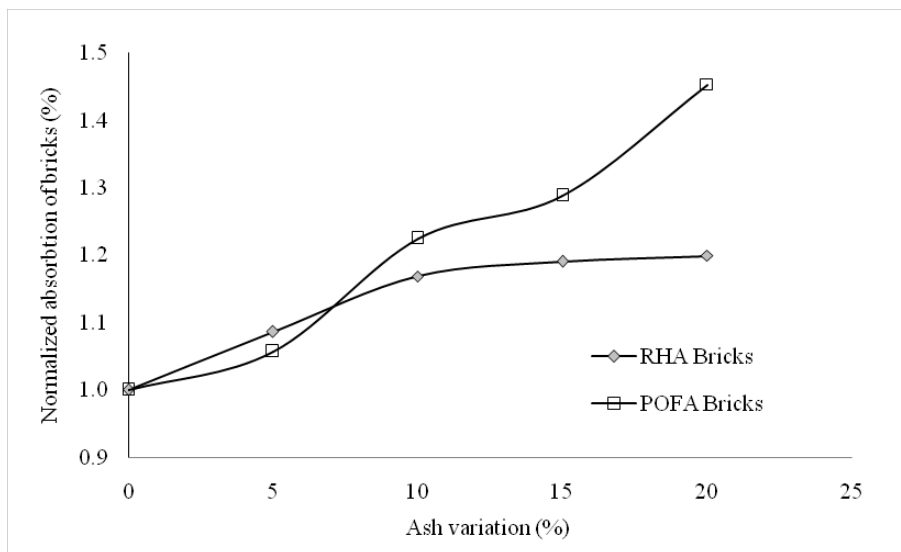
Figure 1. The absorption of RHA and POFA bricks.
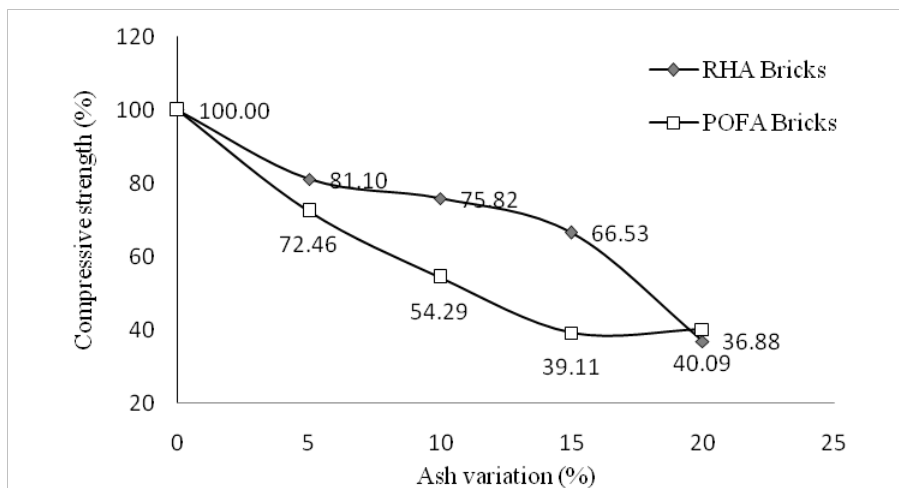
Figure 2. The compressive strength of RHA and POFA bricks.
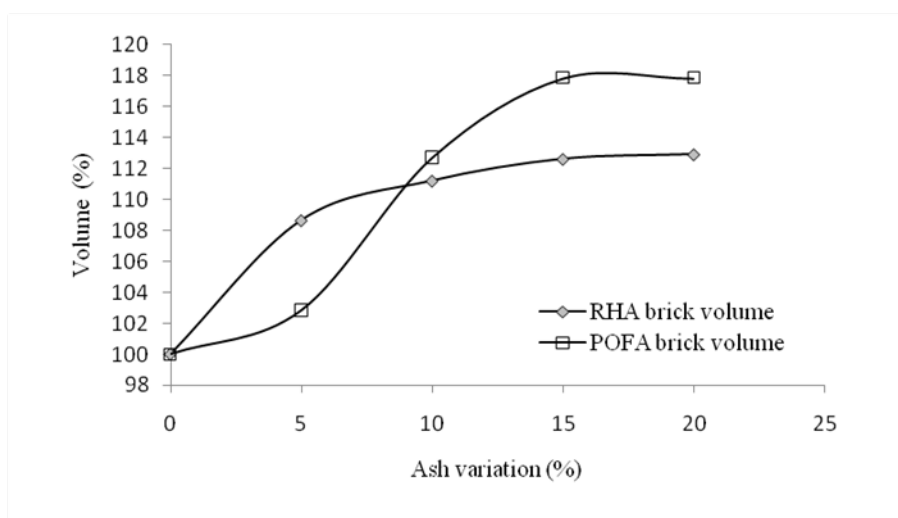
Figure 3. The volume of RHA and POFA bricks.

RHA and POFA expand the brick volume in different trends (Figure 3). The RHA brick volume keeps expanding but the trend is in slow rate when the RHA is more than 10%. The volume (Figure 3) and the absorption (Figure 1) diagrams of RHA bricks show similar trends. The POFA bricks volume is also comparable to the POFA brick absorption but the volume trend is started decreasing at 20% ash while the absorption is still increased. The bricks volume of 10% to 20% POFA is larger than the volume of RHA bricks while the volume of the brick at 5% RHA is larger than the other. The utilization of RHA and POFA in clay bricks expand the volume and can decrease the utilization of the clay

Conclusions

The compressive strength of RHA bricks is better than the POFA bricks but both of the ashes decrease the brick strength as the ash increased. The utilization of RHA and POFA in clay brick affect the absorption and the volume almost in the same way. The absorption and the volume increase as the utilization of ashes increased. RHA bricks are less porous since the volume trend is lower than the trend of POFA bricks. Both of the ashes increase the volume of the bricks. further research is needed in order to maintain the brick performance so that RHA and POFA can be used as one of the material in clay brick production.

Acknowledgements

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Determination of Micro Watershed Model Based on Ecohydrology for the Management at Krueng Peusangan Watershed

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Abstract

The integration of sectors and regions between the management of natural resources and the watershed environment depends on two factors: the self–important and the ethnocentrism. This case becomes very complex for watershed management between district and province. Studying about soil and water management comprehensively in watershed needs the right approach. The Krueng Peusangan is categorized as degraded area with first priority by Indonesia government and need two decades to improve its situation. This study aims to identify the biophysical environment, water resources, social and institutional conditions of the people in Krueng Peusangan watersheds. Determining the micro watershed models based on the concept ecohydrology according to the site conditions of the watershed. Micro watershed location selected by the variable physical, economic and social in Krueng Peusangan based on the highest score.). Data obtained from the primary data based on questionnaires given to communities and key informants from the relevant agencies. The results obtained a watershed model of integrated and sustainable watershed management of the Krueng Peusangan watershed through the development of micro watershed model based ecohydrology by considering aspects of social, economic, cultural and institutional capacities in and around the sub watershed. further, the critical of natural resource in Krueng Peusangan can be minimized and corrected for maintaining a sustainable watershed conditions. Micro watershed location selected by the variable physical, economic and social in Krueng Peusangan based on the highest score is the subzone Lut Tawar, Krueng Ceulala, Krueng Simpo, and Teupin Mane. Elected district that is the District Bintang, District Ceulala, District Lut Tawar, District Pinto Rime Gayo, District Timang Gajah and District Peudada.

Keywords : Micro watershed models, social, economic, cultural, and eco–hydrology.

Introduction

One indicator that the dominant cause disruption of the hydrological functions of watersheds is the formation of critical lands. The stability of water production at several observation points in the watershed Krueng Peusangan slope downward and only on the upstream side of the observation that tends Landscape (Ichwana, *et al.,* 2013) The trend shows that there are some sub–watersheds in Krueng Peusangan degraded. Micro Watershed (small catchment) is part of a sub–watersheds that respond directly to rain in case the system changes the function of production area of less than 5,000 ha which is used as a place to demonstrate the process participative natural resource management, forest and land rehabilitation, engineering conservation of soil and water, farming systems in accordance with land capability, social, economic, cultural and community institutions (Directorate General of land Rehabilitation and social Forestry, 2009).

Change of one physical parameter. Watershed will respond to changes in the watershed system. Physically, the micro watershed is part of the watershed that is belong to the order 1–3 where 1 is the order of the most upstream river flow (Strahler, 1979). Through eco–hydrology concept that focuses on the ecological processes that occur in the hydrological cycle and trying to take advantage of the process to improve the environmental sustainability (Zalewski and Wagner, 2005). Then the micro watershed can restore the degradation of water resources and the environment to the improvement of ecosystem services for the

community. So that eco–hydrology is the use of ecological to control hydrological processes and the otherwise, using hydrology to regulate ecological (Zalewski, 2010).

The complexity of the problem is the fragmentation pattern of use of natural resources in the watershed based on approach pattern watershed management and regional development. Problems on the major watershed associated with the quantity and quality of water. A small scale watershed is easily controlled and identified for its management. Therefore the aim of this paper is to determine the location of micro watershed at watershed Krueng Peusangan so it can be a consideration and also income for local governments, businesses and communities to be used in formulating policies and appropriate activities that provide a double benefit such as preservation of natural resources and the improvement of people's income.

Material and Methods

Research has been conducted in Krueng Peusangan watershed. Watershed Krueng Peusangan disgorge in Lake Laut Tawar located in Central Aceh district and flows approximately 88 km across the Bener Meriah district before it finally empties in Bireuen district. Has extensive 2.557,8 Km^2. Geographically, Krueng Peusangan watershed is at the position of East Longitude (EL) 96°21,7'12"– 97°02'40" and North Latitude (NL) 4°30'38"–5°16'34" (Figure 1).
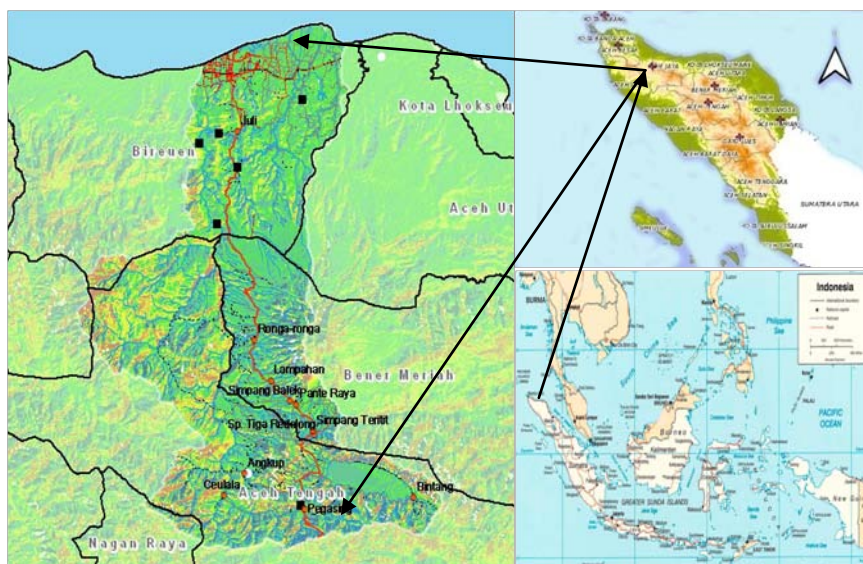
Figure 1. Krueng Peusangan watershed.

For social data, economic and institutional created to shapefile (shp) to provide an overview in the form of a map in Krueng Peusangan watershed. Identification of site selection is done in accordance with standard guidelines directorate general. The scoring can be seen in Table 1.

On the Table 1 (code x1), the value for an area has condition such as: erosion, landslides, floods, degraded land, deforestation, land conflicts, low land productivity, high level of urbanization and poverty. If the issue appears only 2 issue means low risk, if 3–5 (moderate risk) and > 5 (high risk). Code of x2 is accessibility to the area of the capital city (Kabupaten). Code of x3 is quality of human resources to see people's reliance on agricultural income. Code of x4 and x5 are adjusted to the observation area that is bad (not declined but less support), good enough (to accept and support), very good (ready to participate in both human and financial). Data obtained from the primary data based on questionnaires given to communities and key informants from the relevant agencies. While secondary data are maps and the physical condition of the watershed obtained from the Department of Forestry and watershed management of Aceh.

Results and Discussion

The vulnerability of flooding in the watershed Krueng Peusangan will be combined with the results of the questionnaire from the public to observe the environmental issues of the community. A value of 1 defines the danger of lower region flooding, a value of 2 defines the region flooding moderately and the value 3 is a region with high floods. Identification of the flood area is one of the indicators of the variable to set a model

of micro watershed in Krueng Peusangan watershed. Flood–prone areas in sub watersheds Krueng Tawar Ceulala and Lut Tawar at the upstream followed by the lower and middle reaches. In the upstream, especially in Ceulala, essentially a flood–prone areas. This is consistent with community reports that the area often floods in rainy season and some of the events that have been reported in the newspapers about the floods and landslides in the area. Krueng Peusangan watershed area is the widest part of the largest sub–watershed consists of three districts, Bireuen, Bener Meriah and Takengon. To determine the location of a model micro watershed which is one of the variables is the level of public revenue dependence on agricultural commodities. The public has a livelihood in agriculture.

Table 1. Determining Criteria of Micro watershed area model (MDM) Location And Measurement

Code	Criteria Description	Attributes measured	Score	Weight (%)
x1	The existence issues problems	a. two issues	1	25
		b. 3–5 issues	2	
		c. >5 issues	3	
x2	Accessibility	a. Distance from the town center >40 km	1	15
		b. Distance from the town center 20–40 km	2	
		c. Distance from the town center <20 km	3	
x3	The level of Community dependence on agricultural income	a. <30% RT income from agriculture	1	20
		b. 30–70% RT income from agriculture	2	
		c. >70% RT income from agriculture	3	
x4	Potential support community, private and NGO against MDM	a. bad	1	20
		b. good enough	2	
		c. very good	3	
x5	Goverment support potential against watersheds	a. bad	1	20
		b. good enough	2	
		c. very good	3	

City center is center for district city. Krueng Peusangan watershed includes three district (Kabupaten), Bireuen, Bener Meriah and Takengon, so it has three main centers in the area to be viewed accessibility area of micro watershed models. To determine the location of the Micro watershed model of one variable is the level of public revenue dependence on agricultural commodities. The public has a livelihood in agriculture. The dependence of high society for agricultural land led to an area of land and water management needs.

Community potential support is needed for the success of watershed management in micro scale. Survey and results of questionnaires in all districts in the watershed Krueng Peusangan, The potential of the community in supporting model of micro–watersheds are divided into three categories: poor (1), moderate (2) and good (3). Issue presence obtained from the questionnaire and also data from Bappeda office to determine the issue of sub districts problem in Krueng Peusangan watershed. Issues cover issues such as the problems of flooding, landslides, degraded land, erosion etc. Micro watershed area model (MDM) is a development model of integrated watershed management in micro scale involving various stakeholders in a participatory and realization model of natural resource management (sustainable) is based on biophysical, social, economic, and institutional measured to be developed on a large scale.

Through this research produced the criteria and standard guidelines for management of natural resources in accordance with the conditions of the local watershed. To compile this micro watershed model, guided by the directives of RLPS director general rule no. 15/V–SET/2009. Selection criteria Physical from the Overlay map geology, land use, degraded land, to determine the critical lands overlay maps. Identification of the landslide area is one of the indicators of the variable to set a model of micro watershed in Krueng Peusangan watershed. slope, rock type, land cover, a map of erosion, a map of productivity, map management, to determine erosion hazard overlay soil type, slope and cover land.

Social Criteria culture technology of farming, Indigenous culture, Institutions, NGOs/NG, Norma of community, Criteria Economics Infrastructure (market, transport, roads), demographics (livelihood), farming(the type of commodity, farm livestock, fisheries, agro–forestry), income of Farmers and farm income, plant seed, Community preferences, market and marketing system, production, revenue, income per capita, economic institutions and information systems.

Of the provisions set out in accordance with the conditions in the watershed Krueng Peusangan, this research determined the five variables to determine the location of the micro watershed models based on the concept ecohydrology. The results obtained from scoring which has been settled. The highest scoring value is the location chosen for the location of the micro watershed. The location obtained from 12 sub–watersheds Krueng Peusangan which are only four that got the highest score, namely sub watersheds Lut Tawar, sub Krueng Ceulala watersheds, sub–watersheds Krueng Simpo, sub watersheds Teupin Mane. Selected for the District can be seen in Table 1 which certainly are in sub watersheds were selected for micro watersheds (Figure 2).
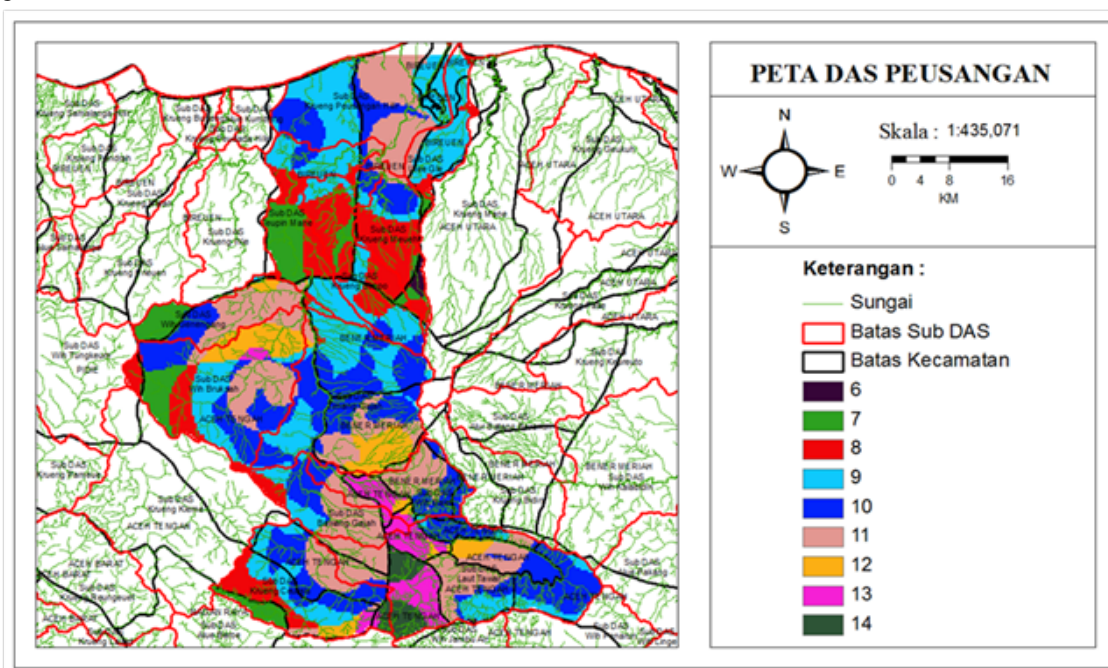
Figure 2. The sub watersheds were selected for micro watersheds

Though much research focuses on the interaction between ecology and hydrology has been applied in some time (Bonell, 2002), but the true integration (especially between related and coupled hydrological and ecological processes) remains incomplete. It is caused by what, how, where and the relationship of research to be, and what has been practiced still debated. That is why, the logic to adopt a persuasive approach hydro–ecological has been done but the integration of the integration of hydrology and ecology still require further careful evaluation. Currently, ecologists and biologists seem to look at the question from the perspective of research and hydrologists from another perspective. Scientists are attempting to address and solve the same problem without looking at the science that is superior because of the absence of a clear theoretical understanding of the elements of these disciplines as the key to its success.

Eco–hydrology future prospects of the concept should be based on three principles, namely the framework, targets and methodology (UNESCO, 2004). Continuous management efforts become a major focus in the concept eco–hydrology. So through eco–hydrology approach can reduce environmental degradation, ensuring the sustainability of water, ecosystems, and society. For the success in applying the concept eco–hydrology the expert must have data as complete as possible about the object to be handled. Although it takes a long time in the recovery of nature such as the hydrological cycle so that the completeness of the data is very important. According to Zalewski (1997), instability of hydrological processes affecting the increasing of the global temperature as it is now. This is evident from the return stream that is straightened into a meandering natural, reopening again water retention areas such as swamps to absorb water at the conservation area, and planting mangroves in coastal areas (Maryono, 2005). A holistic approach is essential because of the availability of water depends on environmental conditions such as forests, rivers, land cover, and other natural components so that interventions should be cross–sectoral cross. Through micro watershed models, it can be determined in accordance with the conservation model watershed conditions.

Complexity is characterized by a variety of behaviors, which emerge from the system. Changes in land use is an important component of the concept eco–hydrology, but to predict the changing is difficult because of the scale and complexity of the interaction between eco–hydrological non–linear and the process of socio–economic, spatial and temporal scales are different. A framework of the Ecosystem Approach

system, has been developed for the purpose of providing information for sustainable development policy. Ecosystem Approach highlights the problem of managing change in complex systems when the change may involve unexpected changes.

One effort that can be done to address the threat on water resources and climate change issues is to regulate the use of land (Nasution *at al.*, 2013). The main focus is on the management of water hydrology while the ecological protection of the ecosystem so that their integration will be achieved sustainable development. To cope with recent advances in the understanding of the interactions between climate, water, and soil biogeochemical management practices, such as reforestation and ecological restoration indispensable further studies of ecohydrology (Wang *et al.*, 2012). If there is a paradigm shift, the research ecohydrology desperately need an interdisciplinary team to bridge the gap between the boundaries of the subject of applied science research in basic ecological or hydrological. Therefore, it is clearly indispensable original interdisciplinary approach that takes the first step to generate new insights into ecosystem hydrology and their interactions. So that in the future we can identify, provide integrated solutions with new issues in the management of water resources.

Conclusion

Forms of watershed management in an integrated Krueng Peusangan in this research through the development of model–based Micro watersheds ecohydrology to consider aspects of the social, economic, cultural and institutional capacities in and around the watershed. Based on these aspects locations watershed micro–elected based on physical variables, economic and social watershed areas Krueng Peusangan based on the highest scores were sub watersheds Lut Tawar, sub watersheds Krueng Ceulala, sub watersheds Krueng Simpo, sub watersheds Teupin Mane. Elected district that is the District Bintang, District Ceulala, District Lut Tawar, District Pinto Rime Gayo, District Timang Gajah and District Peudada.

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Microstructures Behaviour of High Strength Concrete with Variation of Additives

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Abstract

In general, the production of high strength concrete using cement, aggregates and additives, such as super plasticizer and silica fume. In this research, alternative additives were used instead of silica fume with variation of fly ash, consists of palm shells fly ash, coal fly ash and rice husk ash with the addition of percentage by weight of cement 0 %, 5 %, 8 %, 10 % and 15 %, also used super plastizer type of polycarboxylate ether (Viscocrete N 10) as much as 1.5% by weight of cement Concrete is designed with 0,30 of water cement ratio. In this research, test were conducted on high strength concrete specimen with different additives, also the correlation between measurement of mortar, cement paste, and concrete strength, along with stress–strains correlation. Scanning Electron Microscope (SEM)used to observed the microstructure concrete. Compressive strength test using concrete cylinder by 15 cm in diameter and 30 cm height, cement paste by 10 cm in diameter and 20 cm height, mortar by 10 cm in diameter and 20 cm height, with the size of aggregate cube in 10 cm x 10 cm. the quantities of sample test are 270, each variable using 3 samples. The result of high strength concrete mechanical properties test showed that at the age of 56 days with the addition of 15% palm shells ash produces the highest result of compressive strength 692,30 kg/cm2, follow by coal fly ash (10%) with strength result 669,60 kg/cm2 and rice husk ash (5%) 599,80 kg/cm2. There is addition in strength at 56 days compared to strength of 28 days. The behavior of High Strength Concrete showed Aggregates have the highest strength and low strains compared to the other component that is concrete, mortar and cement paste. Observation SEM showed that concrete with addition of fly ash was compact and solid more than without using fly ash. It also there was micro cracked because imposition.

Keywords : Strength, additives and concrete.

Introduction

In accordance to rapid development in concrete technology especially regarding to high strength concrete that use small water cement ratio, and the use of additive and admixture (super plasticizer), and also it will need further research in order to obtain new materials that can be used as an alternative for the production of high strength concrete

The purpose of this study is to determine the influence of additives variation for high strength concrete mechanical properties, strength, stress–strains correlation and micro structure concrete. 3 variations, consist of fly ash of burning coal, shell palm oil, and rice husk ash with the addition of weight percentage of cement 0%, 5%, 8%, 10% and 15% (Mehta and Monteiro, 2006) for strength, stress–strains correlation and micro structure concrete with 0,30 water cement ratio (w/c). Used super plasticizer of polycarbocylate type (Viscocrete N 10) with the addition of percentage of the weight of the cement 1,5%.

Prior to concrete production, first performed the examination of aggregates according to Anonym (1982), this examination performed of physical properties, that is specific gravity, absorption, bulk density, sieve analysis, endurance of aggregates and the organic content. Performed the examination of aggregates have to according to ASTM.

Compressive strength test and strains–stress correlation test of concrete cylinder, mortar, and paste cement were conducted at 28 and 56 age days. And then for micro structure concrete test was performed after compressive strength test, samples taken from fragments of cylinder concrete and used scanning electron microscope to observing micro structure of high strength concrete.

High strength concrete mix design calculated for strength design at 70 MPa (Aulia, 2005). Design using crushed stone (split) for aggregates with 16 mm maximum diameter. Gradations of aggregate used in this mix design that is (0–2) mm, (2–5) mm, (5–8) mm, (8–11) mm and (11–16) mm (Mahdi, 2008).

Material and Methods

Mix Design, Sample and Test

The composition of concrete mix (concrete mix design) is planned based on the method of concrete weight ratio. In this research, Mix design for concrete strength is 70 MPa, with concrete cylinder (Ø 15, T30 cm), water cement ratio 0,30, percentage of fly ash coal burning, palm shell ash and rice husk ash 0%, 5%, 8%, 10% and 15% for weight of cement. In this research, total cylinder specimens for test are 270 pcs, and cube specimens are 3 pcs. concrete cylinder size Ø 15 cm, T = 30 cm are 90 Cylinder specimen for mortar (Ø 10 cm, T = 20 cm) are 90 pcs, and cement paste with (Ø 10 cm, T = 20 cm) are 90 pcs. The aggregate cube is 3 pcs. The test conducted for concrete cylinder used to measure the strength, strain, microstructure and visual observation, and for mortar, cement paste, and aggregate cube are used for strength and strain only

Compressive strength test was conducted at 28 and 56 ages days, except cube aggregates was conducted at 0 age day. Compressive strength test used compressive machine test (Merk Ton Industrie). Test of structure micro concrete were conducted with scanning electron microscope observation to know how structure micro behavior cause compressive strength.

Table 1. Design of Specimen concrete, mortar, paste cement and aggregate.

Specimen Concrete	Variation of Additives	Percentage of Additives					SP (%)	Period of Test (days)
		0%	5%	8%	10%	15%		
Concrete Cylinder (Ø15 cm, H = 30 cm)	FABB	3	3	3	3	3	1.5	28 & 56
	ACS	3	3	3	3	3	1.5	28 & 56
	ASP	3	3	3	3	3	1.5	28 & 56
Mortar Cylinder (Ø15 cm, H = 30 cm)	FABB	3	3	3	3	3	1.5	28 & 56
	ACS	3	3	3	3	3	1.5	28 & 56
	ASP	3	3	3	3	3	1.5	28 & 56
Cement Paste Cylinder (Ø15 cm, H = 30 cm)	FABB	3	3	3	3	3	1.5	28 & 56
	ACS	3	3	3	3	3	1.5	28 & 56
	ASP	3	3	3	3	3	1.5	28 & 56
Aggregates Cube		3						–

Figure 1. Specimen of concrete, mortar and cement paste

Materials

Material used in this research is cement Portland, aggregate, additive of fly ash coal burning, palm shell ash and rice husk ash, also admixture super plasticizer.

Results and Discussion

Mix design of concrete for all variation showed at Table 2.Compressive strength test was conducted at period 28 and 56 days, the result of test shown at Figure2.The figure shows that in high strength concrete with addition of 15 % palm shell ash produces the highest compressive strength up to 692,30 kg/cm2. for all variation. The testing period for variation of additives added strong influence in strength.

Table 2. Materials composition of 1 m^3 concrete

Fly Ash (FA)	FA (%)	Water (kg)	Cement (kg)	FA (kg)	SP (kg)	Aggregate (mm)				
						11–16 (kg)	8–11 (kg)	5–8 (kg)	2–5 (kg)	0–2 (kg)
0% FA	0	165	550	0	8,25	496,68	248,34	248,34	165,56	496,68
Coal	5	165	550	27,50	8,25	470,61	235,30	235,30	156,87	470,61
	8	165	550	44,00	8,25	454,96	227,48	227,48	151,65	454,96
	10	165	550	55,00	8,25	444,54	222,27	222,27	148,18	444,54
	15	165	550	82,50	8,25	418,47	209,23	209,23	139,49	418,47
Shell Palm Oil	5	165	550	27,50	8,25	482,13	241,06	241,06	160,71	482,13
	8	165	550	44,00	8,25	473,40	236,70	236,70	157,80	473,40
	10	165	550	55,00	8,25	467,58	233,79	233,79	155,86	467,58
	15	165	550	82,50	8,25	453,04	226,52	226,52	151,01	453,04
Rice Husk Ash	5	165	550	27,50	8,25	460,47	230,23	230,23	153,49	460,47
	8	165	550	44,00	8,25	438,75	219,37	219,37	146,25	438,75
	10	165	550	55,00	8,25	424,26	212,13	212,13	141,42	424,26
	15	165	550	82,50	8,25	388,06	194,03	194,03	129,35	388,06
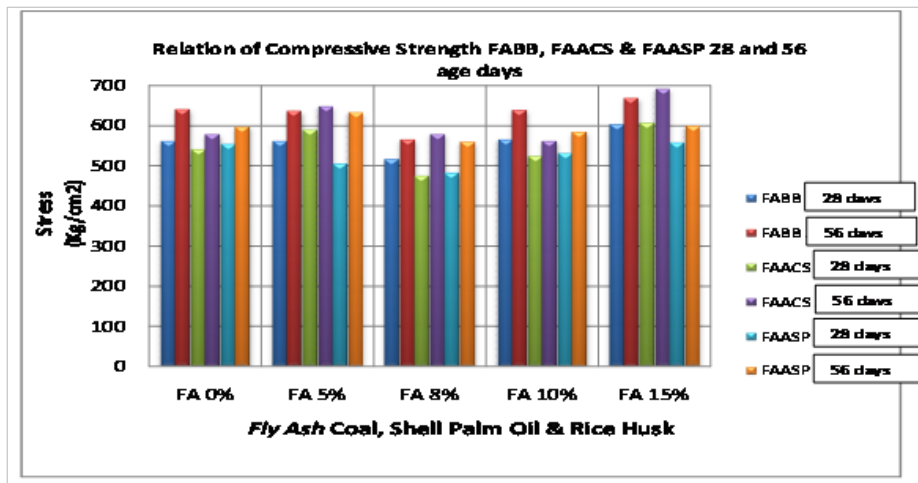
Figure 2. Bar Chart of Compressive Strength test.

Figure 3. Form of coarse aggregates distribution.

Visual Observation

The function is to see the coarse aggregate distribution in concrete mixture has performed a visual observation perception visually at concrete cylinder which have cracks apart effect of compressive strength test.

Aggregate, concrete, mortar and cement paste stress–strain relationship

From the result of research and data processing obtained a tension relation stress–strain of aggregates , concrete, mortar and cement paste at each variation of additive and variation of use percentage. Showed that graph of stress–strain relation in generally very similar . Between aggregates and concrete, mortar and cement paste was tend to far, while between concrete, mortar and cement paste was tend to close. This matter show the strength of aggregates more big than strength of concrete, mortar and cement paste. Where strain that happened to smaller of aggregate than strain of concrete, mortar and cement paste. The behavior of high strength concrete showed aggregates have the highest strength and low strains compared to the other component that is concrete, mortar and cement paste. The relation stress–strain of used palm shell ash 15% showed at Figure 4.
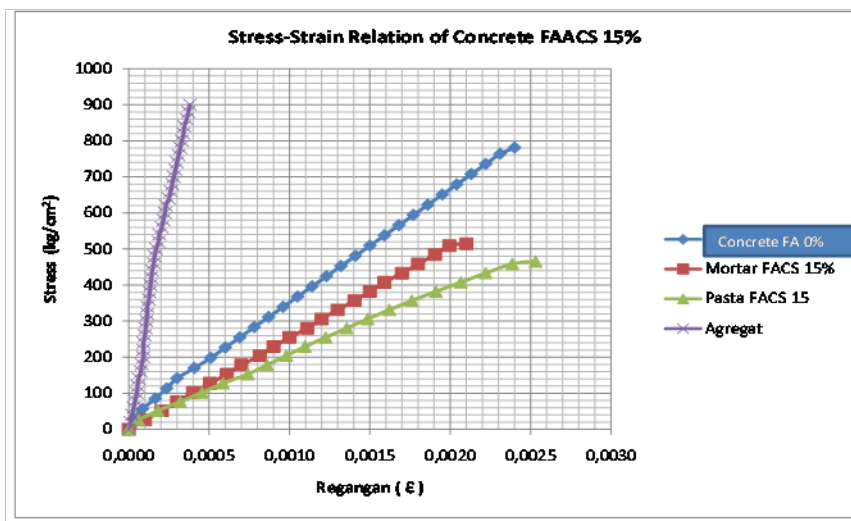
Figure 4. Stress–strain relation of concrete, mortar, cement paste and aggregate.

Figure 5 showed stress–strain relation of high strength concrete using all variations of additives. The graph showed the similar stress–strain relation for high strength concrete with all variations of additives.
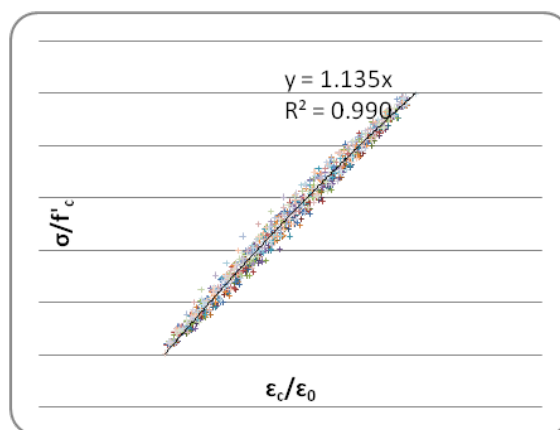
Figure 5. Stress–strain relation of high strength concrete.

From the computation of double polynomial order 2, the formula built as shown below:

$$\sigma = f'c\left[-0,279\left(\frac{\varepsilon'}{\varepsilon co}\right)^2 + 1,135\left(\frac{\varepsilon'}{\varepsilon co}\right)\right]$$

explanation:
σ   = concrete strength
f'c   = maximum concrete strength

ε'   = concrete strain

ε_{co} = maximum concrete strain

SEM Observation

Microstructure concrete tested using scanning electron microscope (SEM) for application fly ash at cement paste, aggregates and interface area.
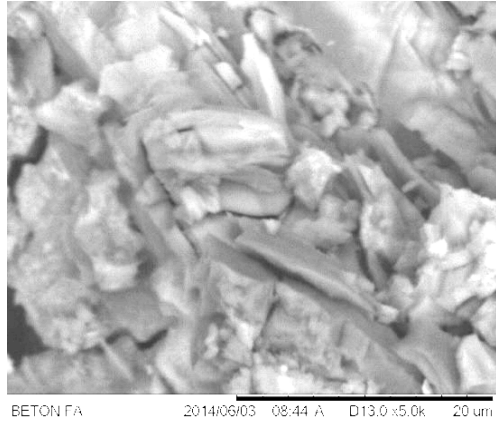
Figure 5. Observation by SEM ofconcrete 0% FA
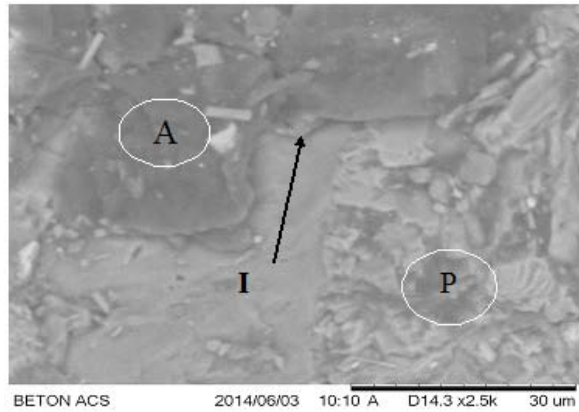
Figure 6. Area of aggregates (A), cement paste (P) and Interface (I) at concrete with FAACS 5% by SEM

Figure 5 shows that in the observation of SEM on concrete using 0 % fly ash there are still many pores in the concrete itself. Figure 6 shows that from the observation of SEM indicates that A is the area for aggregates, P is the area for cement paste and I is the interface area in concrete with the use of 5 % of palm shell ash. The figure also shows pores in the area of interface and cement paste in high strength concrete.
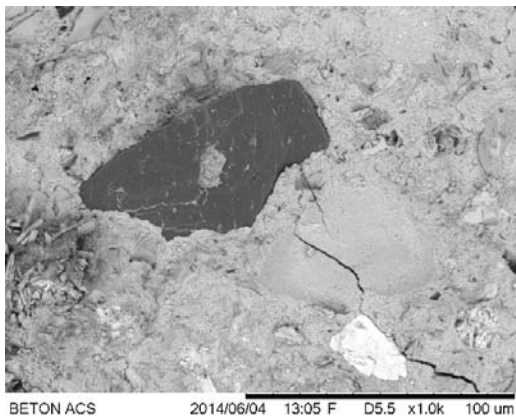
Figure 7. Micro crackat cement paste area by SEM
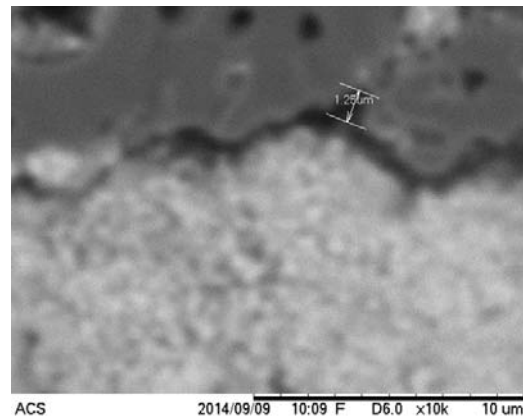
Figure 8. Pore at interface area by SEM

Figure 7 shown the microstructure area of high strength concrete suffered micro cracks due compression test. Figure 8 shows Pores in the interface area. From SEM observed still there are pore at high strength concrete. Observation SEM showed that concrete with addition of fly ash was compact and solid more than without using fly ash. It also there was micro cracked because imposition.

Conclusions

1. The compressive strength test results obtained from fly ash concrete using palm shell oil 15% with strength of 692,30 kg/cm2, at 56 age days.
2. Stress–strain relation between aggregates with concrete, mortar and paste cement tend to far.
3. The use of additives (fly ash coal, ash palm shells and rice husk ash) increase the compressive strength of concrete, it indicates that the additives can be used as a substitute Silica Fume, as an alternative substitute materials for making high quality concrete.

Acknowledgements

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Economic Feasibility of Krueng Mane–Buket Rata Road Development Project on Agricultural and Livestock Farming Production

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Abstract

Transportation infrastructures are substantial in supporting urban and rural development. National road network connects capital provinces, toll road, and national strategic roads. The development of national road is expected to give contribution to the economic city growth. Specific Economic Zones (SEZ) Lhokseumawe, located on the national trunk road in North Aceh District connects the vital projects areas and downtown. Since 2012, an alternative road from Krueng Mane to Buket Rata has been built, for about 32 km, to overcome the traffic problems. However, this alternative road has not been working properly, since there is about 6.65 km still remains unpaved. If the construction has been completed, a higher contribution to the development and economic growth will be received by people who are mostly living from agricultural and livestock farming. This study aims to analyze the economic feasibility of national strategic road to support agricultural and livestock farming sectors at Krueng Mane – Buket Rata in North Aceh District, in particular in Nisam and Kuta Makmur sub–districts. Data used in this study was road length, population, and Gross Domestic Product of each production sector from 2010 to 2014. The methods used in this study were Producer Surplus Method. The results showed that the development of an alternative road influence on the rising production of rice farming and livestock farming, and hence the road development is feasible.

Keywords : Alternative road, producer surplus, agricultural sector, livestock farming sector, economic feasibility.

Introduction

Transportation infrastructures play important role in supporting the economic improvement in urban areas. The government of Republic of Indonesia has recently declared a strategy for developing economic activities through the utilization of natural resources, demographics, geography, and transportation that exist in the region. The road network in particular, is expected to stimulate the existing potential resources and improving the economy of the region.

North Aceh District is one of districts in the Province of Aceh, surrounded by Bireuen regency in the west, East Aceh District in the east, the Strait of Malacca in the North and Central Aceh district in the south. North Aceh District has abundant natural resources, such as liquefied natural gas. Several industries exist there, such as PT. Arun NGL Co, Kertas Kraft Aceh (KKA), ASEAN Fertilizer, and PT. Pupuk Iskandar Muda I and II. Those companies complex located next to national road connecting North Aceh District and Aceh Pidie District. As a result, traffic volume is increasing, in particular in Alue Awe to Krueng Mane, the areas become very crowded and often congested during peak hours.

The local government built an alternative road along 32 km as the existing road (national road) is increasingly crowded. However, in 1998, there were riots in North Aceh District, so that the road construction development was stopped. In 2001, North Aceh District was split into two regions, i.e Kota Lhokseumawe (Lhokseumawe as capital city) and North Aceh District. Since then, North Aceh District no longer prioritizes on the alternative road construction. Instead, a higher priority was given on the development of building infrastructures, in which Lhoksukon become a new capital of North Aceh district.

The alternative road construction has been started since 1992 across the five sub–districts of Muara Batu, Sawang, Nisam, Kuta Makmur and Muara Dua. The alternative roadis located in two districts, STA 0+000–STA 26+000 lies in North Aceh District, and the following STA 26+000–STA 32+000 lies in Kota

Lhokseumawe. The road length of 32 km, has been completed about 25.35 km, the remaining road is still unfinished.

The presence of an alternative road is expected to give significant contribution to the economic growth in surrounding area. Local people's livelihood is in agriculture (rice), livestock (cattle, buffalo, goat and chicken), and home industry (brick). The growth rate of farming production will increase along with the improvement of transportation infrastructure (Master Plan of North Aceh District 2012–2032).

This study aims to determine the effect of the alternative road development project in supporting agricultural and livestock farming production, in particular rice farming and poultry productions in Nisam and Kuta Makmur Sub–Districts, North Aceh District. The economic feasibility will be taken into account based on Producer Surplus Method.

Research Methods

Project Investment Criteria

According to Gray, 1992 (cited from Serena, 2014), the objective of analysis of the project is to determine the level of profits that can be achieved through investment in a project. Waste of resources can be done by avoiding the implementation of projects that are not profitable, conduct an assessment of the investment opportunities that exist, so it will have the most favorable alternative project, and hence, determine the investment priorities.

To determine the level of benefits of a prospective project, the benefit and costs over the life of the project needs to be calculated. With regard to determine the standard of acceptance, rejection and sorting the project priority, it has developed a variety of ways, called the investment criteria. In this study, the investment criteria are based on Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR). Those criteria rely on the estimation of present value (present value) of the current benefits and costs over the life of the project.

Net Present Value (NPV)

Tamin (2008) stated that, Net Present Value (NPV)is the difference between present value benefit and present value cost. A project is economically feasible if NPV has a positive value. The equation is as seen in Eq. (1).

$$NPV = \sum_{t=0}^{n} \frac{Bt}{(1+i)^t} - \sum_{t=0}^{n} \frac{Ct}{(1+i)^t} = \sum_{t=0}^{n} \frac{Bt-Ct}{(1+i)^t}$$

(1)

NPV : net present value;
Bt : benefit of the project at year t;
Ct : cost of the project at year t;
i : the interest rate;
n : economic life of the project, starting from the planning phase to the end of the design life of the road.

Benefit Cost Ratio(BCR)

According to Tamin (2008), Benefit Cost Ratio (BCR) is the ratio between present value benefit and present value cost. A project is economically feasible if BCR >1.The equation can be seen in Eq. (2).

$$BCR = \frac{\sum_{t=0}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=0}^{n} \frac{Ct}{(1+i)^t}}$$

(2)

BCR : Benefit Cost Ratio;
Bt : benefit of the project at year t;
Ct : cost of the project at year t;
i : the interest rate;
n : economic life of the project

Internal rate of return (IRR)

According to Tamin (2008), Internal rate of return (IRR)is used to determine the level of interest rates when NPV = 0. The IRR of a project should be greater than the value of prevailing interest rates or the specified method return rate based on a determination of the value of the applicable interest rate, in which all future benefits is equivalent to present values. IRR percentage value can be found by trial and error, as shown in Eq. (3).

$$IRR = i_1 + (i_2 - i_1)\frac{NPV_1}{NPV_2 - NPV_1}$$

IRR   : Internal rate of return
i_1 : The discount rate from the smallest negative NPV;
i_2 : The discount rate from the smallest positive NPV;
NPV_1 : Present value using i_1;
NPV_2 : Present value using i_2

Producer Surplus Method

According to Tamin (1999), producer surplus method is conducted with respect to certain sectors (eg agriculture, livestock, etc.). These sectors need to consider a wide range of production data, such as the type of production and selling price of the year. Given assumptions are as follows: (1) The road project increases the planting area or the level of production; (2) Reducing the transport costs due to accessibility improvement; (3) Products sold at uniform prices in certain locations within the same region (on average) from all regions considered; (4) Additional production will have no effect on the market price down; (5) Household consumptions remain stable and is not affected by the production price; and (6) Equity on transportation and production costs to all farmers

The savings received by consumers due to prices decline is called as consumer surplus (Gray, 1992 (cited from Serena, 2014)). These savings should be considered in the estimation of project benefits. Effect of lower prices is not only received by consumers, but also by manufacturers who have produced the same products before their projects. The excess amount of the price above marginal cost is called producer surplus.

Data and Analysis
Description of Location

North Aceh District is a region situated in strategic areas in Aceh Province. It has a number of commodities production center such as agricultural and livestock farming. Krueng Mane–Buket Rata Road, was initially built as an alternative road, to avoid traffic congestion in Lhokseumawe city center. It also aimed at diverting heavy vehicles traffic flow out of the city. However, this road has not been working properly due to the remaining of 6.65 km is still unpaved, in particular at the STA 14 + 750 to STA 21 + 400, located in Nisam and Kuta Makmur sub–districts. Krueng Mane–Buket Rata Road is expected to contribute to the development and economic growth of surrounding areas, in particular Nisam and Kuta Makmursub–districts, where the majority of local people depend on rice farming and poultry farming.
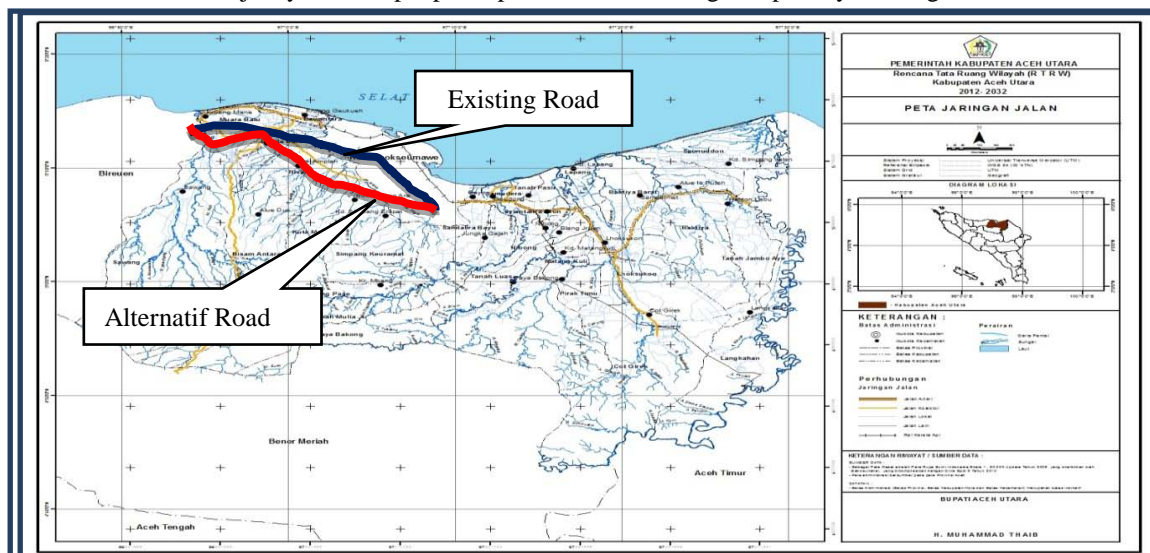
Figure 1. Map of Road Network. Source: Dinas Bina Marga Kab. Aceh Utara (2012)

In this study, there are 3 (three) conditions of location description (Fig. 1), i.e., existing road, alternative road (without project), and alternative road (with project).
a.   Existing Road, is a national trunk road of Banda Aceh–Medan, located at STA 241+000(Sp. Krueng Mane) and STA 274+550 (Buket Rata),
b.   Alternative road (without project), is an alternative road that has not been completed about 6,5 km yet, located at Sp. Krueng Mane–Buket Rata passing by Gp. Alue Awe
c.   Alternative road (with project), is an alternative road assuming the completed built construction of (b)

Data Collection Methods

Data type for this study consists only the secondary data. The data obtained from government institutions in North Aceh District and Aceh Province are as follows: population of North Aceh District, Gross Domestic Regional Product (GDRP) year 2010–2014, Master Plan of North Aceh District (RTRW) year 2012–2032, Agricultural and livestock production data from the Department of Agriculture of North Aceh District, and Map of road network from Department of Highways North Aceh District.

Farming Production without Road Project

1. Rice Farming sector

    Production of rice farming considered in this study was the amount of benefit to farmers for once harvesting time, in particular in Nisam and Kuta Makmur sub–districts. Farmer profits derived from production costs minus operating costs that include land rover, preparation of the land, seedlings, seeds, planting, fertilizing, spraying (treatment), and harvest. For this study, agriculture (paddy) farmers' profits derived from the calculated cost of production is reduced by operating expenses include land plowed, land preparation, seedlings, seeds, rice cultivation, fertilizing, spraying, and crop. It is assumed that, the benefit acquired by the farmer is the total revenue (with project) minus the total revenues (without project).Rice farming production in Nisam and Kuta Makmur sub–districts without project is shown in Table 1.

Table 1. Rice Farming Production (without project)

No	Sub–District	Harvested Area (Ha)	Rice Production (ton/ha)			
			2012	2013	2014	2015
1.	Nisam	3,604	7.70	7.63	6.15	6.93
2.	Kuta Makmur	3,145	5.61	6.01	5.31	5.32

2. Poultry Farming sector

    Production of poultry farming considered in this study was the total net revenue acquired from profits subtracted by the expenses. Profits is derived from the entire poultry selling. Expenditure costs consist of investment, operating cost and depreciation costs. Similar to assumption above, the benefit was acquired from the difference between the total revenue (with project) and the total revenue (without project).

Table 2. Poultry Farming Production (without project)

No	Sub–District	Poultry Production (unit)			
		2012	2013	2014	2015
1.	Nisam	350	250	15,980	16,050
2.	Kuta Makmur	1,001	11,592	20,485	21,030

Results and Discussion

Rice farming/paddy production in Nisam and Kuta Makmur sub–districts were 41,371,370 kg (41,370.37 tons), with average production of 6.13 tons/ha. The planting area of those sub–districts was 7,577 hectares with harvested area of 6,749 Ha. Producer surplus (without project) was obtained at Rp408,747,975,300,– per harvest season, while producer surplus (with project) was obtained at Rp453,177,103,050,–. The farmer's profit margin was about Rp44,429,127,750,–. Rice production in those sub districts was influenced by irrigation. Water limitation often resulted the crop failure. Although it requires high operating costs, the local government has paid much attention to maintain the high quality of rice production. Details can be seen in Table 3 and Table 4.

Rice Farming/Paddy Production Profit

According to local farmers, based on on–site interviews, rice production is considerably affected by the limitations of water, due to the un existed of irrigation. As a results, the farmers have to wait for rainy season. In addition, the logistic cost of grain is quite high. Hence, they expect that, with the completion of Krueng Mane–Buket Rata road construction, the transport logistic of grain will be reduced and the farmers can sell the products at reasonable price.

Table 3. Rice Farming/Paddy Production Prediction (without Project)

No	Year	Sub-Districts	Planting Area (Ha)	Harvested Area (Ha)	Paddy Production (ton/Ha)	Paddy Production (kg)	Production (@Rp. 4600/kg)	Intensification Cost /Operation (Rp.)	Farmer's Benefit (Rp)
1		2	3	4	5	6	7	8	9
1	2017	Nisam dan Kutamakmur	7577	6749	6,13	41.371.370	Rp 190.308.302.000	Rp 161.762.056.700	Rp 28.546.245.300
2	2018	Nisam dan Kutamakmur	7577	6790	7,00	47.530.000	Rp 218.638.000.000	Rp 185.842.300.000	Rp 32.795.700.000
3	2019	Nisam dan Kutamakmur	7577	6790	7,30	49.567.000	Rp 228.008.200.000	Rp 193.806.970.000	Rp 34.201.230.000
4	2020	Nisam dan Kutamakmur	8900	7500	6,50	48.750.000	Rp 224.250.000.000	Rp 190.612.500.000	Rp 33.637.500.000
5	2021	Nisam dan Kutamakmur	8900	7500	8,00	60.000.000	Rp 276.000.000.000	Rp 234.600.000.000	Rp 41.400.000.000
6	2022	Nisam dan Kutamakmur	8900	7500	7,50	56.250.000	Rp 258.750.000.000	Rp 219.937.500.000	Rp 38.812.500.000
7	2023	Nisam dan Kutamakmur	10230	9320	7,50	69.900.000	Rp 321.540.000.000	Rp 273.309.000.000	Rp 48.231.000.000
8	2024	Nisam dan Kutamakmur	10230	9320	7,50	69.900.000	Rp 321.540.000.000	Rp 273.309.000.000	Rp 48.231.000.000
9	2025	Nisam dan Kutamakmur	10230	9320	8,00	74.560.000	Rp 342.976.000.000	Rp 291.529.600.000	Rp 51.446.400.000
10	2026	Nisam dan Kutamakmur	10230	9320	8,00	74.560.000	Rp 342.976.000.000	Rp 291.529.600.000	Rp 51.446.400.000
		Total	90351	80109	7,34	592.388.370	Rp 2.724.986.502.000	Rp 2.316.238.526.700	Rp 408.747.975.300

Table 4. Rice Farming/Paddy Production Prediction (with Project)

No	Year	Sub-Districts	Planting Area (Ha)	Harvested Area (Ha)	Paddy Production (ton/Ha)	Paddy Production (kg)	Production (@Rp. 5100/kg)	Intensification Cost /Operation (Rp.)	Farmer's Benefit (Rp)
1		2	3	4	5	6	7	8	9
1	2017	Nisam dan Kutamakmur	7577	6749	6,13	41.371.370	Rp 210.993.987.000	Rp 179.344.888.950	Rp 31.649.098.050
2	2018	Nisam dan Kutamakmur	7577	6790	7,00	47.530.000	Rp 242.403.000.000	Rp 206.042.550.000	Rp 36.360.450.000
3	2019	Nisam dan Kutamakmur	7577	6790	7,30	49.567.000	Rp 252.791.700.000	Rp 214.872.945.000	Rp 37.918.755.000
4	2020	Nisam dan Kutamakmur	8900	7500	6,50	48.750.000	Rp 248.625.000.000	Rp 211.331.250.000	Rp 37.293.750.000
5	2021	Nisam dan Kutamakmur	8900	7500	8,00	60.000.000	Rp 306.000.000.000	Rp 260.100.000.000	Rp 45.900.000.000
6	2022	Nisam dan Kutamakmur	8900	7500	7,50	56.250.000	Rp 286.875.000.000	Rp 243.843.750.000	Rp 43.031.250.000
7	2023	Nisam dan Kutamakmur	10230	9320	7,50	69.900.000	Rp 356.490.000.000	Rp 303.016.500.000	Rp 53.473.500.000
8	2024	Nisam dan Kutamakmur	10230	9320	7,50	69.900.000	Rp 356.490.000.000	Rp 303.016.500.000	Rp 53.473.500.000
9	2025	Nisam dan Kutamakmur	10230	9320	8,00	74.560.000	Rp 380.256.000.000	Rp 323.217.600.000	Rp 57.038.400.000
10	2026	Nisam dan Kutamakmur	10230	9320	8,00	74.560.000	Rp 380.256.000.000	Rp 323.217.600.000	Rp 57.038.400.000
		Totak	90351	80109	7,34	592.388.370	Rp 3.021.180.687.000	Rp 2.568.003.583.950	Rp 453.177.103.050
		The difference of farmer's benefits = Rice Farming/Paddy Production *(with project)* - Rice Farming/Paddy Production *(without project)*							Rp 44.429.127.750

Poultry Farming Production Profit

Livestock is an integral part of the development along with the development of a region. Poultry farming, broiler chicken in this case, was purchased by traders at low prices. High cost of transportation could probably be impacted by the unfinished construction of an alternative road. If the road finishes, transportation costs will be much cheaper, and farmers can directly sell their products to local traders in the city.

Details of the investment cost for poultry farming, broiler chicken in this case, covering the land provision until the office equipment. The depreciation cost were Rp161,380,000,– and Rp10,818,300,– respectively. Total producer surplus over 10 years (without project) was Rp. 2,155,994,800,– while the total producer surplus (with the project) was Rp. 2,576,244,800,–. The profit margin was about Rp. 420,250,000,–. Details can be seen in Table 5 and Table 6.

Table 5. Poultry Farming Production Prediction (Without Project)

No	Year	Credit				Debet				Net Profit Total (Rp.)
		Poultry Production (Kg)	Price per Kg (Rp.)	Production Price (Rp.)	Total (Rp)	Investment Cost (Rp)	Operating Cost (Rp.)	Depreciation Cost (Rp.)	Total (Rp.)	
1	2	3	4	5 = (3*4)	6	7	8	9	10 = (7+8+9)	11 = (6-10)
1	0	-	-	-	-	Rp 161.380.000			Rp 161.380.000	Rp (161.380.000)
2	2017	9.000	Rp 17.000	Rp 153.000.000	Rp 153.000.000		Rp 97.522.500	Rp 10.818.300	Rp 108.340.800	Rp 44.659.200
3	2018	18.000	Rp 17.000	Rp 306.000.000	Rp 306.000.000		Rp 152.645.000	Rp 21.636.600	Rp 174.281.600	Rp 131.718.400
4	2019	18.000	Rp 20.000	Rp 360.000.000	Rp 360.000.000		Rp 152.795.000	Rp 21.636.600	Rp 174.431.600	Rp 185.568.400
5	2020	18.000	Rp 20.000	Rp 360.000.000	Rp 360.000.000		Rp 156.945.000	Rp 21.636.600	Rp 178.581.600	Rp 181.418.400
6	2021	18.500	Rp 21.000	Rp 388.500.000	Rp 388.500.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 207.418.400
7	2022	20.000	Rp 24.000	Rp 480.000.000	Rp 480.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 298.918.400
8	2023	20.500	Rp 24.000	Rp 492.000.000	Rp 492.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 310.918.400
9	2024	20.250	Rp 24.000	Rp 486.000.000	Rp 486.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 304.918.400
10	2025	21.000	Rp 24.000	Rp 504.000.000	Rp 504.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 322.918.400
11	2026	21.250	Rp 24.000	Rp 510.000.000	Rp 510.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 328.918.400
	Total	184500	Rp 215.000	Rp 4.039.500.000	Rp 4.039.500.000		Rp 1.516.577.500	Rp 205.547.700	Rp 1.722.125.200	Rp 2.155.994.800

Table 6. Poultry Farming Production Prediction (With Project)

No	Year	Credit				Debet				Net Profit Total (Rp.)
		Poultry Production (Kg)	Price per Kg (Rp.)	Production Price (Rp.)	Total (Rp)	Investment Cost (Rp)	Operating Cost (Rp.)	Depreciation Cost (Rp.)	Total (Rp.)	
1	2	3	4	5 = (3*4)	6	7	8	9	10 = (7+8+9)	11 = (6-10)
1	0	-	-	-	-	Rp 161.380.000			Rp 161.380.000	Rp (161.380.000)
2	2017	9.000	Rp 19.000	Rp 171.000.000	Rp 171.000.000		Rp 97.522.500	Rp 10.818.300	Rp 108.340.800	Rp 62.659.200
3	2018	18.000	Rp 20.000	Rp 360.000.000	Rp 360.000.000		Rp 152.645.000	Rp 21.636.600	Rp 174.281.600	Rp 185.718.400
4	2019	18.000	Rp 21.000	Rp 378.000.000	Rp 378.000.000		Rp 152.795.000	Rp 21.636.600	Rp 174.431.600	Rp 203.568.400
5	2020	18.000	Rp 23.000	Rp 414.000.000	Rp 414.000.000		Rp 156.945.000	Rp 21.636.600	Rp 178.581.600	Rp 235.418.400
6	2021	18.500	Rp 22.500	Rp 416.250.000	Rp 416.250.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 235.168.400
7	2022	20.000	Rp 25.000	Rp 500.000.000	Rp 500.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 318.918.400
8	2023	20.500	Rp 26.000	Rp 533.000.000	Rp 533.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 351.918.400
9	2024	20.250	Rp 27.000	Rp 546.750.000	Rp 546.750.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 365.668.400
10	2025	21.000	Rp 27.000	Rp 567.000.000	Rp 567.000.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 385.918.400
11	2026	21.250	Rp 27.000	Rp 573.750.000	Rp 573.750.000		Rp 159.445.000	Rp 21.636.600	Rp 181.081.600	Rp 392.668.400
	Total	184500	Rp 237.500	Rp 4.459.750.000	Rp 4.459.750.000		Rp 1.516.577.500	Rp 205.547.700	Rp 1.722.125.200	Rp 2.576.244.800
The Difference of Netto = Netto (with project) - Netto (without project)										Rp 420.250.000

Economic feasibility

The economic feasibility of the road acquired up to 15 years at a discount rate of 10% was 0.26 BCR–NPV Rp 46,670,732,443,– discount rate of 12% BCR–0.23 with NPV Rp 44,619,364,879,– and at a discount rate 15 0.20% is BCR–NPV Rp 41,490,126,401,–. Economic Internal Rate of Return (EIRR) is a scale that indicates the level of return on investment as a result of the implementation of alternative road development Krueng Mane – Buket Rata based on the interest rate that produces the BCR > 1 when NPV = 0,–. The results showed, the alternative road development of Krueng Mane – Buket Rata was still eligible up to 17.40% discount rate. This results indicated that the road development has impact to the increase of agricultural and livestock farming production as can be seen in Table 7.

Table 7. Economic Feasibility of the alternative road

Economic Feasibility Criteria		DISCOUNT RATE			
		10,00%	12,00%	15,00%	17,40%
Benefit Cost Ratio	BCR	1,47	1,32	1,13	1
Net Present Value (Rp.)	NPV	29.295.628.360	18.338.235.130	6.536.189.231	0
Internal Rate of Ratio	IRR	17,40%			

Conclusions

The economic feasibility of the remaining alternative road construction was still feasible up to 17.40% of discount rate, since current bank interest rate is around 6–8%. It indicates that the alternative road project development at Krueng Mane–Buket Rata influences the production of rice farming and livestock farming in Nisam and Kuta Makmur sub–districs. In addition to that, the road network is also important for the accessibility between those regions.

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Reliability Evaluation of Structural Columns that Affected by Tsunami in Mina Building Hajj Dormitory Banda Aceh

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Abstract

Devastating Tsunami which hit Aceh in 2004, has a direct impact during the incident and a direct impact which until now has become problems to buildings that affected by the Tsunami. Construction of buildings were damaged on the reinforced concrete structure that exposed by tsunami water. One is the Mina Building in Hajj Dormitory Banda Aceh. That condition affects reliability of buildings. The evaluation is conducted directly to the field by reviewing the structural elements of the columns, beams, floors and stairs plate. The review does in the form of visualization of structural elements, and review the quality of concrete, steel reinforcement condition, condition of cracks and determined the level of damage to the building according to Minister of Public Works regulation No. 24/PRT/M/2008 on Guidelines for Maintenance and Treatment of Building and Minister of Public Works regulation No. 16/PRT/M/2010 on Technical Guidelines for Periodic Inspection Building. The evaluation show concrete condition on the column that affected by the tsunami is porous and the strength of concrete structural been crash. Steel reinforcement had been a change in diameter due to corrosion. All columns that affected by Tsunami were damaged in different level of intensity between 50–80cm above the ground. The differences of intensity damaged cause by presence wall on the side of the column. The result showed that the strength of the column is not able to serviceability load building. Damaged sustained in the structural elements of the column, so it can be classified as heavy damaged. Buildings are advised to be handled by improving the broken column or unpacking, if it is considered is not economically viable to repair.

Keywords : Reliability, column structure, mina building, tsunami.

Introduction

Building is physical manifestation of a construction work that integrates with its domicile, and serves as place of human being do various activities, for living, business activities, social, culture and special activities (Anonym, 2002). A building must have the resilience and strength to ensure the safety of those who indulge in it. Loss of function of the building can be caused by human activity or due to a natural occurring beyond previous estimates.

A major natural disaster which hit Indonesia in late 2004, beside lead to deaths and damaged of property, also leads to malfunction of the building infrastructure. The earthquake on December 26 caused the biggest victims along the history of Tsunami. This earthquake killed about 180.000 people in various countries such as Indonesia (Aceh and Nias), Sri Lanka, India, Thailand, Myanmar and Malaysia. This disaster resulted in tremendous damage to infrastructure, particularly in coastal area shit by the waves of tsunami.

Current condition lots of reinforced concrete construction building get a porous and some have not livable despite the concrete structures suffered minor damage. Some have changed or get deformation structures that been classified in the category of heavily damaged. The concrete condition which has been porous in reinforced concrete structures is predicted to have decreased strength of concrete. The study was conducted to evaluate the structure column of Mina Building in Hajj Dormitory Banda Aceh. The building is one of the buildings affected by the tsunami on December 26th, 2004. Existing condition today shows that all the fields affected by the tsunami have experienced porous, and some have already spall and crashes. Dimensional condition of reinforcement is not full anymore because has been corroded.

Changes in the strength of the concrete caused by the tsunami in the column structure can affect of building strength. Building of a tsunami (Rochman, 2006) will be damaged from the mildest; medium until

heavy damaged depends on the duration of tsunami. Part of the building column which affected by tsunami has decreased the concrete strength compared with the part not affected by tsunami (Riskawati, 2015).

The low quality of concrete in this building became one of the causes of damage to the building structure, because the main characteristics of the concrete material is very strong receiving compressive load, so to determine the quality of concrete, in general based on the strong concrete (Hartono, 2007). Concrete compressive strength will decrease if there is damage to the concrete, such as cracks. Crack is cracks on the surface of the concrete due to shrinkage, deflection due to dead load and live load, due to the earthquake and the temperature difference higher during the drying process. Cracks can determine in three types:
1. Small crack with width of crack less than 0,5 mm
2. Medium crack with width of crack between 0,5mm–1,2 mm
3. Big crack with width of crack more than 1,2 mm

The column is element types of stem compression that has function to pass the burden of the system to foundation floor. The damaged in column is medium damaged. The damaged in column are the broken of column concrete and bending of some main column reinforcement. The damaged in beam is medium damaged, the destruction of the concrete beams as well as the release of the bond between columns and beams are showing poor workmanship of the installation of reinforcement (Fauzan, et al. 2010).

The damaged of building rated based on Damage index. A structure with certain ductility when exposed to seismic loads with a specific return period of earthquake resistance should have conformed to the plan, so the level of damage is known (Ratih, 2013).

The following are some of parameter of building damages:
- The plastically deformation of building structure
- Energy dissipation through hysteretic behavior on structure element
- The less cyclic fatigue on structure element
- The changes of structure dynamic parameters, for example in natural period of building structure

The Minister of Public Works Regulation Number 24/PRT/M/2008 (Anonym, 2008) on Guidelines for Maintenance and Treatment of Building, said that criteria of building damaged level can categorized in three level of damaged:
a. Minor damaged
   1. Minor damage especially on non–structural components, such as roofing, ceiling, floor coverings, and wall charger.
   2. Treatments for minor damaged, the fee is a maximum of 35% of the highest unit price to build new building which is applicable, for the type/class and the same location.
b. Medium damaged
   1. Medium damaged is damage to the majority in non–structural components, or structural components such as roof structure, floor, and others.
   2. Treatments for medium levels of damage, the fee is a maximum of 45% of the highest unit price to build new building which is applicable, for the type/class and the same location.
c. Heavy damaged
   1. Heavy damaged is heavy damage to most of the components of the building, structural and non–structural when once fixed premises can still function well as it should.
   2. It costs a maximum of 65% of the highest unit price to build new building that applies, for type/class and the same location.

The criteria of damaged level for assessment needs defined as follows:
a. Minor damaged: the structural or non–structural elements suffered only minor damage (minor) that does not affect performance or architectural structures.
b. Medium damaged: the structural or non–structural elements have been damaged by minor deterioration, loss extents, flaking, cracking, and other yet or only slightly affect performance or architectural structures.
c. Heavy damaged: the structural or non–structural elements have been damaged by a major deterioration, loss extents, flaking, cracking, and other structures that affect performance or architecture

Experimental Methods

Data Collection Methods
The method used at the time of examination building damage in Mina Building Hajj Dormitory Banda Aceh is direct observation to the building element (primary data collection). After the initial review of the building then second data is conducted such as determine the type of construction, parts of the building were broken and photographs of damaged parts.

The Minister of Public Works Regulation Number 16/PRT/M/2010 (Anonym, 2010) on Technical Guidelines for Periodic Inspection Building said that for structural inspection is done by:

a. Visual inspections, carried out on part of building or whole buildings
b. Materials quality inspection, conducted to examine the quality of materials and strength of the material structure by test equipment appropriate material especially after fire disaster, earthquake disaster and others natural disaster.
c. Model analysis, conducted to examine the structural support either for all or part of building, especially for buildings that are changes in the function, room layout, or after natural disaster, by static structure analysis or dynamic analysis.
d. Load test, if inadequate model analysis

Primary data collected by review the existing building. The damage data collect by following methods:

- Capture part of building or structure element that having damaged
- Size the column, level of tsunami water that affected the building, size and analysis the cracks
- Overview of the displacement, bending or deflection of building structural elements such as columns, also on beam, floor and others.
- Listing of non–structural elements of the building were damaged, such as doors, windows, ceilings, walls and other equipment.

Evaluation the Reliability of Building Condition

Evaluations and studies conducted at testing only focused on the safety of the structure of the building. Then, also review of non–structural in the building, especially on the building walls, ceiling and floor tiles. From the evaluation and analysis of data collected from the field, then determined the level of damage to buildings and recommended the follow–up to the building. The level of building damage defined based on The Minister of Public Works regulation No. 24/PRT/M/2008 on Guidelines for Maintenance and Treatment Building and Minister of Public Works regulation No. 16/PRT/M/2010on Technical Guidelines for Periodic Inspection Building. Evaluation of the field, the affected structural elements are dominant in terms column. There are two types of columns in the building, square columns with reinforcement stirrup square and round columns with spiral reinforcement stirrup. The entire column is affected by the tsunami damage either on circular columns or on square columns..

Results and Discussion

Evaluation result

The results of field observations seen the condition of the building columns have been damaged, although some columns have been repaired, but the condition of concrete started to peel. Almost columns affected by the tsunami, is already showing damage and the concrete is no longer functioning as expected. Cement as a binding element is no longer working at the concrete and the adhesions among aggregates have been lost, thus reducing the strength of concrete. Decrease in the strength of concrete results in the strength of the column to be reduced and greatly affect the strength and reliability of buildings. This condition is very dangerous in case of earthquake disasters.

Figure1. The concrete damage and reinforcing damaged by corrosion of column.

Evaluation of longitudinal reinforcement showed that the damaged longitudinal reinforcement. Column that has been chipped concrete cover, all the longitudinal reinforcing had corrodedand got reduction in dimensions. The ionization process in the column continues to occur, it effect increasing the potential corrosion. According Susanto, et al. (2016), buildings affected by the tsunami impaired surface potential at any time. Potential impairment caused by passivation of the reinforcement and some reinforcement in concrete to rust.

The results of the study conducted on all the columns of the building, found that almost the entire column damage. The damage in column that affected by tsunami with a height of 50–80 cm from the ground. Based on interview of the officer, tsunami heights in these areas ranged from 30–100 cm. this show us all damaged of the column caused by tsunami. Damage that occurs are flaking concrete, the main reinforcement corrosion and corrosion of reinforcement stirrups.

Results of analysis of the damage caused to the structure of the building's columns show that with the deterioration of the concrete, will caused reducing the building ability to bear the burden. The potential of steel reinforcement corrosion continued to increase and caused the decreased of reinforcement dimensional. Some of the bar and spiral has broken so confining effect of main reinforcement become weak. The corrosion of stirrups bar resulting weakening of the shear strength in the column. Improved corrosion potential can also cause concrete cover being open as shown in Figure 2. On the pitch is also seen that the dimensions of the column began to enlargement due to weak concrete quality and compression reinforcement due to corrosion. It is very influential on the strength of the column and being susceptible to shear failure in the column during an earthquake and the building will fail.

Figure 2. Reinforcing ties are broken due to corrosion.

Discussion

The damage of column by tsunami affected can be identified in the form of concrete failure, damage of longitudinal reinforcement and rupture of reinforcement stirrup. Concrete damage that occurs in the form of a decrease in the quality of concrete causes the column strength decreases it does not correspond to the quality of concrete design of columns. Damage to the longitudinal reinforcement due to corrosion, resulting in changes in the shape and dimensions of reinforcement due to the massive layer formed on the surface of steel reinforcement, and be a concrete cover to spall. And, reinforcement dimensions and reduced cross–sectional area of reinforcement in columns. Longitudinal reinforcement is an element bearer bending moments and compressive load on the column. The bending moment in the column occurs when the load work in the horizontal direction on the building or if earthquake hazard, so that the longitudinal reinforcement will determine the flexural strength of columns.

Other damage in the tsunami affected of column is the corrosion of the reinforcement stirrup. Stirrup shape in the building is a square cross bar on the square–shaped column and spiral stirrup in the circle column where all reinforcement stirrup also corrosion. In some columns, reinforcement ties are broken and was not seen again. One of the functions of reinforcement stirrups are as bearers of the sheer force. In addition, the reinforcement stirrups also serve as a restraint on longitudinal reinforcement in columns. Longitudinal reinforcement to prevent buckling in longitudinal reinforcement. Reinforcement stirrup also provide confining effect to the concrete in resisting the compressive force. so the column with stirrup is broken, greatly affect the strength of reinforced concrete columns at the building.

The discussion could be said that condition of reinforced concrete columns in a building by the tsunami affect, have been classified as severely damaged. The damage that occurs in the third column material(concrete, longitudinal reinforcement and reinforcement stirrup) have a negative impact on structures. Even the decline in field strength can cause failure of the building, mainly due to the earthquake which often occur in Aceh. For that purpose, it is recommended that the building is temporarily not used until the column structure improvements that have been damaged by the tsunami

From the results of studies conducted, it appears that the columns of the building is already included in the heavy damage. This is caused by the loss of concrete strength due to the tsunami and weak strength of steel reinforcement due to corrosion. The breaking of the steel reinforcement stirrup also affects the stiffness of the main reinforcement in columns, the confinement of concrete core and also happen weakening of the shear strength of the column.

Based on the description and in accordance with the Regulation of the Minister of Public Works No.24/PRT/M/2008 on Guidelines for Maintenance and Treatment Building and Public Works Minister Regulation No.16/PRT/M/2010 on Technical Guidelines for Periodic Inspection Building, this building can be classified as severely damaged the building level. The reason was listed in the damaged level is the result of damage to most of the components of the building, both structural and non–structural when once fixed can still function well as it should. From these results, it is suggested follow–up to this building to be remedied in order not severely damaged or collapsed. If it is not possible economic value to be repaired, it is recommended to immediately dismantle the building.

Conclusions

The results of a review and evaluation of structural damage to the building columns Mina Hajj Dormitory Building Banda Aceh can be concluded that the building is included in the rate of heavy damage. Almost all the fields affected by the tsunami have been damaged with different levels of damage. Damage to the column marked by the collapse of the concrete cover and peeled aggregate concrete forming, the reduced dimensions of the main reinforcement due to corrosion and corrosion of the reinforcement stirrups off. Concrete damage that occurs in the form of a decrease in the quality of concrete causes the column strength decreases it does not correspond to the quality of concrete design of columns. Damage to the longitudinal reinforcement due to corrosion, resulting in changes in the shape and dimensions of reinforcement. Stirrup shape in the building is a square cross bar on the square–shaped column and spiral stirrup in the circle column where all reinforcement stirrup also corrosion. As a result of the damage, the building is classified as severely damaged the building level. The building expected to not be used again and promptly corrected, or if no economic value to correct it immediately should the building be demolished.

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Characterization of Hot Spring Outflow in Geothermal Area of Seulawah Agam's Ie–Seu'um, Aceh–Indonesia Using Induced Polarization Method

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Abstract

The study was implemented at Ie–Seu'um geothermal area, Aceh Besar, Aceh (Indonesia) with the temperature at the hot spring is about 80~90°C. The study was conducted using Induced Polarization (IP) method with the aim is to characterize of the hot spring flow. The surveys were designed with 4 lines of the pole–dipole array and 2 m minimum electrode spacing. The survey lines were plotted across of the 4 sources of hot spring flow. The sources are separated approximately 3 m between of the source. The data was processed using Res2Dinv software. The result shows that at the subsurface of the hot spring flow consists of saturated rocks with charge ability value of 1–2 msec and are identified the water with sulfur containing. The mostly main conductive zone exists at the L1 profile because this line was put above the mounts of hot spring, whereas the other profiles just revealed the small part of conductive zones which are relatively far from the Ie–Su'um hot spring. The other information are obtained the highly clayed zones primarily from the L2 and L3 profiles, where from the L4 profile is a blended feature between conductive zone, quartzite rock and volcanic rock. The chargeability value of conductive zone is in 1–2 msec in range, while the clayed zone has the highest chargeability which is a 35– in msec.

Keywords : Hot spring, geothermal, Ie–Seu'um, IP method.

Introduction

The geothermal energy is recently a worldwide developing issue for a gradually diverted energy of global needs that are currently dominated by fossil fuel whose a very long time of its process within sedimentary rocks. Beside that effect of its usage has contributed toward the global warming, so that the effort of geothermal energy prospecting is really encouraged by conducting an exploration using one of the suitable geophysical methods related to geothermal system setting, such as magneto telluric (MT), gravity, magnetic, seismic reflection and induced polarization (IP) whose their own advantages and disadvantages.

Geophysical methods play a key role in geothermal exploration since many objectives of geothermal exploration can be achieved by these methods. The geophysical surveys are directed at obtaining indirectly, from the surface or from shallow depth, the physical parameters of the geothermal systems. A geothermal system is made up of four main elements: a heat source, a reservoir, a fluid, which is the carrier that transfers the heat, and a recharge area. The heat source is generally a shallow magmatic body, usually cooling and often still partially molten. The volume of rocks from which heat can be extracted is called the geothermal reservoir, which contains hot fluids, a summary term describing hot water, vapor and gases (Manzella, 2000). The hot fluids originated from deep source rises up onto the surface becoming various manifestations such as hot spring as outflow, geyser mud pools, and fumaroles. These manifestations physically come out through fractures or veins. To study the characteristic of mineralization around manifestation has effectively utilized the Induced Polarization (IP). The main reason for using IP in a mineralized rock is passing reaction of stimulated electron and current between metal and electrolyte ions. An IP event is the ion polarization between the electrode filled with electrolyte in the pore and the mineral conducting the electron. When the free pore passages of the metallic mineral are filled with electrolyte, the electric current sees a freeway. The mineral constructing the rock itself is highly resistant to the current passing from this freeway as usual, and the rocks resistance decreases in an important measure. Polarization is related to the amount of the current

passing through the rock, structure of the pores, type of the electrolyte, property of the rock and the faults (Tezel, *et al.*, 2010).

The Induced Polarization (IP) method is used to determine the ion zones in the rocks. IP method determines these areas with the help of break surface polarization which is made by ions in the rocks. IP reflects electrical resistivity and ion positions in the ground. It is one of the most frequently used methods in recent years. The measurement of the multiple parameters at the same time is an advantage of the IP method. In time domain IP direct current is sent to the ground with the help of two electrodes for a certain time and then it is cut off. Voltage which is coming from the ground will not be zero after we cut off the current. But it will be reached to the zero beginning from the certain value. The voltage that is taken from the ground, although without current, is developed as a result of spoiling polarization order of the ions in the rocks (Tezel, *et al.*, 2010).

This research was exactly conducted within the Seulawah Agam volcano area reaching to the one of its manifestations which is the Ie–Su'um hot spring and administratively included in Aceh Besar Regency of Aceh province, Indonesia and its geological background of the study area is generally litho logically dominated by Lamteuba volcano which consists of andesitic to dacitic volcanic, pumiceous breccia, tuffs, agglomerate and volcanic ash flow which intrude of the Seulimum formation composed of tuffaceous and calcareous sandstone , conglomerates and minor mudstones (Abubakar, *et al.*, 2015, and Nordiana, *et al.*, 2014 after Bennett, *et al.*, 1981). The detailed information about its geology describes that it is dominantly by the fine and coarse–grained and of tephra and only a apart of rhyolite and andesite in the South and the rest is the volcanic alluvial in the Northeast region. Furthermore, the area is also existed faults compartelized into several segments which are Aceh Fault closed to and passed the Ie–Su'um hot spring and its orientation is toward the Southeast–Northwest as marked by yellow color in Fig. 1 (Anonymous, 2016). These faults are highly probable to control the hydrothermal system of Seulawah volcano.
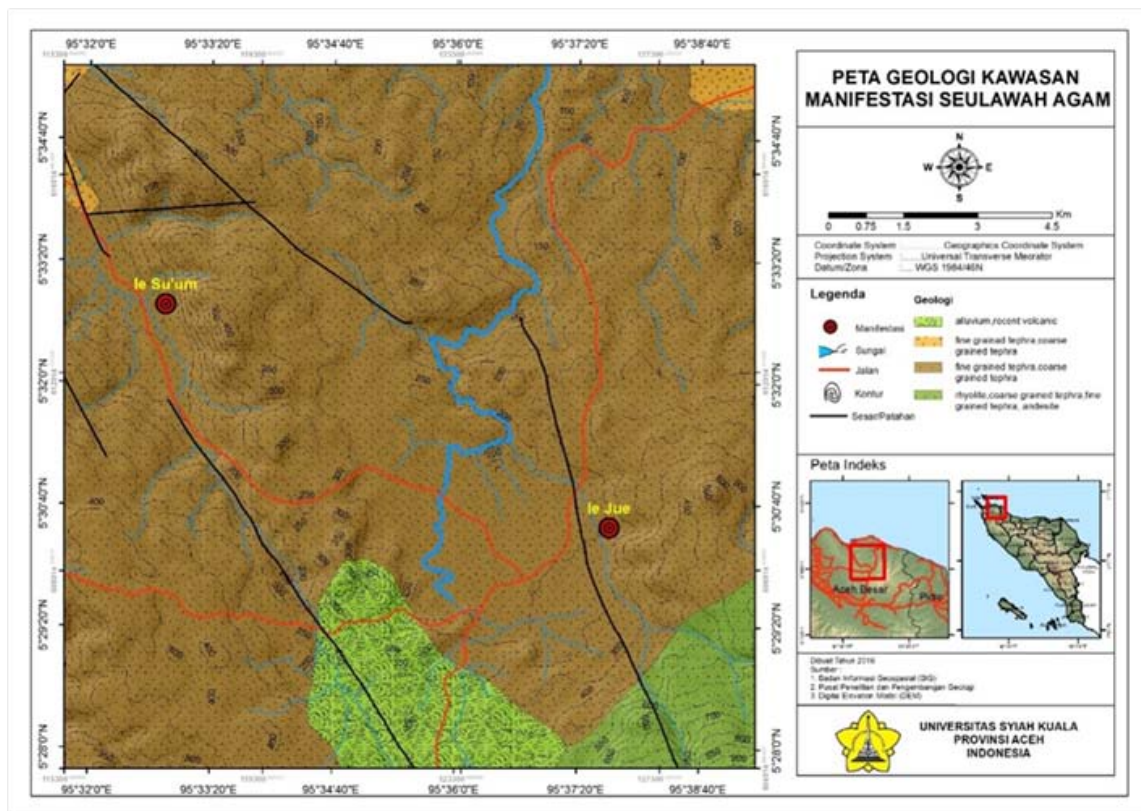
Figure 1. The geological map of the study area.

Methods

The data were carefully acquired by setting the four lines of plotting Pole–dipole array and the electrodes were spaced within 2 meters for the first two lines (line 1 and line 2), whereas the rest of lines (line 3 and line 4), their electrodes were in 5 meters spacing. All the lines were oriented around the Ie–Su'um hot spring. This survey equipment was deployed the ABEM SAS4000Terrameter consisting of smart cables and

stainless steel electrodes. To obtain the 2–D resistivity profile whose chargeability parameter, the data were modeled by using Res2Dinv software.

Results and Discussion

According to data processing, it was get the 2–D profiles of chargeability value of L1 until L4, as can be seen from the figure 2 to figure 5 below:
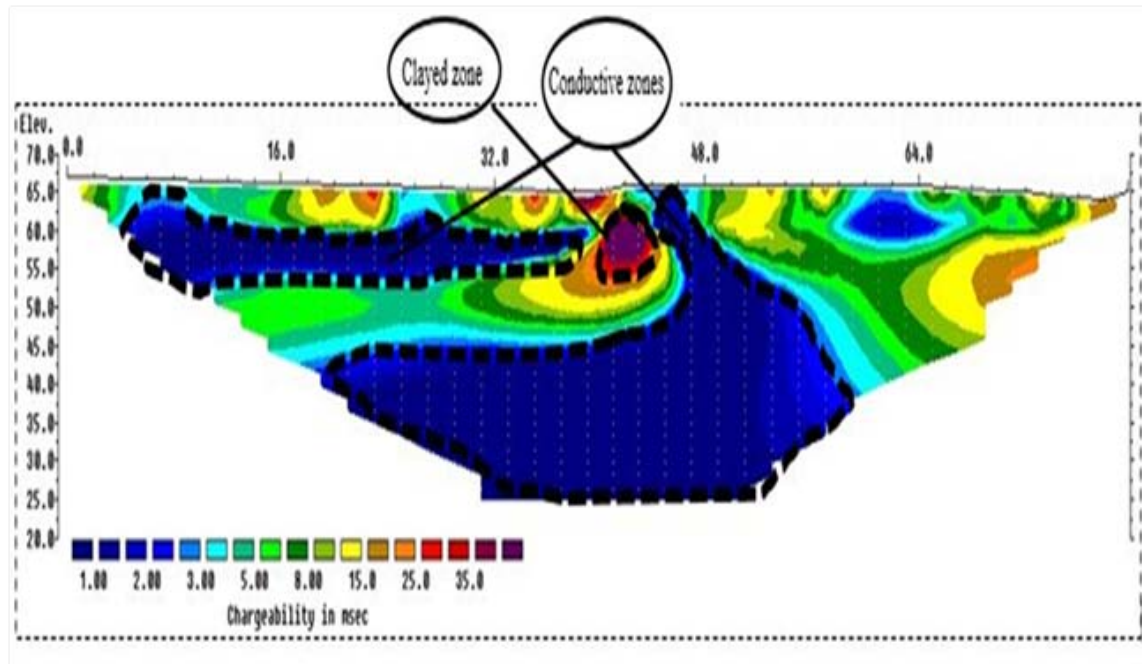
Figure 2. The 2–D chargeability value profile of L1

From figure 2 it can be pointed out that there is dominantly existed the conductive zone having the lowest chargeability value from 1–2 msec. That conductive zone is predicted as an outflow path of Ie Su'um hot spring because this profile is derived from the L1which was exactly arranged on the hot spring mounts and its depth starts from 30 to 50 meters, where laterally this crossed section of the conductive part is located from 20 to 58 meters.
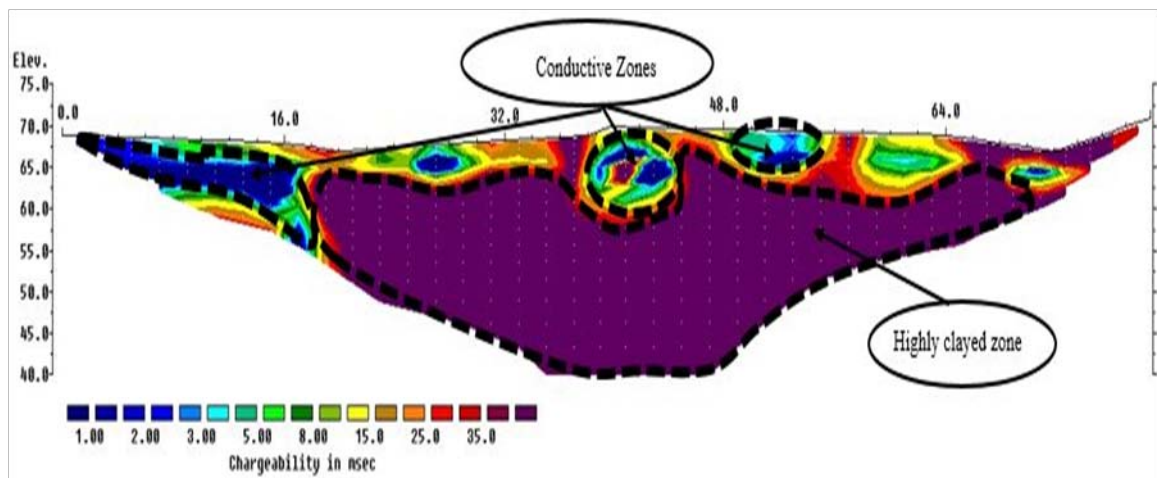
Figure 3. The 2–D chargeability value profile of L2.

The 2–D profile of L2 there are also pictured that the presence of conductive zones but they only small of parts. While the dominant feature is mostly a highly clayed zone which has the highest chargeability value around 35 msec. This part is projected as a high capacitance of originally volcanic rocks that have been

altered to sedimentary rocks which are clayed sediment and plays the important role to retain electrical current in longer time than another. This remarkable zone lies vertically from 10 until 25 meters depth reaching the bottom of its profile.
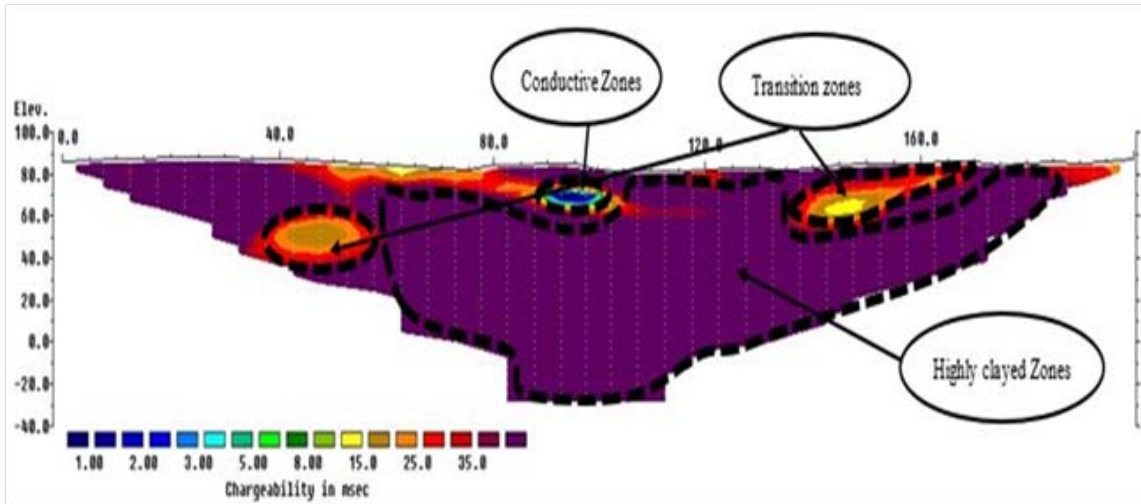
Figure 4. The 2–D chargeability value profile of L3.

This L3 profile of chargeability in figure 4 is mostly also consisted of the highly clayed zone and there are just a small apart of conductive zone and transition zones. The lithological information about its is more and less same as the L2 profile as elaborated above. However, the obtained depth is more higher than the previous two profiles this is because the electrodes in this line was laid out in 5 meters long, so then in consequence it has been get the deeper penetration of electrical current.
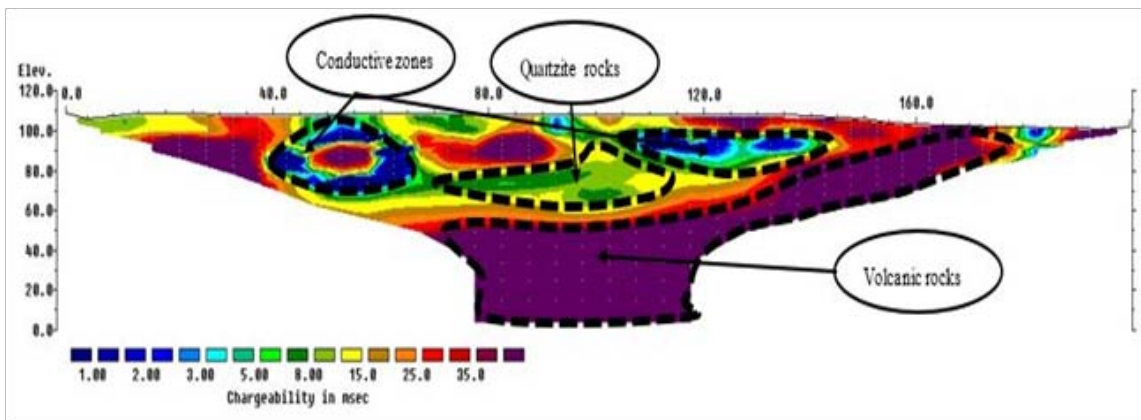
Figure 5. The 2–D chargeability value profile of L4.

From the last profile (Figure 5) it can be derived information about there are two conductive zones lie within a shallow depth surface and the is also an almost completely weathered of volcanic rocks that are possibly as a clayed layer having 35 msec its chargeability value. This layer is overlaid by an quartzite rock which is not found on the other 2–D profile. This feature has its chargeability 5–15 msec in range and its interpretation is referred to (Telford, *et al.*, 1976).

Conclusions

Based on the result and discussion it can be concluded that the mostly main conductive zone exists at the L1 profile because this line was put above the mounts of hot spring, whereas the other profiles just revealed the small part of conductive zones which are relatively far from the Ie–Su'um hot spring. The other information are obtained the highly clayed zones primarily from the L2 and L3 profiles, where from the L4 profile is a blended feature between conductive zone, quartzite rock and volcanic rock. The chargeability value of conductive zone is in 1–2 msec in range, while the clayed zone has the highest chargeability which is a 35–msec.

Acknowledgements

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Water Profile Estimation on River Flood Discharge by Using Hec–Ras (Case Study: Air Manjuto River, Bengkulu, Indonesia)

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Abstract

The purpose of this study is to calculate the return period flood discharge and designing specific height and location of flood protection embankments to Air Manjuto Bengkulu province. Flood discharge calculated using the Rational Method for some period (2, 5, 10, 25, 50 and 100 year). Water profile, Height and position of embankment analyzed using computer program HEC–RAS 4.1.0. The results of the study showed the maximum flood discharge river water Manjuto to discharge the 2, 5, 10, 25, 50 and 100 year return period amounted to 440, 706, 942, 1.249, 1.575, and 1.879 m³ / sec . In case of flooding for a return period of 100 years, runoff that occurs on the right side of the river just at station 24, 49, 74, 98, 122, 147, 171, 196, 220, 445, 947, 1450, 1952, 2455, 2957, 3459 , 3962, 4464, 4967, 5469, 5971, and 6474. While the runoff that occurs on the left side of the river just in station 9488, 9990, 10 493, 10995, 11498, and 12000. The conclusion of this study is Air Manjuto flooding caused by runoff that occurs in the left and right of the river. Therefore, the decision maker can use the output of the HEC–RAS program to develop programs of flood control on the Manjuto river. If the selected flood control efforts is the construction of embankments, the position and height of the embankments that will built to be adapted from the output of the HEC–RAS 4.1.0.

Keywords : Flood, water profile, HEC–RAS, Manjuto river.

Introduction

Floods are natural disasters that afflict almost all regions in the world today. The threat of flooding is a natural disaster that most frequently cause loss of property and lives (Di Baldassarre, 2012). Total area experiencing flooding continues to increase over time. therefore, the problem of flooding should be recognized as a priority program of government and society.

Planning of flood prevention programs require flood characteristic data. But, the availability of complete data is still a serious problem in many areas in Sumatra, Indonesia. However, advances in computer science and satellites can help obtain various data required. One of the computer software that has been popular among academics and practitioners are HEC–RAS. This software is a computer program to model the hydraulics one–dimensional and can be used for water flow through natural rivers and artificial (Croke, *et al.*, 2013). Already many researchers using HEC–RAS software for modeling flooding in various countries (Hicks and Peacock, 2005; Istiarto, 2011 ;. Olaniyan, *et al.*, 2014; Salajegheha, *et al.*, 2009; Sinnakaudan, 2009; Suharyanto, *et al.*, 2001 ;. Yang, *et al.*, 2006; Abdeveis, *et al.*, 2013; Hicks and Peacock, 2005; Salajegheha, *et al.*, 2009; Suharyanto, *et al.*, 2001). The results were satisfactory. This study intends to test the use of HEC–RAS software on a river that poor data. The research objective is to forecast the flood water surface profile on a return period of 2, 5, 10, 15, 25, 50 and 100 years. This study is part of a research titled model of water allocation in the context of adaptation and mitigation to climate change funded by the Ministry of Research and Technology from 2014 until 2016 years.

Material and Methods

Study Site
Research conducted in the Manjuto River, Residence of Mukomuko, and Bengkulu province (Figure 1.)
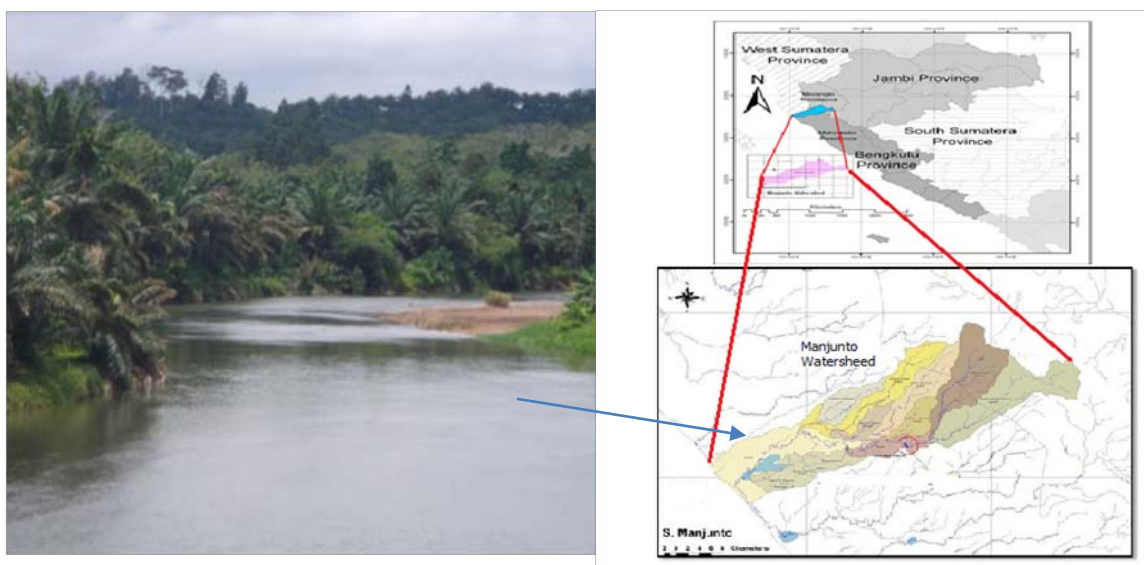
Figure 1. Location of research (Source: Gunawan, 2013)

Rainfall Data

Rainfall data is used daily rainfall from 1989 to 2015. The data obtained from the Department of Public Works (Central River Region VII Sumatra), Bengkulu Province, Indonesia.

Frequency Analysis of Rainfall Data

The procedures are applied to analyze the rainfall data that hydrological data were collected, calculated, presented and interpreted using frequency analysis methods. Statistical parameters used are Mean, standard deviation, coefficient of variation (Cv), Skewness coefficient (Cs), and kurtosis coefficient (Ck). The next test Normal Distribution, Log Normal, Gumbel and Log Person III. Selection of the type of test that distribution based on the distribution compatibility with the hydrological conditions in the watershed Manjuto, Bengkulu Province.

Rainfall Intensity

The formula used to determine the intensity of rainfall is Mononobe. The mathematical equation is as follows:

$$I = \frac{R_{24}}{24} \times \left[\frac{24}{t_c}\right]^{2/3} \tag{1}$$

Where :
I = the intensity of rainfall (mm/ hours);
R_{24} = Maximum Rainfall in 24 hours (mm);
Tc = time of concentration (hours).

Time Of Concentration (Tc)

Time of concentration is the time required by the rain water to flow from the furthest point to the outlet point. The method used to predict it is using Kirpich equation. The mathematical equation is as follows:

$$t_c = 0,06628 \times L^{0,77} \times S^{-0,385} \tag{2}$$

where:
tc = Time of concentration (hours)
L = Distance between the furthest point to the outlet point (m)
S = Slope

Flood Plan

There are several methods of analysis of flood discharge provided such methods Rational, Weduwen, Melchior, Haspers, Synthetic Unit Hydrograph Method (HSS) Nakayasu, HSS Gama I, and others. In this paper the method used to analyze the design flood discharge is Rational method. The mathematical equation is as follows:

$$Q_p = 0.287 \text{ C IA} \tag{3}$$

where:
Qp   = Peak discharge (m³/sec)
C   = Runoff coefisien
I   = Rainfall intensity (mm/sec)
A   = Cacthmen Area (m²)

Flow Modeling Using HEC RAS Software

Step modeling with HEC RAS software is as follows (USACE1:US–Army Corps of Engineers, 2002):
a.   Making the projectfile
b.   Geometry modeling channel by entering the channel geometry data.
c.   Modeling the flow channel by entering the data flow and the boundary conditions.
d.   Count hydraulics flow by executing the program.
e.   Presentation of the results by displaying the results on screen or print it.

Results and Discussion

Parameter Statistics of Rainfall Data

Statistical methods used to analyze the rainfall data is Normal Distribution, Log Normal, Gumbel and Log Person III. The result shows that distribution of rainfall data in the watershed Manjuto follow the distribution of Log Person III. Statistical parameter values in the DAS Manjuto rainfall data is as follows: Average = 1.253; Standard Deviation (Sd) = 0.091; Skewness coefficient (Cs) = –0, 201; Kurtosis coefficient (Ck) = 3.32 and a coefficient of variation (Cv) = 0.073. Furthermore, the suitability test to the rainfall data using the Chi–square test and Kolmogorov–Smirnov test. The result shows that the distribution of Log Pearson Type III relevant for the two tests.

Flood Plan

Flood plan will be used as input for the program HEC–RAS. The design flood peak discharge will be simulated are 2, 5, 10, 25, 50 and 100 years. The value of the design flood discharge for different return period is presented in Figure 2.

River Reach of Air Manjuto River

Air Manjuto River modeled in this study has a length of ± 12 km and cross section were 42 cross–section. The value of the Manning coefficient for the left and right banks is 0:30 and the value of the coefficient of Manning's main channel is 0:45. The coefficient of contraction and coefficient coefficients respectively 0.1 and 0.3
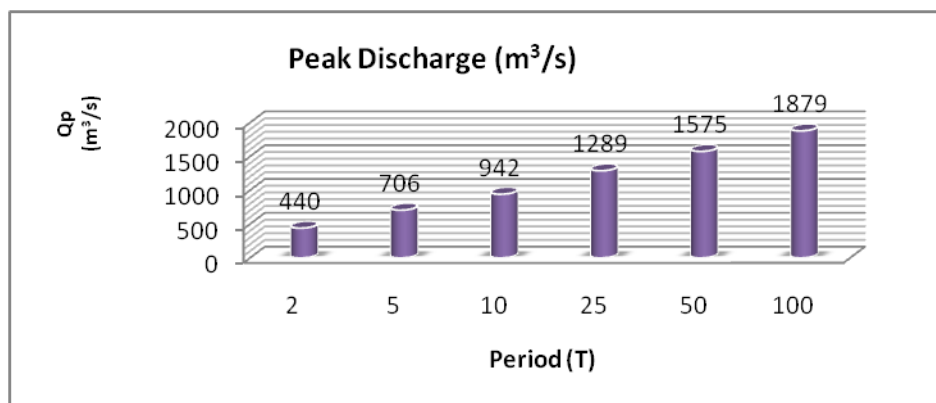
Figure 2. Peak discharge for some return period.

Water Profile of Manjuto River

Forecasting flood water surface profile performed to flood with return period of 2, 5, 10, 25, 50 and 100. Profile of water level is presented in Figure 3.
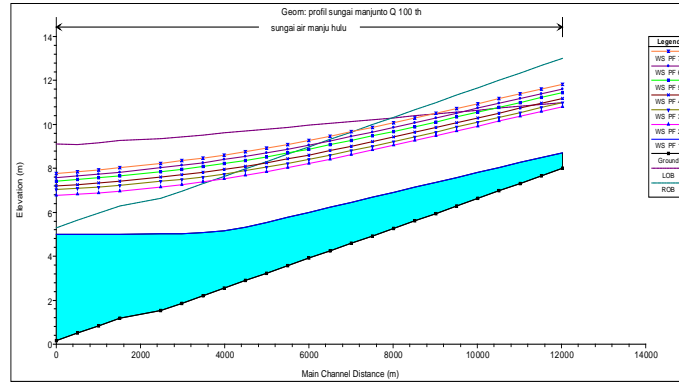
Figure 3. Water profile of Manjuto river for some periods.

The simulation results of water level for periods of 2, 5, 10, 25, 50 and 100 years respectively is 1.46; 1.73 m; 1.9 m; 2:12 am; 2.28 m and 2.46 m (Figure 3). In addition, HEC–RAS program also displays the condition of the channel cross section. In Figure 4 demonstrated a cross–river conditions using the input 2–year flood discharge plan (440 m^3/sec), 5 years (706 m^3/sec), 10 years (942 m^3/sec), 25 years (1,289 m^3/sec), 50 years (1,575 m^3/sec) and 100 years (1,879 m^3 /sec). The simulation results showed that the water of the river on the right side of the river has overflowed when the flood plan–2 year is 440 m^3/sec (Figure 4.a).
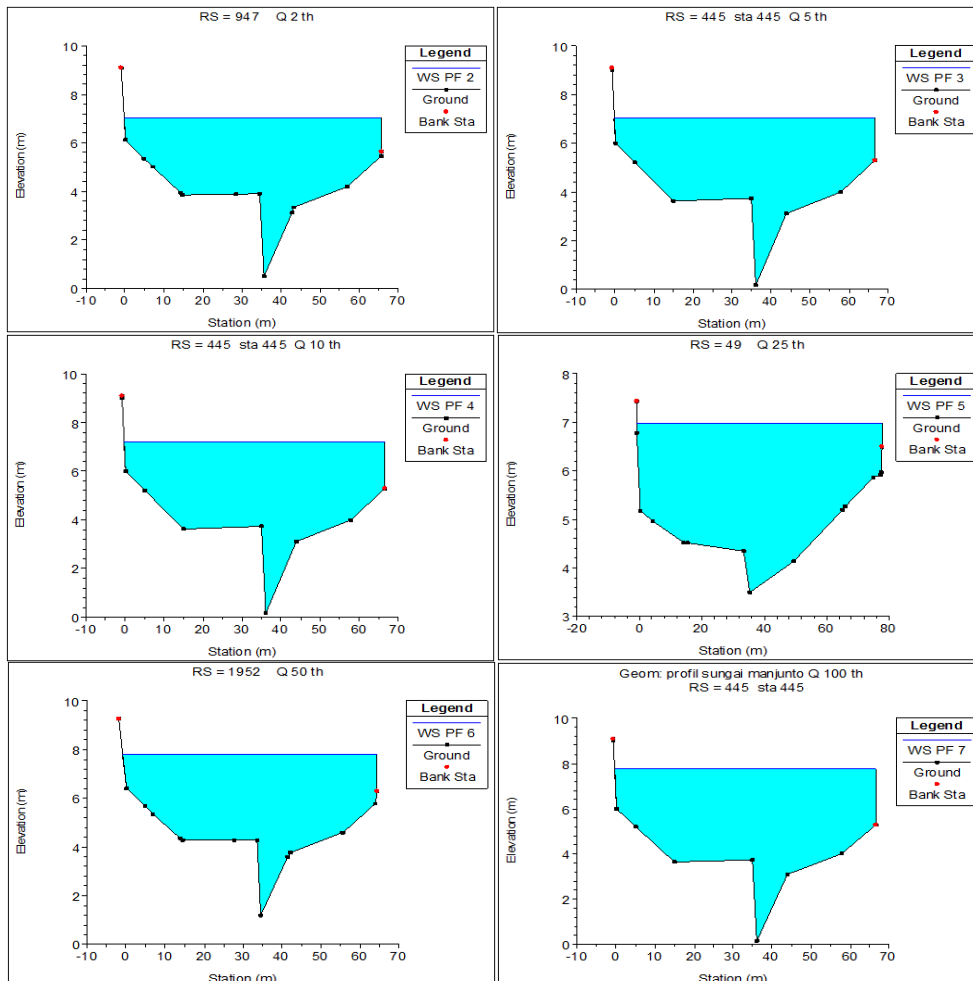
Figure 4. Output HEC–RAS of Manjuto river cross section

The output of the HEC–RAS program can be used by decision makers to plan the program for flood control on the river Manjuto. The simulation results for a return period of 100 years, dikes should be built at station 24 to 6474 on the right embankment of the river, next station new on river left. High levees ranging from 0.89 to 2.76 m. An explanation of the position and height of the embankment to be constructed are described in Table1.

Table 1. High and Position of Embankment For Flood Plan Return Period 100 year. Flood Plan Return Period 100 year (continued)

Station	Left Embankment	Right Embankment	Station	Left Embankment	Right Embankment
24		0.89	2957		1.68
49		1.04	3459		1.46
74		1.13	3962		1.27
98		1.19	4464		1.08
122		1.24	4967		0.91
147		1.28	5469		0.74
171		1.31	5971		0.6
196		1.34	6474		0.45
220		1.37	9488	0.46	
445		2.76	9990	0.6	
947		2.51	10493	0.73	
1450		2.25	10995	0.86	
1952		2.02	11498	0.99	
2455		1.89	12000	1.12	

Source: Output of HEC–RAS, 2015

Conclusions

The conclusion of this study is Air Manjuto flooding caused by runoff that occurs in the left and right of the river. Therefore, the decision maker can use the output of the HEC–RAS program to develop programs of flood control on the Air Manjuto river. If the selected flood control efforts is the construction of embankments, the position and height of the embankments that will built to be adapted from the output of the HEC–RAS 4.1.0

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Alternatives for Settlement Area Management of Meureudu River watersheds towards Flood Mitigation (Case Study of Meureudu City Center, Pidie Jaya–Aceh)

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Abstract

Meureudu City is a regency capital of Pidie Jaya and located along the Watershed (DAS) Meureudu River up to its estuary, has repeatedly experienced a flood that affected material and non–material damages. Efforts to reduce the effects of flooding caused by overflow of water Meureudu River have been done structurally, such as construction of dams and levees (polders, dikes, flood the canal). But these have not made the Meureudu City free from flooding and still occur repeatedly. Relocating of people is not easy, because the local people already living in the area since long and bound with historical value as an area of development of Islam. Therefore it is necessary and urgent to think about effective pre–disaster planning for the region. The purpose of this study is to find alternative strategies to protect residential areas from flooding through a strategy of adapting to floods and capture the benefits for economic development. Using qualitative description and analysis of management strategies to carried out a method. Results of the study found the handling settlements with waterfront concept can be expected to be one of the solutions that will minimize the risk of flooding. This strategy is effective, easy to apply and compatible with the environment. More importantly, can be incorporated into the long–term development program for the Meureudu City. Therefore, this effort requires consistency of all stakeholders. The participatory approach of stakeholders is a key to the success of the efforts of non–structural.

Keywords: Management strategy, spatial planning, settlement, Meureudu River, flood mitigation

Introduction

City of Meureudu roles as a Capital of Pidie Jaya Regency, as a result of expansion region in early 2007. As a new Capital, Meureudu continue to develop various infrastructures, especially in the areas of housings, human settlements and trade. However, conditions in settlement areas caused by flooding which overflow of the Meureudu River have not been resolved, even though solutions and handling already developed. Various causes of flooding, which is due to damage to the environment in the upstream areas, indiscriminate building of settlements, poor drainage system, reduction in water catchment areas, and various people's behavior toward the river and river border which can cause constriction, sedimentation and water quality degradation. Development that is not sustainable has resulted in a negative drastic change to the environmental conditions of natural resources Meureudu River. Inability to coordinate the urban water system in flood control, one of them is due to lack of coordination in the management of water resources, especially in the watersheds less addressed holistically and professionally, resulting in flooding in urban areas. This was triggered by user behavior that does not care about the existence of river functions.

To improve the environmental quality of the riverbanks Meureudu River, it must be examined and realignment of the region. Aceh Medium Development Planning Year 2012–2017 (RPJM) stated that the quality of the environment and disaster is one of the priorities of development which affects handling regional economic development. Waterfront city development concept is an alternative choice of settlements on the riverbanks in an effort of spatial planning and improvement of environmental quality. Region has been corrected so as to support small to medium sized businesses, the public can be independent and have economic value, as well as have entertainment attractions of the city. The main function of a waterfront city that is the pool that will serve as a retarding basin, which will dampen the flow of local flooding making it useful as a temporary flood shelters.

The term waterfront city contains many typical meanings that reveal the cause and goal, which can be interpreted as a city that used the river or canal as a means of transportation, recreation, and other livelihood sources. Waterfront city development will have a positive impact on communities around the river, because the surrounding community can benefit from the rising groundwater level, which could be used as a means of leisure/water tourism, sports and transportation alternatives. It can be used as water tourism so that it will increase the role of public concern. The results of this study are expected to be a cornerstone in the implementation of policies, rules and guidelines, especially with regard to the arrangement of humanist region of Meureudu City residential area, which eventually can be a proposed regulation followed by a related party.

Natural potential development with waterfront development is a space which when processed will produce a space to be able to do activities as well as the existing space on land. In this case refers to a concept which is a solution waterfront development concept that ties into the water's edge of the mainland, where the notion waterfront is a meeting area between land and water (Hornby, 1972; Pranoto et al, 1993). The establishment of settlements in the area waterfront at Meureudu River a state of perceived human visual capable of scenery natural and artificial. Meureudu River is part of the city's history as old as age Meureudu City itself. Part of Meureudu River which included in the study located at BWP–4, which prioritized to handle a flood, is planned as residential areas, services and trade, education, offices and water catchment areas, nature and sports. Development and construction of waterfront is as a development model that is very concerned about the environment, so the riverfront or waterfront development is built building design and planning of the area identified patterns as building synergy with the local ecological conditions. Activities are developed in the waterfront area cannot be separated from the potential that the region possessed. This potential will also affect motivation waterfront development concepts that bring ideas developed complete functional space with its supporting functions. It is needed to do a study on housing conditions to be proposed concept of handling the settlement bank of Meureudu River that minimizes the eviction but may reduce the impact of flooding in the region.

Methodology

The study area is located at Meureudu City Center, exactly in the residential areas of the old town. Meureudu River region which is the object of this study, extends through the town Meureudu and Meunasah Balek village (*Gampong*) ended towards the estuary. The width of the watershed area of study is ±100 meter on the riverbank.
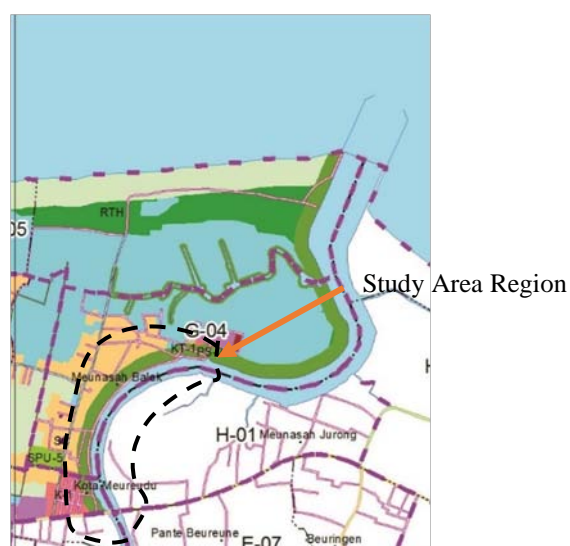
Figure 1: Map of Krueng Meureudu watersheds (Source: Authors' document)

The method used is descriptive qualitative, the methods that is used to collect information and describe on the ongoing situation at the time. Aiming to describe a situation that existed at the time the research is done and examine causation through the identification of conditions that exist on the problem. The selection and arrangement of functional components (as a region segmental) on a segment or piece of the Meureudu River that supports behavioral habits (behavioral settings as a forum for the socio–cultural) surrounding community that supports the potential of the activities and the surrounding environment

(recreation, trade, transport water and cultural tours). Processing site footprint right to exploit the potential, optimizing the open spaces and freedom of circulation as well as attention to the factors that come from within and the environment that supports the objectives of the planning and building functions.

Activities exploration phase conducted data collection: 1). by observation and survey the field (observation and existing survey sites, survey on the development of eco–tourism in the city Meureudu), 2). Interview (on the development of container recreation and creativity for the city Meureudu, flood mitigation), and literature (literature supporting a review of the concept design, literature that support the discussion of architectural, the result of disaster flooding to the region and regional regulations are summarized in Pidie Jaya Spatial Planning (RTRW) and Meureudu City Detailed Spatial Planning (RDTR). The data that have been grouped are presented through a review of the flood mitigation, and leisure/entertainment criteria for the city, review the concept of waterfront and review the condition and potential Meureudu City. Phase conception performed data processing and analyzing the data with the qualitative method. Furthermore, formulated the basic concepts of planning and response strategies residential areas for improvement the space and the anticipated flood with waterfront concept.

Results and Discussion

Conditions of Krueng Meureudu Watersheds

Meureudu Urban Area in Pidie Jaya classified as medium city growing, with functions that will be developed as a Regency Center, tourism, trade centers and crossing town. Topographic study sites in the form of sloping plains with a height of 2–5 m above sea level, has a slope classification < 8%. Measured from the height of the river which is about – 0,5 –1 meters, meaning there are some settlements are under the water level of the river and is limited only by the embankment. This is due to the last few years an increase in the surface elevation of the river are the consequences if the intensity is high enough rain water and flood water beyond the embankment then immediately there was a flood in the area of the settlement. The condition of the river is quite good with a width of 20–30 meters with water depth ranging from levels 5–8 meters. Along the river side of the levee was constructed with a height of 1 meter, rebates concrete materials and giant stones (boulders).

Figure 2. Conditions of Meureudu River with fishermen activity (Source: Authors' document).

Riparian setback lines did not meet the minimal standard from Ministry of Public Works which is 0–2 meters, where most of the water bodies directly adjacent to the walls of residential buildings. Most border areas become breeding places for cattles, terrace houses, motor parks, latrines, a trash and others. This causes the border area as a safety protective river and residential areas no longer exists. Based on Detailed Sub–District Spatial Planning Meureudu City 2014–2034 (RDTRK), Meureudu River classified as river with embankment in the urban area and must have a border of at least 5 meters along the foot of the other side embankment.

Figure 3. River setback line is not functionally normal. Source: Authors' document

Building Alignment Conditions

Housing facilities in urban Meureudu is spreading clustered in front close to the road (Ribbon Style). Density residential buildings in the study area were medium, but the position and orientation of buildings is not clear as it develops sporadically. The distance between residential buildings close enough, with the distance between the buildings of about 0–1 meters. Building density leads to loss of water catchment areas and green open spaces in the area and the absence of evacuation flood routes.

Figures 4. Settlements condition along the riverbanks Meureudu River (Source: Authors' document).

The structure and construction of most buildings in the area at high risk of damaged or washed away by floods because about 70% of the buildings in Meureudu River area are residential with conditions of non/semi–permanent. About 30% is residential with a permanent condition.

Infrastructure Conditions

As a safeguard river levee was constructed along the watershed to the estuary with concrete material rebate (non–gabion) and boulders, a height of about 1 meter. Conditions dike built in good condition, but the way the inspections are supposed to follow the embankment is not constant because undercut by the presence of buildings on embankment position. Inspection road has a width of 1–3 meters so it can only be accessed by a 2–wheel vehicles and one car, and even then only halfway. Due to this condition as a safety benefit embankment river border becomes less. Replotting be proposed land for the building is very worth getting up in the river border area in order to build a green open space along the river side with the concept Riverfront–Waterfront Settlement.

Figures 5. Inspection roads along the riverbanks. Source: Authors' document

Drainage channel is also available on a number of point locations with varying channel dimensions: height 30–40 cm, width up and down 20–30 cm, the concrete material and the condition of most do not work because it was covered with sediment soil, grass, garbage, transformed into a function parking, terraces, and others. The circulation system is inadequate. The main roads in the study area have a width of 3–6 meters that can be accessed by two cars on a number of certain roads. For a neighborhood street/alley, a width of about 1–2 meters. This makes it difficult for residents to evacuate when the flood occurred. Material on major highways settlement with a width of 6 meters is bitumen, while for local road/tunnel is paving and some are still in the form of compacted soil.

Figures 6. Roads conditions at settlements area (Source: Authors' document).

Signage for disaster mitigation has not been found in the study area. Compliance with standards for residential areas prone to disasters should be design signage for environmental orientation and evacuation in order to minimize loss of life and materials. The signs of disaster mitigation, among others in the form of an information board evacuation routes, signs of danger ban, river water level monitoring post and others. Percentage of green open space in developed and undeveloped land is 90:10. This means that the availability of public open space or green open space was minimal. 10% undeveloped includes roads, river banks and parks, gardens on the backyard.

The Potential Region

Gampong meunasah Balek community located in the vicinity of Krueng Meureudu, mostly working as fishermen catch and fish farmers. This condition is strongly supported by the potential of the village which is located near the coast. Meanwhile, the women also helps meet the daily needs by producing a mat woven with raw materials obtained from potential around. The existence of Krueng Meureudu used by people around the extent to irrigate the fields, shrimp farms, and as an in–out fishing boats as well as utilize the river bank as a place to moor their ships.

Figures 7. Conditions and Potation at settlements area (Source: Authors' document).

Settlements area is land that used by fishing communities for housing and other support activities. Residential area on the outskirts of the watershed is an area of river border. Around the residential area there is a boat mooring area on the edge of the river and close to housing. Settlement zone tend to be above the soil moist and watery. Housing surrounding communities tend turned the river and watershed areas not utilized as an area that has the potential view and tours that can improve the quality of the environment and the local economy. Based on Meureudu Capital District Detailed Spatial Planning (RDTR), the area is recommended as a riparian area with a minimum distance of 100 meters. Houses mostly located beyond the river embankment, so that the inspection road cannot go thru towards the estuary. However, to relocate the community in this area is difficult, because in this region was began Meureudu growing urban settlements. Development of Islam also through this river, and around the area there are several historical sites of the greatness and sacred of Islam.
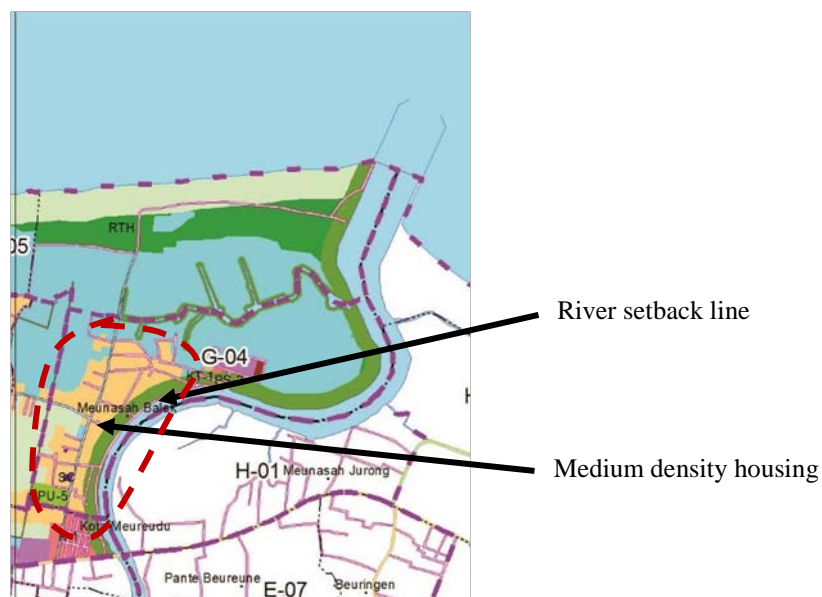
Figure 8. Settlements area. Source: Authors' document

Likely to be developed as a residential neighborhood with a stilt–up building concept. Area under can be used as security against a puddle of water runoff and flooding when the river as a public park area when dry. The potential of the river is the orientation of the buildings around. While the zones are located along the jetty river have easy attainment of housing to the fish auction and so the market potential as a fishing boat mooring area. Improved watershed areas Meureudu River as waterfront area development environment and disaster mitigation is expected to improve the quality of the environment and disaster management. With regard to the protection and maintenance of rivers and improving the recreation area, regional development banks of the Meureudu River to do with the provision of such: road infrastructure inspection continuous, open space, garden sitting, playground, docks, restaurants, fishing areas, sports facilities, and local craft facilities, as well as improving other facilities that characterizes the region.

Flood Mitigation

Krueng Meureudu barriers to erosion in the form of a stone embankment that extends from the town Meureudu towards the estuary aims to restrain and avoid flood water flooding inland. From the top of the embankment of the river that created extends till towards the city, visitors can enjoy a view of nature that is winding river flow, pacing boat fishing, expanse of rice fields, plantations and traditional embankment. Based on the Detailed Spatial Planning (RDTR) Capital District Meureudu this area was part of a border river which is a protection zone with a function as protection and control of the environment of the river. Flood canal which is the flow of Meureudu River into the waterway has an attractive tourist potential. The area is often used by local people for fishing and enjoys the view of Malacca Strait, passing fishing boats, and the city center. Flood canal was in the river mouth Meureudu River made to control the flow of water from upstream rivers and adjust the volume of incoming water. This channel is also intended to be crossed by boat or fishing boat. This zone is an area of habitat of various species of fish, and became a favorite area for fishing communities. Canal existence serves as one disaster mitigation being done to reduce the risk and impact of a disaster on the settlement communities prone to flooding.

Potential of Region and Problems

The potential of the area around the Meureudu River can attract visitors to enjoy its beauty, thus providing development opportunities in services sectors and entertainment around the area. This potential can improve the quality of space in the watershed areas with considered as protected area, in accordance with the Capital District Meureudu Detailed Spatial Planning (RDTR). The existence of the Meureudu River no longer an area behind the building and dumping areas that have an impact on pollution and silting of the river, but it will be interesting view environment.

Utilization of the area around Meureudu River by the user, each day has increased, especially people who use the existing natural potential as an attractive view for refreshment, fisheries and ponds as well as the potential for local crafts. The local community and the surrounding communities with activities that do not yet supported by environmental infrastructure, public and social facilities were adequate and also not well ordered. Facilities available in the surrounding area are like a fish sales area, fishing area, and parking. While environmental infrastructure such as roads inspections is only available to the market environment, rain water channels are also not well ordered.

- Facilities Inspection roads only in that market area from the bridge down to the neighborhood mosque and yet connected up to the coast. The width of the road inspection + 5 M of the embankment, the condition are not perfect (yet ready paved). These conditions do not provide comfort and convenience for users who want to reach the residential area and the beach, and who want to enjoy the river flow Krueng Meureudu. The existence of this road is expected to function for river maintenance to keep them clean and does not become a dumping ground for debris.
- Drainage of rain water, especially in residential areas has not been functioning well, so it looks wet and humid environments. These conditions provide non convenient for users and gives the impression of a seedy.
- Facility fish sales that were above the embankment must be disciplined and set its placement in the market area.

A planning of public space oriented to the river and recreation into a place for children, youth and adult age to socialize built with processing area of micro includes determining the concept of orientation, system mass, the appearance of the building and landscape, so as to pour expression of joy and interact socially as well as provide design is contextual to their environment. The room is equipped with a pedestrian green open space (RTH) must meet criteria of comfort, climatic conditions and physical characters. RTH pedestrian paths can be used as: 1). Facility to allow for social interactions both passive and active as well as provide an opportunity to sit down and look at other pedestrians; and 2). To balance the temperature, humidity, texture underfoot, vegetation, vehicle emissions, vegetation emit an odor, the smell of garbage and abandoned, audial factor (sound) and visual factors.

Recommendation

Based on a number of the above analysis, the proposed concept of handling the settlement to address/minimize the risk of flooding in the study area, which is as follows:
a. Setting land use by increasing the percentage of green open space up to 20% along the outer dike. This can be done through the control/arrangement of river border area. In accordance Ministry of Public Works Decree No. 63/PRT/1993 regarding Line Border Rivers, the area benefits of a river, stream mastery determined based on the condition and location. The sweets were followed through 2014–2034 Meureudu City Detailed Spatial Planning (RDTR), that the Meureudu River is categorized a levee river

including rivers in the urban area must have a border of at least 5 meters along the foot of the embankment outside.

b. On the banks of the area that does not have the inspection, the inspection must be made paths and green space on the outside of the dike, with land acquisition.

c. Occupancy potentially is developed as a residential neighborhood with a building concept stage. Area under can be used as security against a puddle of water runoff and flooding when the river as a public park area and when dry.

d. In addition to setting the border, can also be done as well as the application of the concept of normalization river riverfront / waterfront settlement. This is so that the river can be kept clean. But this should be monitored (river border control system utilization should be firm) to avoid going over the river border.

e. Returns Greenbelt role in Meureudu River to improve the quality of the watershed area that has a function for flood mitigation. Settling the riverside area in order to create a waterfront city, raised the river as a transportation alternative, maintaining a protected area, covering greenbelt (retarding pond), bog, technical irrigation, and protected areas and strengthening urban functions improved by providing the necessary facilities and infrastructure.

f. Make a commitment to linear greenways and public access to the waterfront, the area along the Meureudu River. Riverfront Development Principles Emphasis on interconnectedness, waterfront development linearly with widespread public access to: 1. Promote the use of green lanes riverfront as a way commute daily and recreational facilities. 2. Indicate the relationship between access, development of green belt and demanders market. 3. Creating an arrangement coherent and pleasing to the eyes towards the waterfront. Create synergy between residential and recreational waterfront by selecting the concept of development and the most imaginative architectural design.

Conclusion

Besides influenced by regional topography sloping river banks that do not meet the standards, the floods in Kota Meureudu exacerbated by housing and infrastructure conditions that do not respond to flooding. Construction of houses and the distance between buildings is not possible to provide a water catchment area neighborhoods, there are only a few houses were constructed stage. Treatment room rivers such as the inspection and its green open space are inadequate, evacuation and flood warning system is not yet available.

The concept of handling the above proposed based on the study of the condition of the settlement, and tailored to the needs and desires of citizens (the interview). Because the concept has been minimized in the eviction of the houses and the most important is the construction of the security system of the river and the protection of settlements are better than the existing condition. Hopefully, through this treatment concept could be one solution to prevent and minimize the impact of the risks posed by floods in Gampong Meureudu and Meunasah Balek. This study needs to be followed up with studies on aspects/other areas, such as socio – cultural studies or economics or government policy. It is intended that the handling of the flood–prone settlements in the study area can take place in an integrated and comprehensive.

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Spatial Variation of Water Supply Provision in Bandung Metropolitan Area

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Abstract

World is rapidly urbanizing. The urban population significantly grows and expands to its surrounding areas; forming a metropolitan area. It leads some problems such as difficulty in integrating water supply provision. This paper is intended to explore the conditions and problems of water supply provision in metropolitan area. This paper explored water supply condition in the Bandung Metropolitan Area (BMA), which is divided into the core area, peri–urban, and rural areas. By knowing the conditions and problems of infrastructure provision, right solution to overcome the existing problems is expected to be proposed. Using descriptive statistic, analysis was done by comparing criteria of water service coverage, quantity of water consumed, quality of water consumed, continuity of water supply, and average cost with existing condition based on the location (the core area, the peri–urban area, and the rural area) as well as type of customer: PDAM customer and non–PDAM customer. By comparing those five criteria based on location and type of customer, the condition of water provision in BMA can be analyzed. Moreover the problem of water supply provision can be identified.

Keywords : Bandung Metropolitan Area; spatial variation; water supply provision.

Introduction

World is rapidly urbanizing. This immense growth cannot only be accommodated by the core areas, particularly in the context of land availability. As a result of lack of land availability in the core areas, peri–urban areas start developing. Allen, *et al.* (2004) projected that for the next five decades most of the growth in the world's population will be in urban areas and much of this growth and the accompanying spatial expansion will be in peri–urban areas of medium–sized cities and metropolitan regions. Population growth in the urban centers have significantly declined, whereas in the adjacent areas population growth is relatively high, which may reflect the rapid spillover of population growth in the urban centers to the surrounding areas. The peri–urban areas are currently experiencing the most active urbanization (Shia, *et al.*, 2012).

The emergence of the peri–urban areas bring on some phenomena in various spatial dimensions such as spatial segregation, structural fragmentation, and infrastructure deficiency that occur between different new towns built by different developers as well as between the new towns and their surrounding areas (Firman, 2004; Hudalah, *et al.*, 2007). As a consequence, it is difficult to integrate the infrastructure provision. Moreover, some of the peri–urban areas are not served yet with the infrastructure and services.

The imbalances in access to all sorts of essential infrastructure and services not only occur between core and the peri–urban areas but also between urban (consisting of the core areas and the peri–urban areas) and the rural areas within metropolitan areas. In accordance with UNESCAP (2001), there are significant disparities between urban and the rural areas within the countries of Asia and the Pacific such as in the form of access to essential infrastructure and services. Furthermore, according to Satterhwaite (2000) in UN–Habitat (2008), access to infrastructure and services in the rural areas is more limited than in urban area largely caused by: (1) the distance; (2) low density; and (3) limited capacity to pay.

Household water supply problem is one of the major challenges faced in developing countries (Palamuleni, 2002). Some developing countries have been unable to match investments and maintenance in urban infrastructures especially in urban water (Keener, *et al.*, 2010). This mismatch has led to a slow down and in some cases a complete halt in the expansion of service delivery to informal settlement (Jimenez–Redal, *et al.*, 2014). This problem is not only due to financial problems (Ferguson and Navarrete, 2003) but also technical and social (Jimenez–Redal, 2014) as well as lack of political will (Davis, 2004) therefore the government must be really selective in determining the service priority (Ferguson and Navarrete, 2003).

As explained before, it seems complicated to meet the needs of basic service delivery such as water supply in the context of metropolitan areas. For that reason, interventions for water provision are required to ensure adequate water to all (Nickson, 2002).

This research is conducted in BMA which in 2012 has 8,194,645inhabitants that spread in a 2,308.028 km^2 area. Spatial pattern of BMA can be classified into core area, peri–urban area, and rural area (see Fig. 1). The classification is based on the proportion of built up area, number of population, and economic activity.
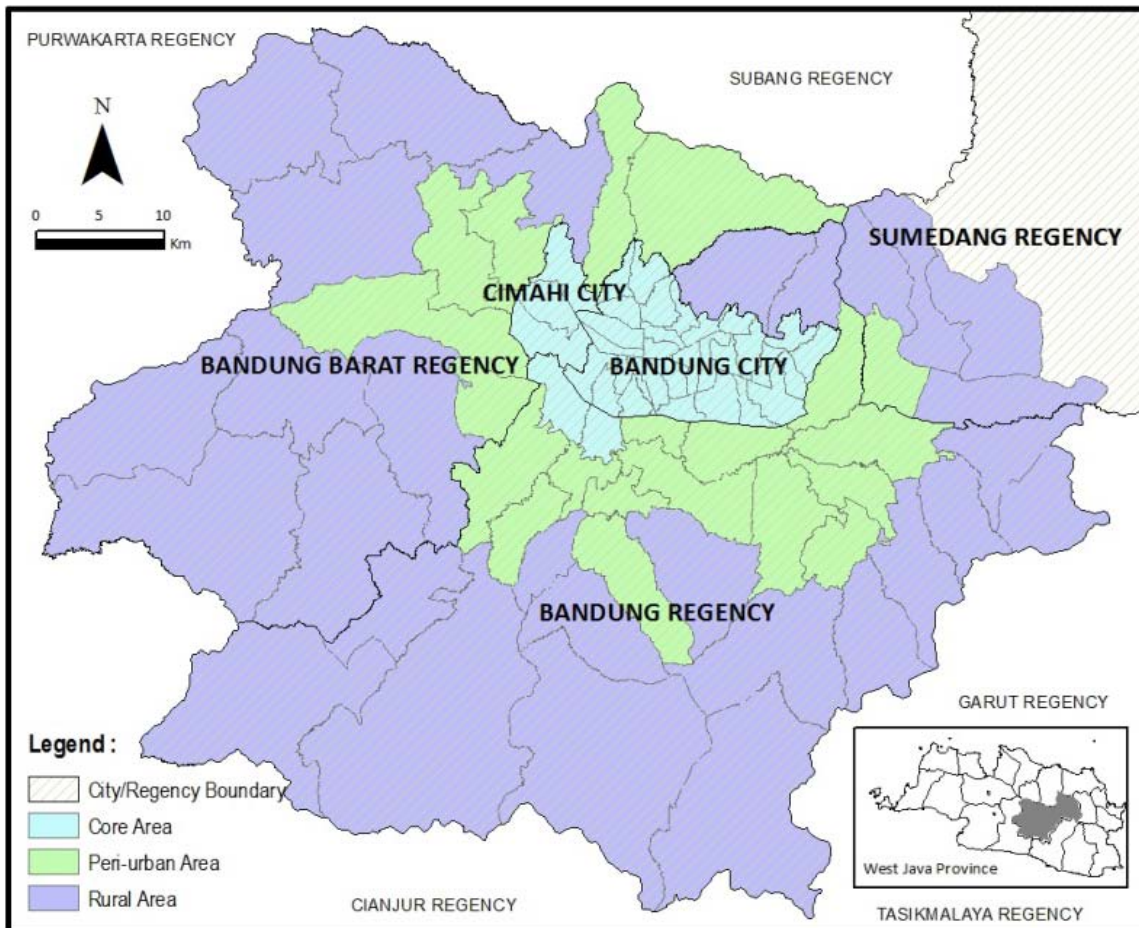
Figure 1. Spatial Pattern of Bandung Metropolitan Area

Public water supply provision in BMA is managed in region or city level by local water enterprise, namely Perusahaan Daerah Air Minum (PDAM). There are three PDAMs that operate the water service delivery in BMA. They are PDAM Tirtawening which serves Bandung City, PDAM Tirta Raharja which serves Bandung Regency, Cimahi City, and West Bandung Regency, and PDAM Tirta Medal which serves Sumedang Regency. From 8,194,465 populations in BMA, only 2,342,876 or 28.59% were served by PDAMs. PDAM Tirtawening has the largest coverage compared to other PDAMs in BMA which is 21.84% of total population in BMA, followed by PDAM Tirta Raharja (6.46%), and PDAM Tirta Medal (0.28%).

Material and Methods

The data used in this research consist of primary and secondary data. Primary data was collected through distributing 176 questionnaires to the households in the core, peri–urban and rural area of BMA. The questionnaires were designed in order to gather information related to water supply condition in each area that was evaluated based on criteria developed by WHO (1997): (1) water service coverage, (2) the quantity of water consumed; (3) the quality of water consumed; (4) the continuity of water supply; and (5) the average cost. Analysis was done by comparing the five criteria with existing condition based on the location (the core area, the peri–urban area, and the rural area) as well as type of customer: PDAM customer and non–PDAM customer.

Results and Discussion

Characteristics of Respondents

Characteristics of respondents can be categorized as PDAM customer and non–PDAM customer. For PDAM customers, according to housing ownership, most respondents are the homeowners (94%) and mostly number of family member is four. The education level of the head of household for PDAM customers in this study varied and ranged from those who have never been school to those who have completed high school education. The majority of the head of households have attended high school. The average of total income of all respondents is Rp 4.5 million per month with the minimum amount is Rp 0.6 million per month and the maximum is Rp200 million per month.

For non–PDAM customers, most respondents are the homeowners (92%) and mostly there are four people (members of the family) that live in a house. The majority of the head of households have attended high school and the range of income earned is between Rp 0.35 million to Rp 35 million per month, with the average income of all households is Rp 3.7 million per month.

Water Service Coverage

Public water supply which is operated and managed by PDAMs has not served the entire population in BMA yet. As explained in Table 1, only 28.59% of population in BMA served by PDAM. This coverage was below the national target that had been set by the central government, which was 60% for urban areas and 25% for the rural areas (see Table 1). In general, there are several obstacles that impede the target achievement of the service area coverage among such being minimal investment and trouble in sourcing water resources (VNG International, 2008).

Table 1. PDAMs service coverage based on spatial pattern

Area	PDAM Tirtawening	PDAM Tirta Raharja	PDAM Tirta Medal	Total	Population Served by PDAM	Population	Coverage (%)
The core area	150,684	15,453	–	166,137	1,921,282	3,239,755	59.3
The peri–urban area	–	44,362	1,881	46,513	421,594	4,954,890	8.51
The rural area	–	6,322	3,834	10,156			
Total	150,684	66,407	5,715	222,806	2,342,876	8,194,645	28.59

Source: PDAM Tirtawening, 2012; PDAM Tirta Raharja, 2012; PDAM Tirta Medal 2012

Some of PDAM customers not only acquire water from PDAM but also from multiple water sources from groundwater and bottled water. For those who do not use PDAM as primary source of water, the main sources of water in the peri–urban and in the rural area of BMA area are individual pumped water and piped water network provided by collectively–managed piped water schemes using groundwater and spring as source of water. On the other hand, in the core area, the households mostly acquire safe water from individual well and small proportion of piped water network run by community using groundwater. Some part of the area actually serves by PDAM pipeline, however there are several reasons why households do not want to be PDAM customer or use PDAM as primary source. Water quality, quantity, and continuity in their area are better compared to water from PDAM. Besides, cost of water from PDAM is more expensive compared to others. For those who neither use PDAM as primary source of water nor PDAM customers in the core area, they use secondary sources of water from vendors, bottled water, PDAM, groundwater, and communal system.

Quantity of Water Consumed

The total amount of water consumption by those used water from PDAM is nearly in accordance with the national planning average range between 150–190 liters per person per day. It can be seen that water consumption in the peri–urban area is the highest compared to other areas. Most respondents in all area perceived that the quantity of water consumed is sufficient for them.

Most households used water from PDAM acquires drinking water from other sources. It is because water supplied by PDAM cannot fulfill their needs in term of quantity and or quality. Apart from consuming safe water supplied by PDAM as the primary source, PDAM customers consume safe water from other alternative sources, such as bottled water and groundwater from wells.

Unlike those served by PDAM service, households which do not use water from PDAM have more flexibility to use water they need. It is because there is neither the calculation of the amount of acquiring water nor the water tariff structure for each volume of water consumed. Almost 100% of respondents who do not have access to PDAM perceived that the quantity of water consumed is sufficient for them.

Table 2. Average water consumed based on type of service

Water source	Type of service	Average water consumed (liters/person/day)		
		Core	Peri–Urban	Rural
PDAM	Only primary source	169	190	185
	Primary and secondary source	192	208	149
Non–PDAM	Only primary source	307	260	235
	Primary and secondary source	314	260	235

Quality of Water Consumed

Water quality in this research is assessed from physical indicators. All of respondents using water from PDAM stated that there were not any problems regarding taste and temperature (see Table 3). To fulfill the need of safe water without any risks, most PDAM customers both in the peri–urban area and in the rural–area also derive water supply, especially for drinking, from groundwater (wells and/or pumps).

Table 3. Quality of water consumed by households

Water source	Quality	Percentage by its location (%)		
		Core	Peri–Urban	Rural
PDAM	Colorless	95	37	77
	Odorless	81	53	43
	Tasteless	100	100	100
	Normal temperature	100	100	100
Non–PDAM	Colorless	87	94	94
	Odorless	91	97	100
	Tasteless	91	100	100
	Normal temperature	100	100	100

Table 3shows that households using primary source of water from non–PDAM perceived the quality of water better than that use primary source of water from PDAM. The existence of odor in water from PDAM is usually caused by the addition of chlorine in order to remove the bacteria in the water. Lower quality of water requires more quantity of chlorine. For those who are not PDAM customers, water quality is not a problem. If one source of water is in bad quality, they will find the better one. Sometimes the condition of water quality which is better compared to PDAM causes them not to be PDAM customers. Regarding the location, the quality of water for those using PDAM as primary source of water is better in the core area than in the peri–urban and rural area, meanwhile for those using non–PDAM as primary source of water, the quality of water is better in the rural and peri–urban area compared to those in the core area.

Continuity of Water Supply

As described in Table 4, continuity of water supplied by PDAM is worse than that of non–PDAM and overall the continuity in the core area and the peri–urban area performs better than in the rural area. One of the reasons of the unstable continuity of water supply is PDAM's lack of capacity to get raw freshwater from upstream water bodies. The problem is PDAM does not manage water smartly (IRSDP BAPPENAS, 2011). The unmanaged water bodies (river basin, lakes, and water retentions ponds) have caused reduced amount of raw freshwater for the water treatment plant intake (Juliman, 2014) thus causing limited availability in distributing safe water to the costumers at the same time.

For this case, PDAM priorities to build the facilities such as water treatment plant and reservoir in the core area and they are extended to the peri–urban area and the rural area. It is one of some factors causing difference performance between the locations for PDAM service. Since safe water produced is limited, the households in the core area get the priority. Besides, since there are three different PDAMs operating in BMA, the differences can be caused by the different service performance itself.

Table 4. Continuity of water supply

Water source	Service duration	Location		
		Core	Peri–Urban	Rural
PDAM	24–hours per day	80%	80%	53%
Non–PDAM	24–hours per day	96%	100%	87%

Cost

Table 5 shows most respondents in BMA can afford to pay the average monthly bills to get water services from PDAM. It is also known that the average monthly spending for PDAM users is higher than non–PDAM users. The proportion of respondents with monthly water spending less than 3% of income is

also smaller for group of PDAM than non–PDAM. Based on the location, households in the rural area pay less compared to those in other areas. It can be caused by less volume of water consumed in rural area than those in the core area and the peri–urban area. In addition, different water tariff for each PDAM (for those using water from PDAM as primary source) is one of the aspects that make the difference of average monthly cost of water consumed as well.

Table 5. Cost of water and ability to pay

Water source	Water cost	Location		
		Core	Peri–Urban	Rural
PDAM	Average monthly cost	99,000	101,000	74,000
	Percentage of respondents with Water spending < 3% of income	95%	80%	93%
Non–PDAM	Average monthly cost	26,000	24,000	13,500
	Percentage of respondents with Water spending < 3% of income	96%	97%	100%

Conclusion

Water service provided by PDAM in Bandung Metropolitan Area is still limited and concentrated in the core area. Households both in the peri–urban area and the rural area have less access to water supply provided by PDAM compared to them in the core area. In some areas, although it is easy to get a PDAM connection, the communities are not preferred to acquire safe water from PDAM as a primary source. In many cases, the households reveal that quantity, quality, continuity of safe water provided by PDAM are as not as good compared to other water sources that they are able to use. Moreover, the cost of water supplied by PDAM is higher compared to other sources such as individual water provision system and communal water provision system.Although most households in BMA are not PDAM customer, they can acquire safe water with good quantity, quality, continuity, and cost. The quantity of water used by a non–PDAM customer is greater than a PDAM customer, with better continuity and cost than the services provided by PDAM. For quality of water, the proportion of non–PDAM customers which perceive the water with good quality is larger than PDAM customers.

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Factor Affecting the Willingness of Community in Application of Green Infrastructure Component

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Abstract

Green infrastructure (GI) has several benefits compared to gray infrastructure in terms of environmental services and sustainability, such as reducing energy consumption, improving water quality, providing carbon sequestration, and increasing property values. Nevertheless in practice, the implementation of the concept in Indonesia is still limited. This paper aims to explore the perception and willingness of the community to apply the concept of GI and the factors influencing the willingness. The case study is in Cikahuripan Village, Lembang District. The methods used are descriptive statistics and cross–tabulation. The result of analysis shows that after an education the willingness of community to apply the GI component is high (40 of 51 respondents), but most of them cannot finance the application of the concept. Occupation is factor influencing the willingness of respondents to implement GI Component.

Keywords : Community, factors affecting willingness, green infrastructure.

Introduction

Green infrastructure (GI) is defined as an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife (Benedict and McMahon, 2006). Green infrastructure is an alternative to provide infrastructure, especially storm water infrastructure in combining with green open space infrastructure. Because of its characteristics, GI is stated as multifunction infrastructure. The benefits of GI among others are reducing cost of infrastructure provision, reducing energy consumption, improving water and air quality, providing carbon sequestration, and increasing property values. There are various forms or components of GI, such as rain garden, bioswales, permeable pavement, infiltration basin, dry pond, green roof, downspout disconnection, and rainwater harvesting.

Although GI has multiple benefits, the implementation of the concept in Indonesia is still limited. In order to implement GI component, the willingness of the community to implement the component is very crucial. GI can be defined only if the people involved in the implementation of the concept (Nauman, et al., 2011). This paper aims to explore the perception and willingness of the community to apply the concept of GI and the factors influencing the willingness. Callahan (2007) stated that information from community is very important for the implementation of GI. Barau (2015) stated that household perception of urban greenery is a vehicle for understanding socio–ecological dimensions of grassroots urban sustainability. It also helps in advancing public participation in urban green infrastructure initiatives. In the case of infrastructure provision, there are several factors that usually considered as factors influencing people participation, such as demographic factors, economic, and individual preferences and awareness (Dwivedya and Mittal, 2013).

This research used Cikahuripan Village as a case study. Cikahuripan village is located in the northern part of Lembang District, West Bandung Regency. In the context of Bandung Metropolitan Area, Lembang district is classified into periurban area that plays a role in accommodating developments in the core/urban areas. The total area of Lembang District is 9,826.54 ha that consists of 16 villages. It is geographically located at an altitude between 1,250 meters to 1,750 meters above sea level. Lembang district consists of the hills and mountains with slopes ranging from 0% to over 45%. Level slope in Lembang district is dominated by steep slope.

Cikahuripan village is situated on the slopes, with a gradient ranging from 15–25 degrees. The total population in the Cikahuripan Village based on *Potensi Desa* (2011) was 10,527 inhabitants and it consists of 3,082 families which 1,674 of them are farmer family. The main source of livelihood of the villagers is agriculture. The main agricultural commodities are fruits, vegetables, ornamental plants, and medicines. Land

use in the Cikahuripan Village is still dominated by farm land. There are also a little settlement and forest in fairly large amount compared to other villages in the Lembang District. Cikahuripan Village is a catchment area, especially in the southern part of the Village.

Natural disaster that has occurred in the Cikahuripan Village based on Potensi Desa (2011) was landslide. This relates to topography and rainfall in the village. Rainfall in the Cikahuripan Village ranges between 2,000–2,500 mm/year therefore is included into high rainfall intensity category. Almost all the land in the Cikahuripan Village is andosol type. Andosol is quite sensitive to soil erosion. High rainfall and its soil type cause this area prone to erosion. That indicates that the Cikahuripan Village has risk of ground movement natural disaster. Besides the land movement, this village is also in the high risk of earthquake (Kurniawan, 2014).
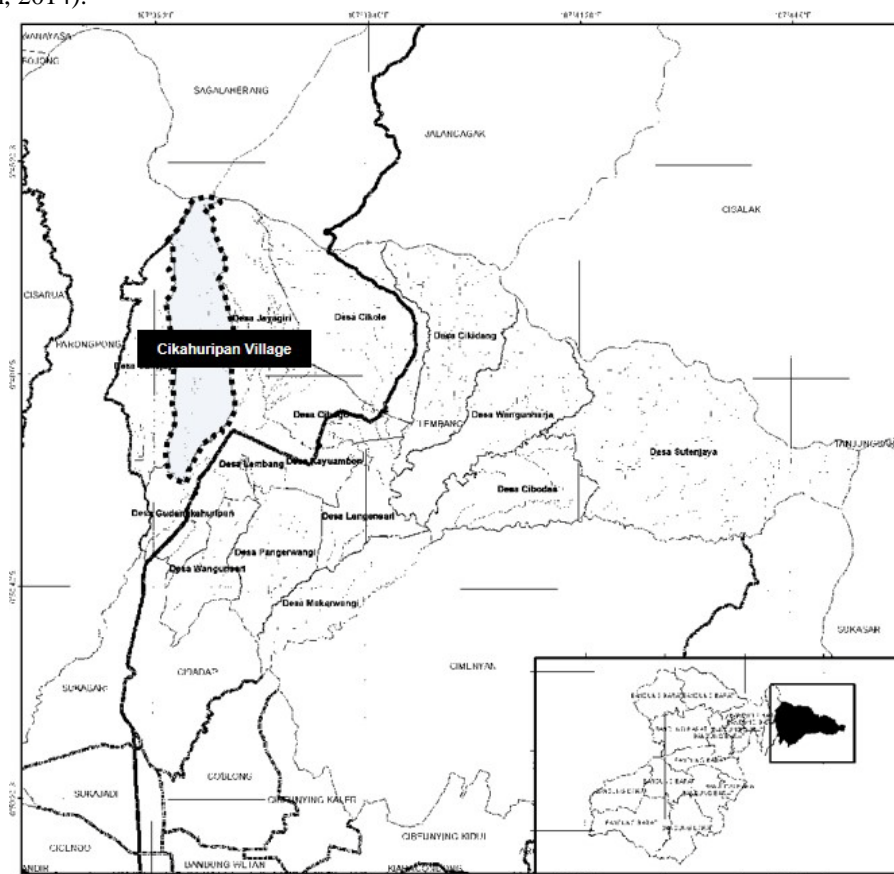
Figure 1. Cikahuripan Village in Lembang District (Kurniawan, 2014)

Material and Methods

Primary data is collected in two stages. The first stage, called pre–questionnaire or education step, is a step where researchers introduce the concept of GI to the community. In this step, the community was educated through video playback in Sundanese language. Through the video, GI concept, benefits, elements, and precedents were introduced. Since the concept is relatively new, the objective of this step is to assist respondents in completing questionnaires. The second stage was questionnaire distribution to determine public perception of the GI, its benefits for the community, as well as potential and constraints in applying the concept. Questionnaire was written in Sundanese; traditional language in that area. Questionnaires were distributed by using non–probability sampling technique with quota sampling. The type of sampling technique was selected based on the objective of the research; to know the perception of community towards relatively new concept. Quota sampling is a technique to select sample from population who has certain characteristics in specified number. The criteria used to select respondents are women with diverse occupation, education, income, and age.

For correlation research, minimum sample required to obtain the good result is 30. In this study, the number of samples was 51 samples. The samples have diverse characteristics in terms of level of education, occupation, and income. Cikahuripan Village consists of 10 RW(s); neighborhood unit, and those 51

questionnaires were distributed proportionally in all RW(s), except RW 9. The process of survey was done by utilizing regular religious gathering held every Friday and regular events of women gathering in the village hall.

The analytical methods used for each objective are listed as follows:

1. Identification of Public Perception regarding GI
   Quantitative approach by using descriptive statistical techniques is used to gain the information concerning public perception regarding GI seen from the experience of implementing GI.
2. Community Willingness in Implementing GI Component
   This objective is analyzed using descriptive statistical techniques. Some tasks done are reviewing some plans and community ability in implementing GI.
3. Factors that Affect People's Willingness in Implementing GI Component
   Identifying correlation between factors that affect people's willingness in implementing GI with the willingness in implementing GI Component is conducted using descriptive statistical techniques and cross tabulation analysis technique (crosstabs). Factors used in this study is education, income, occupation, access to new information, and information related GI.

Results and Discussion

Perception of Respondents towards Green Infrastructure

Current conditions indicate that there are respondents who already use their yard for gardening. Types of crops grown are food crops, ornamental plants, and medicinal plants. Gardening cannot be classified as implementation of GI since it does not involve the concept of water management. Although this gardening activity cannot be categorized as an activity in the implementation of GI, this condition indicates that there is desire to utilize their existing open space. From 51 respondents, 21 of them already carry out this gardening activity.

In general, respondents need to implement the GI Component. From 51 respondents, 50 of them stated that they needed to implement GI component. The needs are based on a number of benefits that will be accepted by respondents by implementing GI, such as health, greening and water absorption, air coolness, environmental, and aesthetics benefits. The respondents who stated that they needed to implement the GI component, in general, experience environmental problems, such as lack of clean water in term of quantity and quality, flooding, air and water pollution. They realize that the problems could be minimized by implementing GI component.

Willingness of the Community in Implementing the GI and Factor Influencing the Willingness

Based on the survey result, it is known that most respondents are willing to implement GI component, but they are not able to finance the implementation of the GI component yet. There is only a small proportion of respondents said that they could apply the funding for the implementation of GI component. From 51 respondents, 8 of them are willing and able to finance the implementation of GI, 32 of them willing to implement but still cannot finance the implementation, and 11 of them are not willing and cannot finance the implementation of GI.

Table1. Categories of factors influencing the willingness of community in implementing GI component

Factors	Categories	Factors	Categories
Education	No Education	Occupation	No Occupation
	Elementary School		Farmer
	Junior High School		Labor/Employee
	Senior High School		Breeder
	Higher Education		Trader
Income (IDR)	0–500,000		Civil Servant
	500,001–1,000,000		
	1,000,001–1,500,000		
	1,500,001–2,000,000		
	2,000,001–2,500,000		
	2,500,001–3,000,000		
	3,000,001–3,500,000		
	3,500,001–4,000,000		
	4,000,001–4,500,000		

In order to know the factors influencing the willingness of the community in applying the GI component, cross tabulation analysis is conducted. The factors which are considered as factors influencing the willingness in this study are education, income, and occupation. The willingness consists of three categories: (1) willing and able to finance the implementation of GI; (2) willing to implement but cannot finance the implementation; (3) not willing and cannot finance the implementation. The categories for education, income, occupation are shown in Table 1.

From the five factors mentioned above, only Occupation have significant value (below 0.05) (see Table 2). It can be concluded that occupation influence the willingness to implement GI component. Respondents with all types of occupation tend to implement GI but cannot finance the implementation, except farmers. Almost all of respondents with farmer occupation are not willing to implement GI component. It is because they feel that they have worked with plant and the most important thing that they do not have time to apply the concept.

Table 2. Result of cross tabulation analysis

Factors	Phi Value	Significant Test (Sig)
Education	0.501	0.118
Income	0.508	0.514
Occupation	0.685	0.021

Conclusions

It can be concluded that most of respondents will to apply the GI component after education. Occupation is factor influencing the willingness of respondents to implement GI Component. It is recommended that government conducts socialization regarding GI to community. Besides, subsidy from government to implement the concept is also important. Based on the result, most farmers are not willing to implement GI due to the fact that farmers perceive that they already implement this concept in their daily life and they do not have enough time to implement the concept. In this case, the role of government to educate people is very important since farmer's activity is quite different from activity in implementing GI.

Acknowledgements

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Re–Envisioning Lost Built Cultural Heritage: POST–Tsunami Aceh

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Abstract

Post–tsunami Aceh, Indonesia, represents a contemporary example of lost built cultural heritage. Catastrophic events of 2004 resulted in the destruction of significant buildings, whole communities and archival materials. This paper examines the potential of reconsidering "the archive" as an interactive set of multi–modal representations. Analogue and digital modes are explored focusing specifically on re–envisioning lost heritage through disparate data collection. Data ranges from social and oral histories, newspapers, maps, surveys, and artworks to produce outcomes of graphic, narrative and interactive representations of cultural sites. This paper discusses using VERNADOC—a low cost, low technology documentation method involving detailed observation through measurement and hand–drawing to record built cultural heritage. This method produces detailed analogue representations through participant immersion in the built and natural environment facilitating critical situational and cross–cultural understandings of context. Without onsite interaction and experience, recording built heritage represents an intellectual exercise that is detached from "real" physical appreciation of socio–cultural conditions. A virtual representation has valid applications, however this paper argues that an immersive analogue methodology informs the digital enabling an enriching and critical process in re–envisioning lost cultural heritage. Drawing together stages of data collection, observation and analogue documentation, this paper also discusses the distributed sustainability of the archive. Extending the standard physical repository, the multi–modal archive sits in the digital ether with dissemination to a wider and interdisciplinary audience beyond community stakeholders for global access. The archive as a digitally, immersive virtual environment offers applications beyond a record–keeping mechanism. In addition, it may be considered a toolset to safeguard collective memories of built and urban environments by re–presenting historical data to reflect on the human condition for disaster relief situations. Re–envisioned archival material may assist healing through reflexive discussions around shared memories beyond affected communities of the lost built heritage to resonate and remain visible to global observers.

Keywords : heritage archive, VERNADOC, BIM, re–envisioning, multi–modal.

Introduction

Built cultural heritage plays a significant role in the evolution of identity in any community. This paper is proposing a research methodology to contribute to the re–creation of Aceh's destroyed built heritage archive post–tsunami 2004. Archives are repositories where culturally significant knowledge is preserved. Usually in the form of artefacts, archival records generally consist of, but are not limited to, drawings, photographs, letters, newspapers, cartographic material, sound recordings and other media. Together these records form narratives of the past, present and future identity of a place. Therefore they are an invaluable resource not only to interest and professional groups but to safeguard a community's shared identity. The existence of a built cultural heritage archive empowers a community with intact collective memories of its building stock, their stories, socio–cultural contexts, socio–political conditions around their evolving spatial design conceptions as well as knowledge networks and/or limitations around their construction and procurement processes. Archival records enable graphic and visible recounts of past built form and the potential to re–construct and re–imagine community identity through the lens of architecture. Aceh's predominant archives did not survive the 2004 tsunami. This research is essentially a four phase pilot project proposal. It aims to investigate the possibility of re–documenting lost built heritage and populating a new archival collection with pre–tsunami images of Aceh's built heritage using remaining historic examples in rural and urban settings as exemplars. This recapture process, it is proposed, will also add another layer to the archival material, introducing multi–modal forms of representation. The creation of a digital platform

through which archival data can be disseminated beyond the immediate community, in forms such as combined hand–drawn documents, digital models and recordings, as well as virtual immersive strategies for local and remote users. As a pilot precedent this research proposes an archive where analogue processes inform the digital and then the digital re–imagines and augments the analogue to capture, re–envision and safeguard Acehnese built heritage.

The methodology for this reproduction archival process comprises of four distinct stages. Firstly, the documentation of remaining traditional Acehnese houses and their urban design configuration sited in rural villages in proximity of Banda Aceh. These select building types will be identified by the community, universities and heritage groups with a passion for built conservation. The building traditions of Acehnese houses highlight many intrinsic socio–cultural practices which have endured in Aceh prior to the arrival of Islam in the thirteenth century. These practices inform the organisation of social space as well as building methods, spiritual parameters of the internal domestic spatiality together with material availability and response to climatic conditions. The method of recording the Acehnese house in its village context will be via the VERNADOC (an acronym for vernacular documentation) process of on–site cultural immersion and immediate transfer of measured information of the house to the drawing page. This process is distinct from typical architectural measured drawing, as all recorded information is applied to paper immediately on site. This process will be elaborated upon in more depth in the subsequent discussion. Secondly, the employment of VERNADOC will be utilised in an urban setting, this time capturing the built form amidst the machinations of the modern city of Banda Aceh. In the city centre's building stock, architectural heritage significance depicts Aceh's mixed cultural beginnings from Chinese shop houses to Dutch colonial buildings intermingled with the Dutch/Indonesian hybrids of Jengki styles amongst others. This urban form communicates an evocative socio–cultural heritage of ethnic diversity and socio–political upheaval. The unique and eclectic nature of these surviving buildings offer an insight into a fascinating narrative from seventeenth century Aceh through to the 1970s. The third stage of this pilot project aims to consolidate the findings of these preceding stages to establish an informed and meaningful data collection method as well as appropriate subjects for the graphic reproduction of non–existent built cultural heritage. Identifying those buildings now lost, in built form and archival record that are still considered significant contributions to the collective memories of the Acehnese community. Utilising the onsite immersive strategies obtained from the practice of VERNADOC methods together with cross–referencing to other data sets such as socio–cultural histories, old photographs and maps, the lost buildings are to be re–imagined graphically to reintroduce their role in Aceh's rich historical narrative. Finally, the analogue material and social history audio recordings are translated to a digital platform for both accessibility and sustainability purposes. Virtual reality software will respond to the needs of remote and local archival users enabling a better understanding of the socio–cultural conditions and physical context of the re–envisioned subject, disseminating and sharing knowledge to safeguard and cultural heritage and identity. It is the combination of these four stages that will form the framework for the archival database of the built cultural heritage archive.

Research Method

Analogue methods: VERNADOC

The analogue component of this research proposal will be underpinned by an established process of documenting vernacular built form. As products of specific social and cultural history vernacular buildings are distinct examples of local knowledge, materials, technology and experience as well as expressions of spiritual beliefs, communal customs and collective understanding. These forms enable traditional everyday life, to reinforce cultural practices and reflect shared memory and social identity. The International Council on Monuments and Sites (ICOMOS) an organisation focussed on the preservation of built heritage sees vernacular buildings as the "fundamental expression of the cultural heritage of a community", as well as an "expression of the world's diversity" (ICOMOS, 1999). Culture and cultural practices including the process of building are dynamic, so whilst a particular structure is an expression unique in time and place, each building forms part of an ongoing dialogue of individual and communal understanding of development. As globalisation accelerates communities everywhere towards "cultural and architectural homogenisation" individual cultural identity and traditions including vernacular buildings and building practices are increasingly under pressure. (ICOMOS, 1999)

VERNADOC, a contraction of the phrase vernacular documentation, is a research and documentation method that originated from the former Helsinki University of Technology (HUT) now known as the Alvar Aalto University and more broadly, a Finnish pedagogical tradition of recording and valuing that country's vernacular building traditions. In 2005 the first VERNADOC project was held in Finland, and was attended by participants from China, Egypt, Finland, Italy and Thailand. The term VERNADOC, denotes a process

that uses simple measuring and drafting tools to accurately document vernacular buildings on–site with high quality hand drawn graphic outcomes. Since its foundation in 2005 over twenty VERNADOC projects have been undertaken across Europe, the Middle–East and Southeast Asia.

Anthropologist Tim Ingold discusses the use of drawing as a process of recording that engages researcher and subject in a dialogue which is "metaphorical and methodological" in outcome and potential. Metaphorically the drawing as an artefact binds understandings and individuals together and methodologically the drawing is both descriptive and participatory. (Ingold & Corporation, 2011, p. 221)The VERNADOC method requires immersive field work ensuring that data is recorded on site and in context both physically and culturally. It is only through this intimate connection with the built subject that non–visual layers of understanding can be comprehended and encoded into the representation. Time and proximity engender understanding and respect as architect and VERNADOC veteran Southeast Asian lead coordinator Sudjit Sanawai describes, the process is like taking care of elderly relatives, custodians of wisdom and truth "who can still whisper to me some of their stories". (Sanawai, 2014, p. 13) Buildings are more than their physical built form, they are repositories of multiple knowledge systems, memory and identity, connecting people to place through time.

A VERNADOC project is proposed for the preliminary stages of this research project to inform both the final process as well as the research question, therefore under–pinning the ultimate outcome as part of an ontological framework. Field research using the VERNADOC method, firstly in rural and then urban settings will immerse researchers in the culture and context of Aceh, Acehnese building heritage and cultural relationships to buildings and place. Each integrant stage of the proposed project will generate research outcomes that are rich in socio–cultural data, accessible on multiple levels and generate meaningful and material outcomes for the local community in the form of a high quality renderings. In the context of this research proposal, the preliminary stages seek to situate and embed researchers in the subject, ensuring an active engagement with environment, process, physical, material and human factors, and thus giving a degree of authenticity to any speculative re–envisioning of lost built heritage that would not be available via more detached or conceptual methods.

Like Ingold, Ana Isobel Afonso uses drawing as a method of recording and re–presenting anthropological research, recognising its potential not only to engage researcher with the material subject but as a collaborative process that enables dynamic input by local stakeholders. (Afonso & Ramos, 2004). While drawing as a method of recording has been used traditionally across most research disciplines, its effectiveness and potency has in recent times been re–evaluated and applied. Initial research stages in this project may be considered "Architectural Anthropology" in methodology, interpretivist in approach, bringing together aspects of ethnomethodology and phenomenology to drive the process and its outcomes. (Groat & Wang, 2002) Unlike photography or other modes of digital image capture and collection the manual production of hand drawings in situ is a reflexive method of observation and recoding that allows input and interaction before, during and after the process. Layers of memory and meaning can be distilled into an artefact that affects a collaborative outcome layered conceptually and symbolically by researcher, collaborators, environment and subject supporting the assertion that social inquiry cannot be purely objective but relies as much on detail and nuance as thematic understanding. (Geertz, 1983)

Analogue: Re–Envisioning

Conducting a rural based VERNADOC project as the first stage and an urban based project as the second stage of this process, it is proposed that an effective method for the third stage will become apparent. As surviving built forms are documented on site it is anticipated that collaborative and acquired understanding through this process will inform the potential for a re–envisioned archive. Community advice and input through shared memories and specific expressions of memory will lead the research project to an effective and responsive final stage.

The third analogue stage of this research proposal will be to address the re–envisioning of lost urban forms and lost archives. This hypothesis asserts that through rural and urban field work (stages 1 and 2) and the careful documentation of surviving Acehnese built environments, a meaningful process of re–presenting pre–tsunami urban forms may be implemented. This process is not the VERNADOC method but utilises insight from the former method to reconstruct manual graphic representations of lost buildings through forensically piecing together surviving records. As a means of re–envisioning lost urban forms, drawing offers opportunities to engage, as Ingold suggested, in the metaphorical. If, as sociologist Maurice Halbwachs suggests memory as a shared experience, rather than history as an intellectual exercise, is linked to collective experience, sudden loss of familiar urban environments results in "memory loss and identity crisis threaten" particularly in the case of natural disasters where that loss is coupled with personal and community trauma. (Crinson, 2005) Retrospectively creating visual records and re–envisioning lost buildings or streetscapes may

communicate the importance of the local beyond those materially affected by loss to the broader global community.

As discussed the 'making' of a manual drawing delivers a very specific experience to its author. The outcome of these research stages will be unique artefacts that illustrate tangible and temporal connections between drawer, subject and audience. This painstaking process demands an awareness of every mark on the page and a contemplation of its meaning and inclusion in the overall work. Whilst processes of selection and omission are intrinsic to all drawings regardless of method, the level of engagement and the physicality of re–drawing and re–envisioning revealed in the manual process is highly instructive. Re–interpreting built forms into technically constructed drawings, requires a first–hand understanding of construction in order to interpret realistic buildable forms on the page.[1] While digital construction drawings produce buildable outcomes their production process can affect a disengagement with technical and cultural understandings not feasible in the manual process. For example, computer aided design drawing packages can be guided by their user to deliver a buildable solution from stock elements. The re–envisioning component of the archival drawings may represent an opportunity forthe union of analogue and digital representations. The following analysis of the possibilities of BIM and other digital techniques in re–imagining built form and re–envisioning their forms in specific contexts exposes the archive to many possibilities. The following section will explore these benefits and opportunities for the case of post–Tsunami Aceh.

Digital re–envisioning
Data Capture

The traditional use of Building Information Modelling software (BIM) in the Architecture, Engineering and Construction Industry (AEC) is in the documentation and administration of new buildings. This integrated process involves the use of BIM enabled software and follows a BIM process, however the two could be used independently. (Eastman, Teicholz, & Sacks, 2011) It is proposed here that the adapted use of a Building Information Modelling methodology in capturing built and intangible cultural heritage may be appropriate to the built documentation needs of the community. The BIM process involves the input from all of the stakeholders from the inception of the project through to its completion. Instead of the core information capture being for a new building project, it is proposed that additional non–tangible details are recorded as part of the process of re–creation and re–envisaging. These details may include (for example, Indonesian concepts of heirlooms or *pusaka*, explained later) personal stories of local people, their families, and their reasons for building in a particular way that may be added to the BIM database.

There are an increasing number of processes available for capturing built cultural heritage using different analogue and digital modalities. These include developments in digital scanning at the building level, and the wider urban level covering multiple buildings or square kilometres of area. The use of laser scanning, photogrammetry, LiDAR and other similar digital processes have been available for many years and the simple automation of the data into BIM software or the creation of three–dimensional (3D) models are well documented. (Alshawabkeh & Haala, 2004) However, built cultural heritage as a concept extends beyond the physical associations of posts, beams and floors located and fixed in an appropriate manner. (Kurin, 2004)

The process of recovering lost heritage, will require a greater level engagement and data re–construction from a variety of sources. By undertaking data collection onsite, the community can be actively involved in the process. This forensic process will require time to reconstruct, manually and then digitally to gather appropriate representations. It is dependent on the amount and quality of data available as images, narratives, drawings, that could be crowd–sourced through social media. Stages 1 and 2 of the VERNADOC process will aid in the creation of new material via cultural immersion, observation of collected images, interpretation of narratives and the manual graphic conversion. The digitization of images and drawings will assist with the construction at either a façade level, or if further detail is available, also for the scope to produce a full 3D model.

Through a process of working with the stakeholders, they will determine the data to capture. Using a variety of drawn, digital image, audio and movie based formats the multi–modal material will be collated. Where possible to expand upon the technical processes of data capture for photogrammetry and laser scanning, the community would inform the capture of the intangible components. Engagement, time and discourse with the direct community and stakeholders is vitally important to identify the images, context and moments forming an integral part of the fabric that is interwoven into their everyday life.

With the stakeholder's requirements identified, a standardized process of digital capture can then be overlaid with the analogue to ensure that built culture may be re–imagined and re–envisaged to suit stakeholder requirements. Though VERNADOC does not require digital input for it to be effective and successful, it will inform the digital data collection. The suggestion that the augmentation of digital with a

VERNADOC underlay will enrich the digital process, and enable a layered experience in re–envisioning lost cultural heritage.

Using a systemized and documented process will produce results that are suitable for capturing high quality images and creating a computer model. (Hanke & Grussenmeyer, 2002) The use of a tripod mounted Gigapan device for automated image capture, where the camera sits in a robotic mount that automatically and systematically takes a sequence of photos based on the Field of View (FoV) of the lens in a three hundred and sixty degree sphere around the camera. These images are then "stitched" together using software that can create an immersive environment, and using software to create virtual tours.

Processing

The collection of data using various digital methods can be advantageous due to the level of detail, speed and accuracy that can be obtained. However, the subsequent processing of the collected data can be time consuming (Grussenmeyer, Landes, Voegtle, & Ringle, 2008). There could be a time delay between the capture of data over a two week period (the general length of a VERNADOC camp) to when the data could be available for review by the stakeholders.

To assist with this process of data collection, it is proposed that the digital capture occurs in parallel to the analogue capture. Working in tandem with the VERNADOC and lost heritage teams, images and narratives can be recorded and processed each day. These images and oral histories can provide an additional resource, but also a method of cross–verification or cross–checking the images with the drawings, by close examination between the two processes. The complimentary and simultaneous production of the drawings through manual and digital forms is considered to be part of the innovation of the project. Working in the context of the community and stakeholders, local people can directly participate and have ownership in the process of collaborative data collection.

The power and portability of recent technological developments in laptop computers and similar devices may allow the processing to be undertaken onsite, reducing travel between locations, and as mentioned previously, allow for earlier verification of images and narratives with stakeholders. The process of data collection, and processing through the pilot studies, and trial and error aims to deliver an efficient process that could compliment analogue processes.

Figure 1. Analogue digitized and overlaid with 2D Photograph and 3D model images.

The correlation of the collected data can be achieved by visual comparison side by side, and with the digitization of analogue to the digital environment. Figure 1 demonstrates the process of a digitized scaled drawing overlaid to a photograph and then a façade model generated from photogrammetry as a trial.

Storage and Output

The offline storage of data is always problematic, with changes in technology, enhancements of standards and the growth of new devices leaving older technology behind. Even the proposition of using LTO[TM] tape and Blue–ray [TM] to store data could be outdated in the decades to come. (Cerf, 2011) Our consideration is not only offline storage, but the persistence of data over time in addition to standard archives

and data storage. Similar to a physical collection of antiquities being maintained, we propose that the data is maintained online, and updated where practical to current formats as new standards and methods become available. This attempts to avoid 'bit rot' however it is not a guarantee that data may not become corrupted by other means. (Rosenthal, 2010).

The use of open formats for data storage and management, and clarification of legal ramifications and ownership of data, must allow data to be publicly available, in an open format for dissemination. The use of a defined management and maintenance process for the up–keep of the data and viability through the use of automated systems and manual oversight.

The use of methods such as "Lots of Copies Keep Stuff Safe" (LOCKSS) originating from Stanford University, and distributed digital preservation assists in the maintenance of live data at a reasonable cost. (Skinner & Schultz, 2010) Maintenance of data, is required through the following processes such as by reviewing current stocks of different data types yearly, and updating them as required to current standards to increase longevity, and check data viability for errors. The issue of storage costs, though relevant over time as a cost to the consumer is still decreasing but probably at a slower rate than is ultimately desirable by data management customers. (Rosenthal, 2010) However with faster networks and collaboration with other external storage providers as well as increasing the availability of cost effective long term online storage, costs might also increase. (Rosenthal, 2010).

The collected data for this pilot project is intended to be available digitally as nominal 2D and 3D materials using an Information System, and Google Earth for an interactive presentation environment. (Prechtel, Münster, & Kröber, 2013) Virtual tours can be created with software such as Kolor's Panotour Pro to enable an immersive and navigable environment with hotspots highlighting points of interest and information. The use of BIM to store the data, can also be utilized for visualization in an immersive environment. The use of an Oculus Rift or other immersive devices to create a virtual environment for interaction, where selecting 'hotspots' or 'information areas' will bring up narratives or video about that particular point of interest. Possibly another mode of immersion to be adopted in this project is the use of eye–tracking in a virtual environment, where what you are looking at can cause the software to read and highlight or present information about what the software determines is the focus of your gaze. These are just some of the technologies which will aid the delivery of the archival project to a diverse and global audience, in addition to enabling access locally in both digital and analogue capacities.

The final section of this proposal analyses the work of Acehnese scholars and others who have been active in the reconstruction and heritage conservation realms in Aceh and other post–disaster sites, it contemplates what is heritage and what is deemed worth preserving documenting and re–envisioning whilst reviewing some housing and mosque re–envisioned examples, considering what went wrong and what might be some alternative approaches?

Post–tsunami Acehnese case studies and identity

To further situate the knowledge, this research proposal is bringing to the re–creation of the archive, a critical analysis of work produced by scholars such as architectural historians Yenny Rahmayati, Patrick Daly, anthropologist Trinidad Rico and architectural historian and Acehnese scholar Cut Dewi follows here, to inform the proposed methodologies around the re–envisioning process.

Yenny Rahmayati and Patrick Daly have analysed "cultural and social mechanisms for community recovery, and how these are related with the material world." (Daly & Rahmayati, 2012, p. 58) Their work identified the role of socio–cultural practices responding to physical and psycho–social conditions in the communities' recovery. For example, whilst NGOs assumed housing was the primary requirement for displaced Acehnese in the post–disaster approach, after these scholars' community consultation, it was the buildings such as the *meunasah* and the *mushollah's* that were most frequently prioritised. These buildings represented the key spaces of autonomous community decision making as well as the spaces of worship. As many tsunami survivors' associated the devastation of the tsunami with a requirement to increase their commitment to their religion, the omission of these community built structures resonated through the affected communities. "Aid and reconstruction efforts that further remove people away from familiar and social contexts run the risk of pulling them away from the basic community infrastructure that is necessary for recovery." (Daly & Rahmayati, 2012, p. 58).

Rahmayati has documented the process of rebuilding and reimagining residential accommodation post–tsunami in Aceh and her study provides valuable insight into how the processes of re–envisioning dominated by external actors falls short of community expectations. Dealing with trauma often involves culturally–specific techniques and measures. According to Daly and Rahmayati the Acehnese identify with both historical and material processes as part of "broader cultural and social trajectories and carried out in meaningfully constituted environments which are integral to their enactment." (Daly & Rahmayati, 2012, p. 60) Trinidad Rico does not see 'the material' as heritage to be preserved or necessarily contingent in the

rehabilitation process but rather as an evolving concept of psycho–social conditions responsive to altered material conditions. Whereas Daly and Rahmayati suggest it is the continuity of physical built form from a cultural heritage perspective, that give the community a sense of familiarity and some coping mechanisms to negotiate the phases of post–disaster recovery.

Human landscapes are culturally constructed and understood through material as well as social practices. This concept is supported by the work of anthropologist Oliver–Smith, where there are specific relationships between cultural groups and place that foster attachments and enable rehabilitation through re–establishing connections with that place. (Oliver-Smith, 1996) Therefore the process of re–envisioning (stage 3) is proposed here as a "giving back" to the community in drawing lost buildings which occurs through a forensic process informed by the VERNADOC rural and urban experiences (stages 1 and 2), and results in an artefact to remember and reinscribe a destructed landscape. As to what the community does with this information or artefact is intended to contrast what de Vries suggests is "losing access to places of cultural and social significance, and the resulting loss of connections to people, undermines the community's ability to turn its 'wheels of healing.'" (deVries, 1995) The suggestion here is that the re–creation of the archive may make a small contribution to the community's sense of identity through built form, it is not the remedy to trauma. The method discussed thus far for production of the archive: VERNADOC–rural, VERNADOC–urban and then re–envisioning through manual and digital modes of production that may address some of the short–comings and issues identified by the communities under NGO–guided programs from the early days to later years of post– tsunami reconstruction. Through the production and insight gathered for this archival project, the main areas which may be informed include the following issues raised in community consultations sourced from the earlier cited scholars: 1. the lack of suitable cultural and climatic housing types 2. The lack of adherence to socio–cultural and religious understandings for essential community buildings, 3. Non–tangible and misunderstood ideas of culturally–specific notions of heritage.

The notion of intangible heritage is discussed by Robert Cowherd as depicting "the symbiotic relationship between material culture and living culture, where the local communities who use their built heritage are arguably more valuable as a cultural asset than the buildings themselves…" (deVries, 1995, pp. 66-67) For this research proposal intangible heritage will contribute directly in the narrative of the processes of construction, material accessibility and techniques for preparation for building, and why these processes are deemed significant to the production of an appropriate building type.

> "…emerging ethnographic approaches have considered that cultures have long had their own methods of preserving their cultural heritage beyond the development of scientific methods and principles that have been used to justify different forms of retention and intervention by the West. …Kreps has convincingly argued that non–Western models of museum and curatorial practices should be observed as unique cultural expressions…a local term for heritage in Indonesia, *pusaka* (although some informants used *pustaka*), reflects an understanding of cultural heritage that is both tangible and intangible." (Kreps, 2006, p. 458)

Pusaka directly translating into the term 'heirloom' yet is also applied to the notion of inheritance, and something which has personal value for the community. Kartiwa states that *pusaka* has a significant role for the transmission of cultural knowledge and traditions over the course of generations. (Kartiwa & Hardjonagoro, 1992) According to Rico, "virtually anything can be *pusaka*, but not everything is inherited becomes *pusaka* nor can objects be created to be *pusaka*—a thing must become *pusaka* in the course of its social life." (Rico, 2016, pp. 67-69)[2].

Therefore this research proposal is moving toward an intertwined or integrative notion of heritage whereby people, their heirlooms and living environments are considered as an holistic narrative comprised of experience and qualities of the natural and built environment that are inseparable, "…with memories narratives that are able to be transmitted, recreated, 'revived' in the same way that heritage is claimed to operate." (Rico, 2016, pp. 70-71) This method is achieved by participant observation, cultural immersion in real and virtual environments as well as the ability to discern between "where the event is memorialised in the reconstruction, in the rows of identical houses, and in the unreconstructed remains, the event is still present." (Rico, 2016, pp. 71-72).

The impact of these measures on behalf of well–meaning NGOs, Rahmayati goes so far as to say how "Acehnese individuals and communities are transformed in post–disaster situations because of changes to house typology and home space without consultation with housing recipients." (Rahmayati & Haigh, 2016) The response is typically instrumented around a macro–condition, for example over one hundred and fifty thousand dwellings were required. The micro–conditions of more idiosyncratic qualities of dwelling and socio–cultural necessities for an holistic, fruitful existence and happy life appear to have been overlooked in favour of the most necessary requirement for shelter. The former situation may be a sufficient short–term

response but on the other hand many temporary housing solutions often become permanent—as was the case for residents of Aceh. Therefore there were limited opportunities offering flexibility to move beyond the original designs imposed upon them. Long–term consequences and necessary foresight were not employed, it may be argued, perhaps for legitimate reasons. Oliver–Smith suggests that the social aspects of housing in reconstruction are typically overlooked in favour of debating whether to adopt say advanced construction techniques rather than traditional forms? (Oliver-Smith, 1996, p. 8).

Out of the housing typologies adopted, that were investigated five to seven years after the tsunami, in Rahmayati's study found the kitchen as well as living rooms, bedrooms and verandah spaces had been modified. There were some circumstances where some dwellers could not afford to modify their buildings. (Rahmayati & Haigh, 2016, p. 8) On the whole residents found their pre–tsunami housing more appropriate to their needs, despite many occupants "choosing" their house typology. The new housing was typically "on ground" designs for the majority whereas previous typologies reflected semi–stilted or stilted designs (referred to as a 'stage house' typology.[3] According to Rahmayati on the whole, the houses were constructed of sub–standard materials, particularly for the donors of traditional Aceh house types.[4] These houses on stilts used timbers such as coconut timber and it was eaten–out by termites deeming the houses to be unsafe. (Rahmayati & Haigh, 2016, p. 9) Typically the donated houses were too small with the 'expandable house' concept omitted from the design which was originally stipulated by the BRR.[5] These findings are to a certain degree to be expected during a calamity of this scale. However, it is the pre–planning and the future investment in disaster management strategies especially around permanent housing which is required. There is a need to expand upon options, research archetypes, consult with, enquire and listen to stakeholders to provide them suitable residential options as a long–term solution to their housing needs. It is both the recovery from trauma of the event, the investment in the socio–cultural heritage of the community, the opportunity presented through the digitisation of re–envisioned built projects, that may facilitate access to, and knowledge of, alternative established housing typologies specific to Acehnese conditions. Community's being able to choose their future types of housing, religious structures as well as *meunasahs* provides empowerment for future rebuilding or for commemoration purposes and events.

A significant omission from the rebuilding processes in Aceh included attention to culturally–required urban planning arrangements of houses, sympathetic to socio–cultural practices for key buildings within the *gampong's* destroyed by the tsunami. The *meunasah* features as a significant building in the *gampong* but also symbolically represents the decision making area are for the community.[6] It is a male meeting space, but its omission compromises the traditional role of meeting space and therefore the self–coordinating role of the Acehnese in affairs of their own. In traumatic situations where loss is overwhelming and then new space neglects to deliver old key functions has a disorientating effect on the community. Many key decisions were therefore removed from traditional forums and transferred to unfamiliar spaces of the NGOs headquarters, and out of traditional contexts and amidst foreign participants. Again these processes were seen as disenfranchising and disempowering affected communities in making informed decisions about their own futures. Capturing the *gampong* in digital and analogue forms as a socio–cultural unit with its *meunasah* and mosques, its public space distributed around the village housing, has meaning and significance to its inhabitants, through documentation, remembering and cross–referencing it may serve as a possible tool of choice for future development. The re–envisioning of lost communities may also provide a reference template to revisit future development and aid unenlightened NGOs, architects and developers to better understand the context within which they need to appropriately respond.

Further to the absence of the *meunasah*, the reticence on behalf of some NGOs to rebuild sacred space was felt also amongst stricken communities. A Christian aid worker observed "…when we ask tsunami victims they say that they don't know who to blame—man or government or who—then they realise that this is God's will for the tsunami." (Dewi, 2016, p. 135) The loss of sacred space is felt severely by communities especially when they turn to their spiritual beliefs to aid the grieving and recovery process. These religious spaces are often ignored in post–disaster recovery as they are deemed a lower priority to housing but in fact these are culturally specific priorities and are deeply intertwined in Aceh. According to architect and historian Cut Dewi in her thesis titled "Iconic Architectural Heritage in Banda Aceh" for the case of the Peulanggahan Mosque—an example of a building predominantly destroyed after the tsunami. Dewi highlights how the mosque served as a significant iconic reference and landmark for the residents of the village of Peulanggahan. (Dewi, 2016, p. 242) Dewi's research shows that the attachment to the mosque for the local population was not significantly influenced when the mosque was rebuilt after the tsunami's devastation. The mosque was rebuilt in the same style but with different materials. This apparently did not affect the locals identifying with it. The mosque was rebuilt in the same location and its function as a place of worship remains. Familiarity of the built environment is important for cultural memory as it eventuates from socio–cultural practices, with the architectural forms assisting in the inscribing of meaning for its participants. It is not so much the materiality and style of the building which is significant but rather the

meanings and practices which permit the continuation of such rituals. The architecture facilitates this process through its presence in the field of relations between practice and memory. (Dewi, 2016, p. 250) The physical qualities of the building act as a backdrop to the everyday experiences of the resident population according to Dewi's research, but its physical presence is necessary in the remembering process. (Dewi, 2016, p. 251)

Conclusion

Reflecting upon proposed processes for re–creating an archive through the stages of VERNADOC rural, VERNDOC urban, re–envisioning in analogue and digital forms followed by digital dissemination and immersion presents a contribution to a potential post–disaster recovery management tool kit. This research would leave the community with a data set of information for rebuilding, remembering and empowering future aspirations for their community. This research process provides a potential platform intended to empower local community groups over their future development whilst taking stock of their past heritage practices. It is a proposal designed to instigate choice and motivate recognition and retention of knowledge from culturally–specific practices, and produce accessible information for user groups including the local community, NGOs and the global community. for future needs. Moving between the production and insight gathered for this archival project, issues raised in community consultations such as:
1.   the lack of suitable cultural and climatic housing types
2.   the lack of adherence to socio–cultural and religious understandings for essential community buildings,
3.   non–tangible and misunderstood ideas of culturally–specific notions of heritage, may go some way toward empowering and returning to the local community in Aceh some control over their future urban environment.

The reconstruction of a built cultural heritage archive is a process heavily–laden with socio–political and religion–cultural complexities. To some extent, Aceh has emerged independently from previous external heritage discourse constraints applied by NGOs during the post–tsunami period of re–building.[7] There are opportunities for the Acehnese to consider their post–tsunami identity and the role an archive may play, as academic Trinidad Rico suggests, "an important role in the manifestation of trauma, resilience, mitigation, and recovery. Heritage can be lifesaving." (Rico, 2016, pp. 88-89) This project suggests a multi–stage process engaging diverse methodologies around data collection for the archive. this diversity has the potential to bridge the divide that is typically understood and described by Shackel as a tension between what may be seen as "authority (the academic viewpoint) and authenticity (the community experience) in the battle for control and promotion of values in the public sphere" Schakel xi cited in (Rico, 2016, pp. 89-91), giving real agency to local communities in both process and outcome. The broadening scope of documentation beyond what remains in the urban and rural fabric, to re–envisioning significant lost built forms for , directed by the community, re–imagines valued communal and individual memories in the process of healing. At the same time this process recognises there are different worldviews and perspectives of different worlds as well as often unforeseen complexities… (Karlström, Spiritual materiality Heritage preservation in a Buddhist world?, 2005) to cater for, in the production of archives and needs to negotiated carefully.

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Note
1. Here the drawing is understood as the artefact which should be as accurate representation of the "rela" or re–envisioned as possible, to the extent where it may be recreated through these drawn insights and reconstructed if sufficient information is able to be forensically collated.
2. "A key theme in Krep's 2003 thesis is that, like pusaka, all heritage constructs need to be integrated into larger social structures and ongoing social practices in order to preserve the socially and cultrally constructed values and meanings that are contingent on specific contexts….the concept of pusaka refers to the ability of objects to possess an intimate, spiritual connection to their custodian, in such a way that if pusaka 'were in danger of theft, damage or destruction, he [the owner] would do everything in his power to save it.'
3. On ground refers to slab or footings on the ground rather than pile based footings and stilt lightweight structures above. On ground structures were typically constructed out of masonry and rendered. Stage house refers the typology understood in Indonesian sources (Arif) as an elevated structure with utility space underneath.
4. Donors refers to the sources of financial support for rebuilding ranging from NGOs to church and religious groups also known as FBOs faith based organisations.
5. BRR refers Agency of the Rehabilitation and Reconstruction for the Region and Community of Aceh and Nias. This was the key agency overseeing aid delivery in Aceh, including rebuilding sacred spaces. Donors and NGOs were required to register their activities with BRR so they could match donors with local needs and priorities. BRR was a contested institution as it was an organisation with many Javanese employees. It also struggled tom raise money for religious buildings.
6. Eg. the mushollah = small mosque and the meunsah = traditional centre of community activities serve

distinct purposes and the meunsah was absent in many reconstruction plans…this was the place of village decision making and around building character as well as regulating behaviour….from a heritage perspective a key cultural historic role was omitted for villagers.

7. NGO refers to Non–Government Organisations ranging from faith based organisations to other charities and stakeholders.

"Kota Madani": Islamism of Urban Planning in Banda Aceh

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Abstract

This paper shows how the spirit of an idealised Islamic past is brought to life in Banda Aceh, though not only Islamic Sharia implementation, but also Islamic city planning. I show this by observing the ways the idea Islamic City, "*Kota Madani*" has been translated into several architecture developments and consequently the ways the architecture form and boost the image of Islamic city. To do this, the paper employs semi–structured interview, participant observation and literature study method. The paper conducts a survey on architectural development and spatial regulation in Banda Aceh. By doing this, I argue, the state, in this case Banda Aceh's local government, through its institutional policies and practices, politically controls the formation of public architecture, especially iconic or monumental architectural heritage. The stakeholders, especially government have translated the idea "*Kota Madani*" into at least three interrelated ways. Firstly, They adopt what so–called the image and Middle East architectural styles, especially Islamic holy places architectural style. Secondly, spatial planning has set and consequently strengthened the Baiturrahman Mosque as a central or landmark of Banda Aceh. Thirdly, Islam is combined with modern concept by enacting several modern buildings and facilities imbued with Islam.

Keywords : Islamic City, *Kota Madani*, Architecture, and Identity

Introduction

I specifically focus on how the Islamic City, "*Kota Madani*" is translated and appropriated by several stakeholders, especially in the design of public architecture such as mosques, schools, government offices, etc in Banda Aceh. *Madani,* which is also literally translated as civil society in English (Rosyid, –), is a translation from the Arabic word *mujtama' madani* which has two meanings: *madinah* which means a city reflecting dynamic activities and *tamaddun* meaning civilization (Hafidhuddin, 2003). *KotaMadani* is the concept of an Islamic city based on egalitarian concepts. An example of this society was strongly associated with Al–Madinah city, Saudi Arabia, during the life of the Prophet Muhammad. If the age of Enlightenment was an important milestone for Western modernity, in Islam, generally speaking, the birth of the Prophet Muhammad is also seen as an important milestone, because he transformed ignorant human beings in to members of a civilised society. His sayings and actions, including the life during his era, have become one source of references for Muslims**.**

The notion to form Islamic City is also in line with the global phenomenon of rhetorical and politicised claims to return to 'Islamic' values and teachings, and to form Islamic cities within the Islamic world. In Banda Aceh this notion is also in line with the implementation of Islamic sharia which, for the government and other elites, is a panacea for the independence crisis that caused a thirty–year conflict in Aceh, as well as a way of distinguishing Acehnese identity from the rest of Indonesia.

The creation of identity imposed by static physical settings, like architecture and urban planning, has become a concern and interest of states through the hands of architects and urban planners. This paper, therefore, sees urban planning and architectural design as state–controlled systems or state–driven systems of constructing and controlling a number of cultural tools in the heritage process. As noted by Billig (1995), architecture is a medium for conveying political messages of government; the banal nature of architecture works to continually reinforce particular understanding of identity. In Addition, as architecture has the ability to convey certain messages as if it is equivalent to a language: either as a "code" or written or spoken language (Hershberger, 1988, p.190). Eventually, landmark architecture is inextricably bound up with collective identity claims (Libeskind in Jones, 2006). The state, through its institutional policies and

practices, politically controls the formation of architectural heritage, especially iconic or monumental architectural heritage. This is undertaken in order to form a certain sense of place. Consequently this can trigger certain memories and construct certain identities.

To investigate the ways Islamic City, "*Kota Madani*", has been understood and translated by various involved stakeholders in the development of public architecture in Banda Aceh, I employed several methods: participant observation and literature study. I have conducted interview with several involved stakeholders, a survey and participant observation of architecture development and literature study on spatial regulation in Banda Aceh. Then I classify the public architecture into several possible themes and analyse using several theories and comparisons with other architectural styles. In addition, a triangulation between participant observation, interview, and literature study has been undertaken to ensure the validity of the data.

Returning to Islamic Principles as a Global Phenomenon

The return of Banda Aceh to its Islamic past is also part of a global phenomenon. This return mostly emerged after colonialization, or the end of World War II, and is part of a reaction to modernization and globalization (Nasr, 2010). Generally speaking, as argued by Frishman and Khan (1994; p.11), colonialism, together with war with Christianity and the Mongols, had caused the displacement of Islamic scholars from the centre of Islamic civilization, such as Cordoba and Granada in Spain. In addition to that, they mention that the fall and secularism of the centres of Islam, such as the Ottoman Empire in Istanbul in Turkey, have also contributed to the fall of Islam, which is now, however, emerging from its backwater and expanding to become the fastest growing major monotheistic religion. Thus, according to Nasr (2010), there are at least three general reactions to modernization emerging in the Islamic Word: Islamic modernism (adoption and Islamisation of modern technologies), a gradual attempt to study the meaning and history of Islamic science, and a study of Islamic science from an Islamic point of view through to re–reading unexplored Islamic manuscript stored in India, Yemen and many other places.

In urban planning, Abu–Lughod (1987, p. 1) finds that urban planners, with a new respect for past achievements, are searching for ways to apply this to today's cities that identify as Islamic, which is happening not only in many part of parts of the Arab world, but it seems now in other parts of the Islamic world, and particularly in Malaysia and Indonesia. See for example the implementation of Islamic Sharia in Kelantan, Malaysia and Aceh, Indonesia. This, according to Abu–Lughod (1987), is really misleading, as the contemporary context of the Islamic world is not as it used to be. The cities in the Islamic world today have followed the Western planning model for cities, especially American cities which are based on modern science and technologies that are not in line with Islamic science principles (Nasr, 2010). To adopt modern technologies, to be modern, for most non–Western culture such as in Southeast Asia, means to be developed (Byrne, 2012, p. 297). Yet, this modernity, as mentioned by Frishman (1994), in the Islamic world today, has negative connotations, as opposed to Islam, which has only positive connotations.

"*Kota Madani*" in the Spatial Planning of Banda Aceh

For the new Banda Aceh, as shown by *Qanun Rencana Tata Ruang Ruang Kota* Banda Aceh (the urban planning law) No.4 year 2009, it is better to return to the past while engaging in appeals to modernity. This is done through the resurrection of past tradition, in this case "Islamic" values, and the accommodation of new technologies to compete with other modern cities in the world. This resurrection is not unusual for a post–disaster city and society, and has marked many societies' efforts to sustain cultural resilience after a surpassing disaster (ICCROM, 2005). In Banda Aceh after the tsunami, the new urban planning law No.4 year 2009 of Banda Aceh clearly aims to form an Islamic city based on Islamic and modern principles. This Islamisation and modernization of planning can be obviously seen through the aims of urban planning of Banda Aceh *"Mewujudkan Ruang Kota Banda Aceh sebagai Kota Jasa Yang Islami, Tamaddun, Modern dan Berbasis Mitigasi Bencana"*(to create Banda Aceh as a modern, Islamic service city based on disaster mitigation) and Long Term Vision of development of Banda Aceh *" Terwujudnya Banda Aceh Sebagai Kota Tamaddun, Modern dan Islami"* (To form Banda Aceh as a Modern Islamic city). In previous urban planning such as Rencana Tata Ruang Wilayah/RTRW 2000–2010 (Banda Aceh Government, 1999 (2000)) and its revision RTRW 2001–2010 (Banda Aceh Government, 2000), the government did not clearly stated that they are forming an Islamic City. In addition, in his speech in a meeting held by the People Representative Council of Banda Aceh on 22 March 2012, Mawardi Nurdin and Illiza Sa'aduddin Djamal – at that time they were still candidate of mayor and deputy mayor – stated that they wanted to continue their success in last five years in leading the city by forming Banda Aceh as Kota Madani, Islamic City ("Mawardy Nurdin–Illiza: Melanjutkan Prestasi dengan Kota Madani", –). The Islamic City they aim to is *"Kota Madani adalah sebuah*

kota yang penduduknya beriman dan berakhlak mulia. Menjaga persatuan dan kesatuan, toleran dalam perbedaan, tata hukum, dan memiliki ruang publik yang luas (*Kota madani* is a city where the citizens are maintaining peace, tolerance, law, and open minded)".

What is interesting to note for these aims is the words "Islam" and "modern", which, following leading literature in Islamic studies such as Nasr (2010), clash in philosophies and principles. Along with its Islamic aims, my interview with the mayor of Banda Aceh also reveals that the government of Banda Aceh wants to turn the city into an Islamic city which is associated with *kota madani*, for example: We will create Banda Aceh as a model for *kota madani*…where there is tolerance among Moslem and other believers…so that people can live peacefully, harmoniously, and tolerantly…this is really like the ways Prophet Muhammad united Anshar and Muhajirin (Anshar was a group of people in Madinah, who helped Muhajirin, a group of people from Mecca who had just moved to Madinah.)…everybody lived peacefully and tolerantly…this is what we hope in the future. Interview with the Mayor of Banda Aceh, date….

In Spatial Planning of Banda Aceh, based on my interview with Head of Spatial Planning Department of Public Work Office of Banda Aceh, "*Kota Madani*" has been translated into green city concept as Islam encourages a state to provide a comfortable place for its inhabitants (interview on 14 October 2016).

Representing "*Kota Madani*" in Architecture

Instead of pursuing more philosophical concept of "*Kota Madani*" like the one during the Prophet time, Banda Aceh many stakeholders, as architecture in its ubiquitous presence and has symbolic meanings, it is a potential tool to be employed in the government symbolic political Urban Planning. Thus this paper observes several efforts to use architecture as a language to describe the idea of Islamic City, "*Kota Madani*". I argue there are at least there ways of implementing and translating the idea of "*Kota Madani*" in architecture by involved stakeholders.

Firstly, the Baiturrahman Mosque is deliberately planned to be the city's symbol. The Qanun No.4 Tahun 2009 tentang Rencana Tata Ruang Wilayah Kota Banda Aceh tahun 2009–2029 (the Spatial Planning Law)stipulates that the buildings around the mosque should not be higher than the minaret of the mosque and should function in accordance with the religious uses of the mosque. For example, surrounding buildings may not operate as hotels, karaoke centres, or have other entertainments that are in conflict with the mosque (Qanun No.4 Year 2009).

Figure 1. The Baiturrahman Mosque (source: photo by Cut Dewi)

Consequently, the mosque styles have become source of reference to architecture development in Banda Aceh. This is evident in the design of the shopping centre known as Pasar Aceh, an old market renovated with modern features through the program "Revitalization of Pasar Aceh". The façade of the shopping center literally replicates the arch and ornamentation of the Baiturrahman Mosque, which is seen as a model for Islamic architecture by the government. The replication is undertaken to give a sense of traditional and Islamic style. See for example the mayor statement on the Government website on 2 January 2013, "*Kita melakukan ini agar Pasar Atjeh dapat terlihat lebih modern, dan tetap tidak meninggalkan substansi tradisionalnya. Kita berharap agar hal ini dapat menjadi contoh untuk daerah–daerah lainnya,*" (we hope Pasar Aceh becomes more modern and still has traditional sense, which consequently it can be an example for other regions) (Purnama, 2013). Another example of this copy–paste architecture is the

Politeknik Aceh, a new college developed along the Krueng Aceh River, just a few kilometers from the mosque. Literally, the skin of the buildings is similar to the Baiturrahman Mosque façade, which is believed to be an expression of Islamic architecture and Acehnese identity.

Figure 2. Politeknik Aceh (left, source: http://www.politeknikaceh.ac.id accessed 2 on June 2014)
Pasar Aceh Shopping Centre (right, source: photo by Cut Dewi).

Secondly, the government copies some styles in Middle East countries, especially cities in Saudi Arabia. This is evident in the new development of the Baiturrahman Mosque. As Banda Aceh is the capital city of Aceh province, the intention of creating a *Kota Madani* has also influenced the decision making at provincial level; the governor, Zaini Abdullah, wants to support the designation of Kota Banda Aceh as *Kota Madani* by refurbishing the Baiturrahman Mosque in the style of the Nabawi Mosque in Medina. He wants to add umbrellas which are strongly associated with the Nabawi Mosque, Medina, Saudi Arabia. Below is the plan for the refurbishment of the mosque, which will be equipped with underground parking, a new ablution area and a wider garden. This plan has commenced in 2015.

Figure 3. The new Plan for the Refurbishment of the Baiturrahman Mosque (left, source: Tribun News, http://aceh.tribunnews.com/2014/12/05/menyulap–baiturrahman–mirip–masjid–nabawi, accessed on 4 February 2015). The Nabawi Mosque (right, Source: Detik i net, http://inet.detik.com/readfoto/2014/01/27/105008/2478939/1280/1/deretan–payung–di–masjid–nabawi–madinah?topnews, accessed on 6 February 2015)

Besides the appropriation of the Baiturrahman Mosque, domes has been literally interpreted as Middle East style and Islamic architecture, ranging from public buildings to recreational places. Domes have been adopted as a style for offices of emerging new organizations related to Islamic Sharia such Mahkamah Syariah (Islamic Court), Kantor Dinas Syariat Islam (Islamic Sharia Office), etc. In fact, Islamic architecture is not necessarily associated with the domes. As most Islamic architecture is derived from Hellenistic and Roman Imperial influences (Grabar, 2004; p.36), the domes actually belong to the era before Islam, and Islam adopted the domes and appropriated it for Islamic purposes. The architectural details, most scholars agree, coming from Islamic civilization are calligraphy, geometry, and garden design (Al–Asad, 1994; Frishman & Khan, 1994; p.13–14). The three details are artworks which are replete with the spirit of obedience to God. The calligraphy, according to Frishman and Khan (1994), expresses the intention of the Moslem scholars to announce to passers–by that the buildings are considered sacred places and convey

spiritual messages. Therefore, they avoid using the form of animal and people in the design, unlike in Classic European design (Frishman & Khan, 1994; Grabar, 2004; Thackston, 1994).

Thirdly, the Islamic city is combined with modern concept. Following Aspinall's (2007) thesis of Sharia Implementation as a political tool to impress inhabitants that government is good, the Banda Aceh government by implementing Islamic City wants to evidence that it is a "good" government by adopting Islamic values in planning the city, but at the same time wants to be recognized as a "developed" government by pursuing modern technologies. At the same time they also wish to make clear that Islam in Aceh is not extreme and has emerged with modern principles. As Islam has become an issue internationally, especially in the west, local government does not want to lose international support by promoting a pure Islamic city. In addition, as Aceh also wants to be part of the wider world (Hasan, 2009), it does not want to lose its opportunity to be part of the world by promoting pure Islamic urban planning. An example of how Islamic Sharia becomes a threat for international aid during the post–tsunami reconstruction was reflected in the case of an aid project initiated by the city of Apeldoorn, the Netherlands. In 2007, this city assisted Banda Aceh in developing waste management and one stop access for public services ("Laporan Master Plan Pengelolaan Sampah Untuk Kota Banda Aceh Pasca Tsunami ", 2007). However, in 2009, this assistance was under review after the Apeldoorn government was informed about the implementation of Islamic Sharia in Banda Aceh ("Apeldoorn Hentikan Kerjasama dengan Aceh," 2009).

To reflect a modern city, the mayor consciously promotes modern architectural styles imbued with the spirit of Islam. To reflect the image of a modern Islamic city, modern dome–roof styles have been adopted in some buildings, especially public buildings. Even though this style emerged before the tsunami, it is favored more now since it was adopted in the architectural design of the symbolic project *Balaikota*, the mayors' office. The building was designed with a hollow–domed metal roof and a cubical ship–shape façade. Color, dominated by grey, and materials, a combination of concrete, glass, and metal, have contributed to a strong modern image.

Figure 4. Balai Kota (the Mayor's Office/Town Hall, source: photo by Cut Dewi)

This building, however, has attracted controversy as it is not harmonious with its surroundings, which are dominated by old buildings from the 19th Century, as well as the nineteen sixties and eighties. Moreover, it has attracted many criticisms from local experts, especially architects, and the general community, both for its controversial architectural style and amount of funding, because it was built in the middle of a housing crisis after the tsunami. The critiques, however, tend to be confined to informal communication in coffee shops or blogs.

There are several other programs for making Banda Aceh a modern city, including: Banda Aceh Cyber Islamic City (BACIC), and Cities Development Initiative for Asia (CDIA). In BACIC, Banda Aceh presents a very strong concept of the Islamisation of modern technology – in this case the use of the Internet – as pursued by other societies within the Islamic world. The pure modern images, such as the pictures below, were taken from a government website in 2012.

Conclusion

Banda Aceh government, through its urban planning, controls landmark architectural heritage, like religious buildings and memorials, to facilitate the remembering of the so–called "glorious Islamic past of the Acehnese", and to formally reform a sense of the city as a self–consciously Islamic city. Literally, the valuation of the Islamic past is registered in the government policy and practice to construct an Islamic city. This is undertaken through at least three interrelated gestures. Firstly, the government regulates the Baiturrahman Mosque as a city symbol. This is followed by several attempts to not only regulate buildings around the mosque, but also to copy the mosque's architectural styles. Secondly, the government copies architectural styles of the Middle East cities, especially adopting the Nabawi Mosque styles in Medina and domes as Islamic architecture. Thirdly, there is obvious intention to form Islamic modern city by establishing several facilities and appropriating buildings in this way. All of these are undertaken to bring back the image of Islamic past and evidence the Islamic identity of Banda Aceh.

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The Masjid Pedestrian Network of Madani City:
Exploring Religious Facilities Exterior Space for Pedestrian Friendly Street Network in Banda Aceh

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Abstract

The urban landscape of Banda Aceh is characterized among other by one significant building type; the masjid and its smaller varian; mushalla, which are present not only in all neighborhood but also attached to major public facilities. This work explores the potential of religious facilities exterior space for linking pedestrian friendly street network in Banda Aceh. The paper argues that within the framework of *Madani* City advocated by the municipality of Banda Aceh, the number and distribution of masjid and mushalla could serve as nodes for generating and prioritizing more pedestrian friendly environment. The strenght of this argument is explored through spatial analysis of masjid number, distribution and service area. The spatial analysis at urban scale is followed by neighborhood observation around five samples of masjid service area, connection to the street network and proximity to public facilities. School is selected as the main reference for public facilities based on availability of city wide school data. School is also a very important public facility that could make most benefits from good pedestrian network. The result suggests that adding to the multiple roles of a masjid, it has great potential to shape pedestrian friendly street network that is developed accordingly with the *Madani* concept advocated by the local government and with the socio–cultural context of masjid centered community in Banda Aceh.

Keyword : Masjid, pedestrian network, madani city, spatial analysis.

Introduction

Masjid as building type

"Masjid" is the arabic word for a mosque. It simply means a space for prayer, a place of worship or prostration in prayer. The origin of the word ispossibly from Aramaic (https://en.oxforddictionaries.com). The Arabic term*masjid* has been absorbed into Indonesian, written either as *masjid* or *mesjid*. The term *masjid* is also preffered by many moslem compared to the term mosque. The use of the word "mosque" in English is discouraged partly based on a mistaken belief that it is derived from the word "mosquito" and is considered as a derogatory term. For many, the use of Arabic term is simply preferred as it more accurately describes the purpose and activities of a mosque, and because it is also the language of the Quran (http://islam.about.com).

Masjid is the most important architectural representation of Muslim identity (Khan, 1990). Along with the spread of Islam, masjids are build all over the world. The building often reflects the local culture, heritage, and resources of its community. Although masjid designs vary, there are some common physical features. These features or elements characterize a masjid as building type (https://www.khanacademy.org). The main features are prayer hall and *minaret* (tower). The elements in the main prayer hall may include a *mihrab* (a niche in the wall indicating the direction of Mecca and where the *Imam* or prayer leader stands to lead the prayer) and mimbar (a pulpit or steps from where the *Imam* delivers the *khutbah* or shermon). Then there is ablution area which is separated for male and female. Dome roof is often associated with masjid even tough there are many masjids both old and contemporary that do not have domes. Beyond these basic features, masjid may be large or small in size, simple or elegant in style. They are also constructed with a large variety of materials.

Modern masjid especially in the area where muslim is minority is often completed with contemporary features such as school (tough education is always an integral part of a masjid but usually conducted in the main hall), community organization offices, halal shop, parking area and other amenities located within the masjid's compound.

The importance of Masjid as building type in Banda Aceh

The majority of Banda Aceh resident is muslim. The city adopts Islamic Law (*Sharia*) and in 2012 set and branded its development goal towards a "*Madani* City". The word *madani,* derived from Arabic means related to civil rights, urban, to emphasize on Islamic values, norms and laws supported by *iman* (beliefs), science and technology (http://kbbi.web.id/madani). The municipality of Banda Aceh translated *madani* spirit into seven strategic missions to improve the practice of Islam towards *kaffah* (comprehensive) implementation. The seven missions are to improve the good urban governance, to improve the people's economics, to foster an intellectually healthy and welfare society, to develop Islamic tourism infrastructure, to improve women participation in the public domain, to improve child protection and to improve youth's role as the city's development strenght (http://syariatislam.bandaacehkota.go.id). This paper focus on how the islamic values could be translated into more meaningful urban planning principles, beyond what are currently seen as a somewhat supervicial applications through for examples, the over emphasis on incidental segregation of male and female in public spaces and the ecletic use of Islamic ornamentation or architecture style. In the socio–cultural context of Banda Aceh, a masjid is not only used as prayer space but also community space such as for community meetings, Islamic classes for all ages, funerals, weddings and other celebrations. Masjid is of a high importance since it is the core of religious and social life of majority of the people in Banda Aceh.

Masjid and the city

Islamic civilization is not merely a set of religious beliefs and laws but also a functioning society that organizes the life of Muslim into a community. The decision to establish a masjid signifies a commitment to build a community either before or after a physical neighborhood is established as the building block of Islamic city. Therefore as a the most important architectural representation of muslim community, masjid is the key element in the Islamic communities, neighborhood and cities (Abu Lughod, 1987; Khan, 1990).

For a simplification purpose the discourse on masjid can be classified into pair classification of the content–container, hard–soft or physical–social aspect. The physical aspect often centered around the building itself such as on its architecture style (i.e. Mustafa and Hassan, 2013), the interior decoration, thermal or the construction. The social aspects is the one that is possibly most often talked about by the general public. This is related to the ritual and social activities in the masjid. It is often termed as *kemakmuran mesjid* (the welfare of the masjid) which is basically the dynamic of religious and social use of the mesjid.

The exterior space of a masjid is usually discussed in the context of Islamic garden. However the Islamic garden concept is not necessarily attached to a masjid and very often is not applied to community masjids. It is usually limited to major historic or grand large scale masjid. Despite the fact that masjid is a very important element of islamic city, the discussion of how masjid compound connects to the surrounding urban fabric and the city is still limited.

Walking to a Masjid

Male muslim is encouraged to perform 5 daily compulsary prayers with *Jamaah* (in a conggregation) at a masjid (Quran, Al Baqarah 43; *Hadith* Al–Bukhari No 131 and Muslim No 649, narrated by Abu Hurairah). Walking toward a masjid for prayer is considered an act of worship as well, then it will be compensated as such for everyone (Hadith Muslim No 1553, narrated by Abu Hurairah). The longer you have to walk the more reward you will get. In this sense, a pedestrian friendly environment should be an integrated concept surrounding a masjid. However this is not always the case. The consideration for masjid design or construction is often limited within the boundary of the masjid compound. In Banda aceh for example, even the city's Grand Masjid Baiturrahman has a very poor pedestrian system beyond its compound's boundary.

Masjid and pedestrian friendly environment

Walkability level is a way to state how friendly and easy it is for pedestrian to walk. Several methods have been proposed by researcher and planner to assess the walkability of a space or a neighborhood. The methods known include simple measure by the presence of standard width sidewalk (at least for 1 person to walk safely along the street to more complex assessment tools as such walkscore (https://www.walkscore.com) and the walkability index (Frank *et al*, 2016; Leslie *et al*, 2005). The

walkability index uses a range of indicators including net residential density (ratio of residential unit to the land allocated to residential area), retail floor area ratio (retail building floor area divided by retail land floor area), intersection density (connectivity of street network, represented by ratio of number of true intersection; three or more legs to the total land area) and land use mix or entropy score which is the degree of land use diversity based on 5 main land uses of residential, retail, entertainment, office, institutional. The walkability index is not immediately applicable to a situation such as in Banda Aceh where city wide primary data of urban fabric is limited and where mixed land use are hardly recorded and continuously change without proper reporting and permitting. Some appropriation is needed to enable quick evalution of the walkability in a certain area e.g surrounding a masjid.

Methods

Data Collection
    The neighborhood, city boundary and initial educational facilities data are acquired from the Remote Sensing and GIS Center–Syiah Kuala University (RSGIS–SKU). The georeferenced religious facilities data is traced using ArcGIS through on–screen digitation over Banda Aceh satellite image (0.5m resolution acquired from GeoEye in 2013). Data for masjid is sorted and updated. Crosschecking is done through Google Earth, Google Map and secondary information of masjid list (http://www.dream.co.id). In several cases verification is done by direct site visit. From aerial view the masjid and its compound can be identified and distinguished from other building type by its orientation towards Mecca, the footprint and sometimes by the larger land size compared to typical housing site.
    The educational facilities information is also updated through the same process and crosschecked using secondary information such as school database from publicly available government data (http://data.bandaacehkota.go.id). Data of actual situation around the site and neighborhood level are collected through site observation.

The service area of masjid.
    In this research the service areas of all religious facilities particularly of masjids are delineated by drawing a circular buffer area around the center of the site with radius of 300m. This distance is based on appropriated easy or conveniently walking distance. The range of walking distance vary across places. It is often set between 400 m as the lower boundary and 1000 m as the upper boundary (http://humantransit.org). In this sense the 300 m is a very moderate distance which correlates to approximately less than 5 minutes of normal walking time. The 300 m radius moderation is also taking into consideration the indirect path range and unfavorable climate for walking.
    In unattractive environment such as under unfavorable climate, parking lot or congested street, people are most likely to walk for as long as 2 minutes or approximately 200 m while the mean easy walking distance in minutes is reported to be around 15 minutes (Colabianchi *et al*., 2007). Based on this information the research set 300 m as the walking distance range for Banda Aceh or approximately less than 5 minutes walking time.
    The actual service area of a mesjid and particularly of a mushalla is often set by social and political association rather than actual distance. Although there is no limitation, a mushalla that belong to a *gampong* (neighborhood or village) serve mainly the resident of that particular *gampong*. This type of service coverage could be considered at the site level but is not included in the calculation at the citywide level.

Spatial Analysis
    The spatial analysis step is as follows
1. Plotting and digitazing the location of all religious facilities in Banda Aceh to see the overall distribution.
2. Delineating service coverage for all religious facilities using buffer of 300 m radius. This will result in understanding area that is within walking distance from religious facilities including the masjids. It suggests that with regard to masjids, people who are within this area when a prayer call is heard could easily walk less than 5 minutes to a masjid.
3. The religious facilities buffer map is overlaid with map of educational facilities. The number of educational facilities within 300 radius of each religious facility is calculated within ArcGIS. Ten religious facilities with the highest number of school consist of 9 masjids and 1 church. Some masjids have up to 6 schools within walking distance.
4. We then focused on selecting masjid for case study. The selection is ideally done using complete data of city wide destination facilities (not only schools), land use, and pedestrian amenities. However since the our citywide data is limited to religious and educational facilities only, we used the two type of data at

this stage of the research and proceed with qualitative judgement when selecting site case studies. We identified 5 samples based on proximity to schools, land use diversity and neighborhood complexity that may represent interesting case study. The 5 masjids are Masjid Al Anshar, Masjid Al Huda, Masjid Al Muttaqin, Masjid Al Fitrah and Masjid Al Mukarramah (See Table 1 for location).

5. Calculating number of intersection (as indication of intersection density) by marking and calculating intersection with more than three legs (three street branching) within the walking distance buffer. Intersection is identified by on–screen digitation in InDesign.

6. Delineating block area using InDesign and presented as figure ground image.

Neighborhood Observation

Neighborhood observation is conducted toward 5 masjids to better understand the urban structure related to pedestrian system and to compare it with the information derived from satellite image and the result of spatial analysis.

Results and Discussion

Prayer space distribution across the city.

Banda Aceh has 90 neighborhoods grouped into 9 districts or *kecamatan*. Every neighborhood has at least one mushalla or masjid. In many areas especially in neighborhood with higher population density there are several masjids. The location of masjid is not necessarily in the middle of neighborhood since the selection of the land is not based on centrality or service coverage but more on the availability of land. Many of the masjid parcels are *waqaf* (endowment) land.
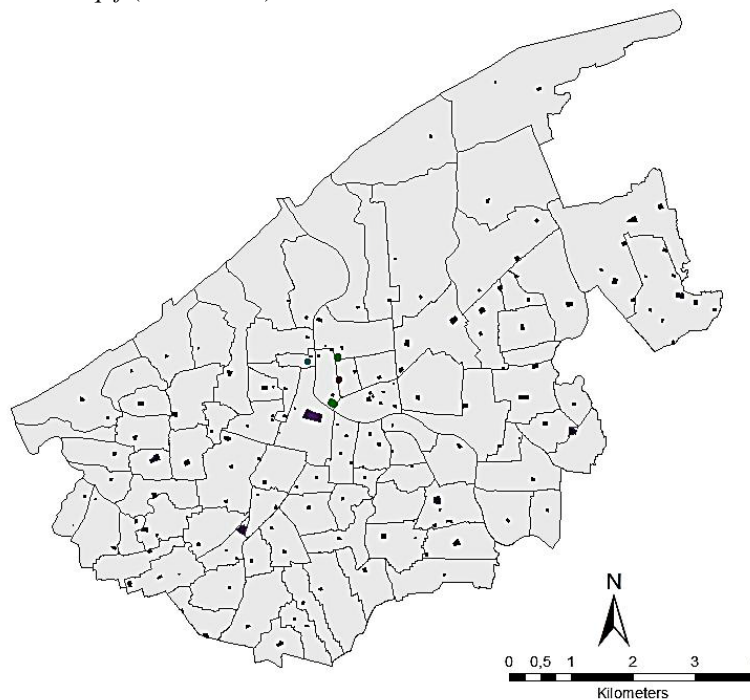

Figure 1. Distribution of all religious facility parcels in Banda Aceh (masjid, mushalla, church, temple) overlaid on neighborhood boundary map of Banda Aceh

The research has so far located 165 religious facilities consist of 161 masjids or stand alone mushalla, 2 churches, 1 Budhist temple and 1 Hindu temple. The masjids comprise of 98 % of the total religious facilities in Banda Aceh. The size of the facilities ranges and the parcel/lot area also varies. Some masjids have large yards, others have very narrow yards with almost 100% building coverage. The churches and temples are concentrated in downtown area while masjids are spread in every neighborhood. The number and distribution of masjid are valuable for setting up city wide spatial planning and policy including pedestrian planning system. The current pedestrian improvement is usually attached to region base e.g. in downtown or in conservation zone or more often it is partially developed for a street segment, not connecting destination points or pedestrian generating activities. The location and distribution of all religious facilities is presented in Figure 1 while Figure 2 shows the location of 161 masjids with walking distance buffering.
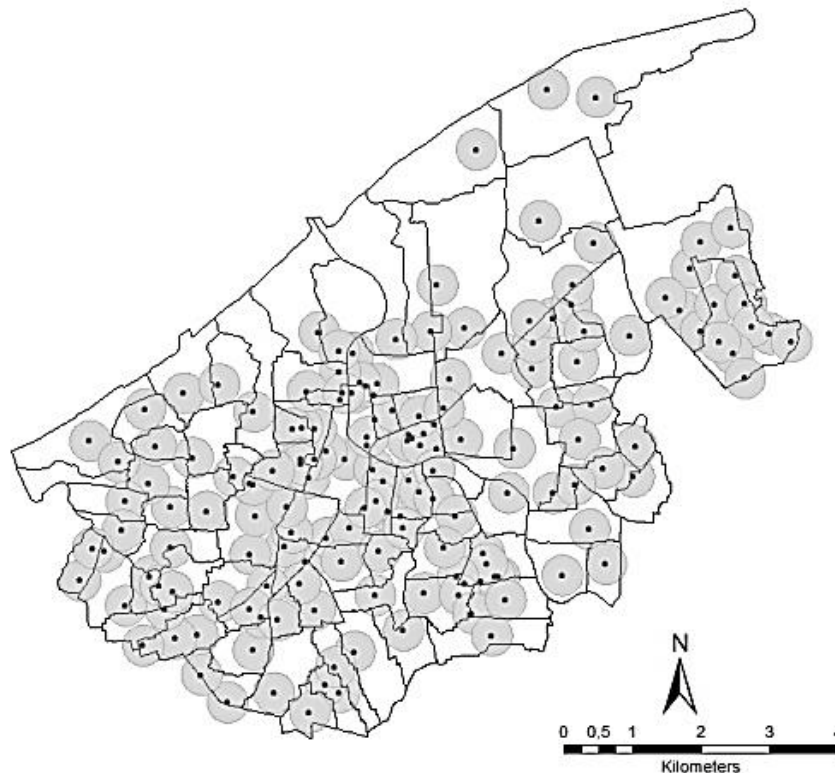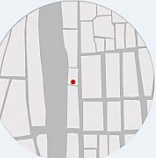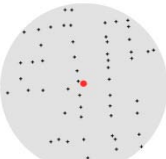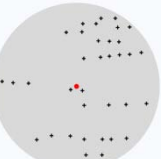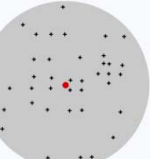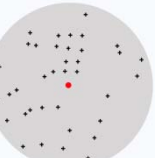
Figure 2. Location of Masjid and Mushalla (161 sites) with 300 m buffer indicating walking distance coverage.

The buffering shows that almost all inhabited area of Banda Aceh is within walking distance of a masjid or a mushalla. This is happening naturally or organically due to population demand and availability of land. It is without pre–design. The walking distance buffer used is very moderate. More area will be covered if we used 400 m or 800 m buffer.

We appropriated some indicators to enable assessment of walkability within the walking distance buffer of five masjids. The indicators are 300 m buffer for service coverage, block size and composition, intersection number and density, land use diversity and population density.The observation indicates that there is a gap between what the urban fabric and structure already provided for good pedestrian system with the final physical service at the neighborhood level. The assessment at buffer and neighborhood level is presented in Table 1. We then proceed to the observation at the site level which include pedestrian amenities on site and at street level, traffic condition and vegetation along the street. The full report on the observation on site and at street level are beyond the scope of this paper.

The five samples comprise of community masjids and institutional masjid. The neighborhoods also varies, ranging from residential dominated neighborhood, military compound to a busy market. In terms of natural features, mesjid Al Muttaqin present an interesting setting as it is located by the working waterfrontt, and next to a central market. The sample masjid each has 5 or 6 schools within the buffer areas. The area observation shows that all have very good actual land use diversity. They are also located in medium to high population density for Banda Aceh. The block size and structure seems to be ideal for a pedestrian friendly environment. Long size blocks o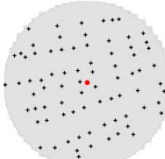nly exist around Masjid Al Fitrah which is a military compound and can be considered less public than the other four. The compact block size and structure correlate with the high number of intersection ranging from 37 to 83 around Masjid Al Huda.

Table 1. Walkability assessment at neighborhood and buffer level for five Masjids

No	Attributes	Masjid Samples				
	Name	Al Anshar	Al Huda	Al Muttaqin	Al Fitrah	Al Mukaromah
1	Location within the city and name of Gampong/ Neighborhood	Mulia	Laksana	Peunayong	Neusu Jaya	Punge Jurong
2	Image within buffer (r=300m) Area = 28.3 ha					
3	Neighborhood within buffer (r=300m)	Mulia, Laksana, Peunayong	Laksana, Keuramat, Mulia	Peunayong, Keudah, Mulia	Neusu Jaya, Kampung Baru, Sukaramai	Punge Jurong, Kampung Baru, Merduati
4	Neighborhood Population Density (per ha in 2013) Min =2, max=188	Mulia = 93 Laksana = 153 Peunayong = 83	Laksana = 188 Keurama t= 153	Peunayong = 83 Keudah = 76 Mulia = 93	Neusu Jaya = 92 Kampung Baru = 39 Sukaramai = 77	Punge Jurong = 55 Kampung Baru = 39 Merduati = 69
5	Block Figure Ground within buffer (r=300m) White=Block Black=Street					
6	Intersection number and density within buffer (r=300m)	57 Intersection Density 2.01/ha	83 Intersection Density 2.9/ha	35 Intersection Density 1.2/ha	37 Intersection Density 1.3/ha	37 Intersection Density 1.3/ha
7	Land Use Diversity within buffer (r=300m)	Diverse	Diverse	Diverse	Diverse	Diverse

Conclusion

- At citywide level, religious facilities number and distribution could be used as nodes to generate pedestrian friendly system and prioritize pedestrian improvement program. The approach is in line with Islamic values that promote walking to a masjid, interpreted into practical spatial planning principles.
- The observation at neigborhood and 300 radius buffer show that the urban fabric of the neighborhood are suitable for pedestrian friendly environment.
- The walkability level assessment should include detail observation on site and at the street level to evaluate whether the urban fabric and physical structure at the city and neighborhood level are met with physical design and actual use on site and at the street level. Further research at that refined detail should be conducted to more masjids in the city.

Acknowledgements

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The Needs of Public Green Structure in the City of Banda Aceh

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Abstract

Banda Aceh was badly damaged by the earthquake and tsunami that occurred on December 26, 2004. After post disaster reconstruction in year 2005–2009, various changes happened in usage of urban spacesin the city of Banda Aceh, including its green open spaces. This study aims to analyze and describe the existence of public green structure or green open space of Banda Aceh, especially urban park and urban forest in terms of distribution and sufficiency. The benefits and practical contribution of this research is to provide information regarding the existence and needs of public park and urban forest in the city of Banda Aceh, so it can be considered in meeting the needs of public green open space in the future planning of Banda Aceh as sustainable city. The result shows the public green open space requirement as public park and urban forest based on city wide and population number mostly can be fulfilled by all districts.

Keywords : green open space, sustainable, urban forest, public park.

Introduction

Planning approach with attention to the existence of the environment, or better known by the term sustainable planning has become a major current issue in the urban planning (Budihardjo, 2005). Therefore approach to environmentally sustainable urban planning will be the wise concept for future planning of Banda Aceh which was badly damaged by the earthquake and tsunami that occurred on December 26, 2004. The wide of damage was nearly 50 % of the city area, tsunami had destroyed infrastructure in most part of the city including residential area and protected area, ranging from area near the coast to most of the downtown area (BRR, 2009).

Planning Banda Aceh as sustainable city is expected to reflect the principles which include compliance with tropical climate, energy efficiency and minimum resource usage and give the smallest possible impact on the environment. As part of urban natural component, the existence of green open space becomes important element to support sustainable city. And also existence of urban green open space is important to control and preserve urban environment quality (DKK, 2014).

The presence of green spaces in the city helped shape the structure of city. This opinion is in line with Sinulingga (1999), where the structure of urban space is an arrangement of settlements, network of infrastructure systems and facilities. The elements that make up the structure of urban space consisting of (a) a collection of services including trade, finance, government which tend to distribute in groups in the service center, (b) collection of secondary industry (manufacturing), warehouses and wholesale trade which tend to congregate in one place, (c) residences and green spaces, and (d) transport network connecting the three places above.

According to Chen (2004), Pauliet and Kaliszuk (2005), green open spaces as urban green structures act to support sustainable urban life, hence the existence of the natural environment and green open spaces are important to consider in order continuing to support human needs and urban development in the future.

Urban green open space as urban green structure can be defined as space in the city or in the wider region in the form of area or region as well as in the form of elongated area or path which is more open in its use and without buildings. Green open space can present as parks, urban forests, sports fields and recreational area, cemeteries, green belts and green yards. While the ownership can be public green open space and private green open space (DPU, 2008).

This study aims to analyze and describe the existence of public green open space of Banda Aceh, especially urban park and urban forest in terms of distribution and sufficiency. The benefits and practical contribution of this research is to provide information to the city regarding the existence and needs of public

park and urban forest in the city of Banda Aceh, so it can be considered in meeting the needs of green open space in the future planning of Banda Aceh as sustainable city.

Methods

This research uses quantitative approach to measure the urban space usage in Banda Aceh and the potential adequacy of green open space in the city. The analysis technique used is the land use analysis of urban space through land use data, to get a picture of urban land use and the distribution of built up space and open space in the city. Land use data of Banda Aceh in 2010 is provided by Bappeda (2009) and BPS (2011).

Land use analysis will obtain information about the land usage in the city. Information obtained in the form of distribution of built up and open space in each district, especially as open and green space. Information of open space is to determine the adequacy of green space required to meet the minimum standard requirements of public park and urban forest as part of green open space based on city area and population.

Furthermore, to determine the adequacy level of public green open space in the city of Banda Aceh, it need to conducted extensive comparisons of urban green open space to the land use results. Minimum green open space requirements based on city area and population will be calculated to meet the minimum standard requirements of public park and urban forest. This research refers to the minimum standards of public green open space requirement in the Regulation by the Minister of Public Works No. 5/PRT/M/2008, about guidelines for the provision and use of green open space in urban area.

This study also used secondary data as support material, collected from several government offices such as Master plan of Banda Aceh 2009–2029 by Bappeda, Banda Aceh in figure 2015 by BPS, management document of public green open space of Banda Aceh in 2014 from the Department of Sanitation and Beauty of the city of Banda Aceh. The data is to be advocates in assessing the use of green open space in the city of Banda Aceh. It also made direct observations on the use of space on the pitch which is equipped recording images as the primary data. Other secondary data also collected from variety of related literature.

Results and Discussion

Built Up and Open Space Distribution

Land use analysis in this study is intended to determine the widespread and the availability of green open space, location and distribution, for subsequent use as a reference in the analysis of urban green open space needs. Based on the interpretation of the results of the secondary data obtained from land use data of Banda Aceh from BPS (see Table 1). From the total area of the city of Banda Aceh which is 6,135.9 hectares, the city has area of 3,789.19 hectares as built up space (61.75 %) and area of 2,346.71 hectares as open space (38.25 %).

Table 1. Built up and open space distribution in the city of Banda Aceh

No	District	Area	Built up Space		Open Space	
		Wide	Building & Landscape		Park, Urban Forest, etc	
		(Ha)	Ha	%	Ha	%
1	Meuraxa	725.80	402.00	55.3	323.80	44.6
2	Jaya Baru	378.00	303.10	80.1	74.90	19.8
3	Banda Raya	478.90	256.89	53.6	222.01	46.3
4	Baiturrahman	453.90	377.00	83.0	76.90	16.9
5	Lueng Bata	534.10	402.00	75.2	132.10	24.7
6	Kuta Alam	1,004.70	781.00	77.7	223.70	22.2
7	Kuta Raja	521.10	78.00	14.9	443.10	85.0
8	Syiah Kuala	1,424.40	864.00	60.6	560.40	39.3
9	Ulee Kareng	615.00	325.20	52.8	289.80	47.1
	Total	6,135.90	3,789.19	61.7	2,346.71	38.2

The open spaces consist of farm, grass, ponds, forests and other fields (see Table 2). Type of open spaces in the city divided into 6 parts:

a. Farm, has shapes character and clustered patterns, spread lies between built up and open space, sometimes mixed with residential areas in almost all districts except Baiturrahman and Kuta Alam, in the area of approximately 464.30 hectares.

b. Grass areas are among the farms, settlements and facilities that spread in the district Meuraxa, Lueng Bata and Ulee Kareng in the area of approximately 9.0 hectares.

c. Ponds and other water area, spread in almost all districts except Jaya Baru, Lueng Bata and Ulee Kareng, in the area of approximately 649.94 hectares.

d. Protected forest area, in the elongated form and clustered pattern, large in size, found only in Syiah Kuala and Meuraxa districts in the area of approximately 6.0 hectares.

e. Rice fields spread in almost all districts except Kuta Raja, in the area of approximately 512.0 hectares.

f. Parks and other open spaces, spread in almost all districts except Jaya Baru, Banda Raya and Ulee Kareng, in the area of approximately 705.47 hectares.

Table 2. Type of open space in the city of Banda Aceh

District	Open Space (Ha)					
	Farm	Grass	Pond	Forest	Rice Field	Parks
Meuraxa	19.4	7.0	82.0	2.0	62.5	150.7
Jaya Baru	11.4	–	–	–	63.5	–
Banda Raya	25.0	–	0.1	–	197.0	–
Baiturrahmann	–	–	1.3	–	26.5	49.0
Lueng Bata	24.0	1.0	–	–	23.5	83.6
Kuta Alam	–	–	204.3	–	4.0	15.4
Kuta Raja	55.5	–	74.1	–	–	313.3
Syiah Kuala	145.1	–	288.0	4.0	30.0	93.3
Ulee Kareng	183.8	1.0	–	–	105.0	–
Total	464.3	9.0	649.9	6.0	512.0	705.4

Areas with lots of vegetation commonly found in area that have less dense settlements. The vegetation are still possible in some area because of the development of the city mostly is dense in the city center. Settlements in the district bordering the city center, are dense and tend to follow the shape and the pattern of existing settlements which are clustered in the city center and spread to other area.

Green Space Needs

Based on data from the Department of Sanitation and Beauty of the city of Banda Aceh (DKK, 2014), known public green open space which has area of 668.948 hectares was managed scattered throughout the city of Banda Aceh (see Figure 1). Amount of public green open space ranged 11% of the city (see Table 3).

Table 3. Types of public green space in Banda Aceh

No	Public Green Space	Area (ha)
1	Park, Garden	49.454
2	Urban Forest	28.596
3	Sport Field	20.350
4	Street Green Line	548.000
5	Cemetery	7.978
6	Riparian Green Line	14.570
	Total	668.948

Public green open space as element of open space also functions as one component of the ecosystem which balances the urban life of the city. Urban ecological balance is necessary for the physical development of the city which continues to increase. To determine the adequacy of green open space as a requirement for stabilizing the city, the results of the land use analysis of the existing green open spaces of Banda Aceh will be compared to government standard. Analysis of the needs of public park and urban forest as part of urban green space will be calculated based on city area and population.
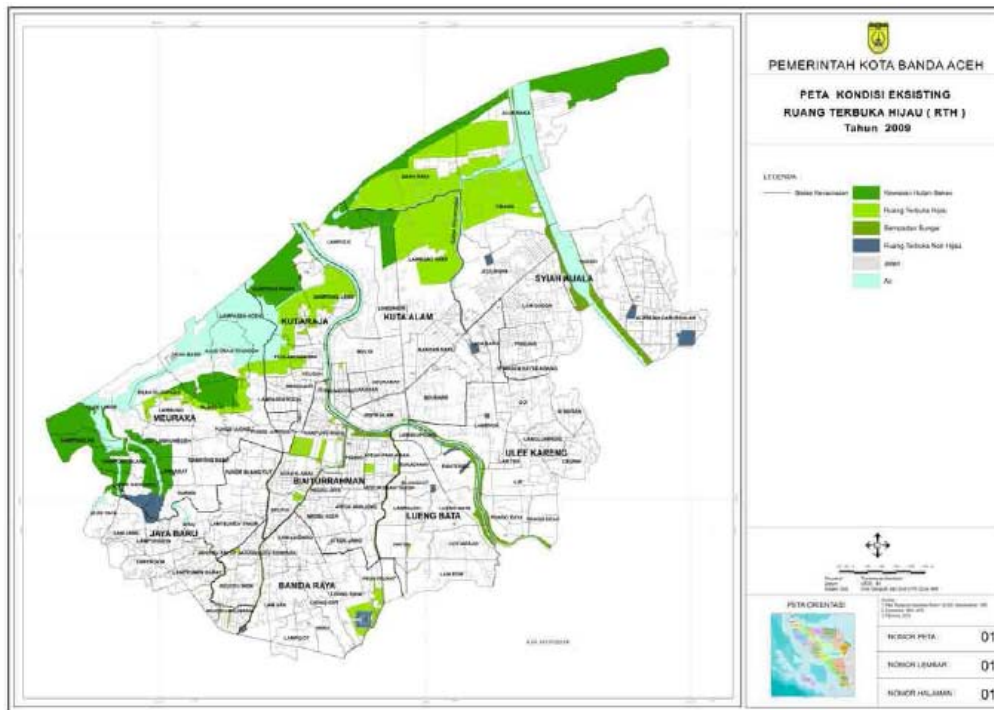
Figure 1. Existing green open space in Banda Aceh.

Public Green Open Space Needs Based on City Area

Regulation No. 05/PRT/M/2008 of Minister of Public Work, about the arrangement of green open space in urban areas, stipulate that at least 20% of the area of the city is public green open space. To provide balance in all area of the city, green open space requirement for each district is presented in Table 4.

Table 4. Public Green Open Space (GOS) needs

No	District	Area (Ha)	% GOS	GOS Needs (Ha)
1	Meuraxa	725.80	20%	145.16
2	Jaya Baru	378.00	20%	75.60
3	Banda Raya	478.90	20%	95.78
4	Baiturrahman	453.90	20%	90.78
5	Lueng Bata	534.10	20%	106.82
6	Kuta Alam	1,004.70	20%	200.94
7	Kuta Raja	521.10	20%	104.22
8	Syiah Kuala	1,424.40	20%	284.88
9	Ulee Kareng	615.00	20%	123.00
	Total	6,135.90		1,227.18

The proportion of green open space in the city should be 30% of city area which consist of the amount of 20% as public green open space and 10% as private green open space. This minimum proportion size to ensure the balance of the city ecosystem and the equilibrium of microclimates in hydrological system, as well as other ecological systems that may increase the availability of clean air, community needed and at the same time can increase the aesthetic value of the city. Based on the regulation standard, minimum area of public green open space of 1,227.18 hectares should be established by the city of Banda Aceh (see Table 4). In accordance with the objectives, standards of green open space are used for the purpose of :

a.   improve the environmental quality of urban living in healthy, comfortable, fresh, clean and safe environment.
b.   create the harmony of the natural environment and the built environment useful for the public interest.

Based on the calculation of urban green space according to government regulation No. 05/PRT/M/2008 of Minister of Public Work, then it will be compare to existing green spaces in all districts. The comparison showed that there were districts that meet the needs of green open space which are Meuraxa, Banda Raya, Lueng Bata, Kuta Alam, Kuta Raja, Syiah Kuala and Ulee Kareng. While Jaya Baru and Baiturrahman not yet qualified public green space of at least 20% of the total area (see Table 5).

Table 5. Difference in public Green Open Space (GOS) needs to the existing condition

No	District	GOS area	GOS needs (ha)	Difference (ha)
1	Meuraxa	323.80	145.16	178.64
2	Jaya Baru	74.90	75.60	–0.70
3	Banda Raya	222.01	95.78	126.23
4	Baiturrahman	76.90	90.78	–13.88
5	Lueng Bata	132.10	106.82	25.28
6	Kuta Alam	223.70	200.94	22.76
7	Kuta Raja	443.10	104.22	338.88
8	Syiah Kuala	560.40	284.88	275.52
9	Ulee Kareng	289.80	123.00	166.80
	Total	2,346.71	1,227.18	1,119.53

There is a tendency that the lack of green open space in Baiturrahman dan Jaya Baru district which are in the center of the city of Banda Aceh. Urban development activities still leads in the city center, where district area is relatively small but the density of public activity and residential area located almost in the center of city. This condition make difficult of getting more open space that can be developed as green open space.

Public Green Open Space Needs Based on Population

Minimum area of green open space as public urban park based on the number of populations in the district will follow standard 0.3 square meter per capita and minimum area requirements of urban forest will follow the standard 4.0 square meter per capita (DPU, 2008). Existing condition shows the distribution of the population in the city of Banda Aceh has not been evenly distributed to each district. Green open space requirement as public urban park for each district is presented in Table 6 .

Table 6. Public park needs based on population

No	District	Population	Min. Std (m^2)	Min. Public Park (m^2)	Min. Public Park (ha)
1	Meuraxa	18,979	0.3	5,693.70	0.57
2	Jaya Baru	24,481	0.3	7,344.30	0.73
3	Banda Raya	22,961	0.3	6,888.30	0.69
4	Baiturrahman	35,249	0.3	10,574.70	1.06
5	Lueng Bata	24,581	0.3	7,374.30	0.74
6	Kuta Alam	49,545	0.3	14,863.50	1.49
7	Kuta Raja	12,831	0.3	3,849.30	0.38
8	Syiah Kuala	35,702	0.3	10,710.60	1.07
9	Ulee Kareng	25,170	0.3	7,551.00	0.76
	Total	249,499		74,849.70	7.48

Table 7. Difference in the needs of public park to the existing condition

No	District	Exist. Urban Open Space (ha)	Min. Public Park (ha)	Difference (ha)
1	Meuraxa	323.8	0.57	324.37
2	Jaya Baru	74.9	0.73	75.63
3	Banda Raya	222.0	0.69	222.70
4	Baiturrahman	76.9	1.06	77.96
5	Lueng Bata	132.1	0.74	132.84
6	Kuta Alam	223.7	1.49	225.19
7	Kuta Raja	443.1	0.38	443.48
8	Syiah Kuala	560.4	1.07	561.47
9	Ulee Kareng	289.8	0.76	290.56
	Total	2,346.71	7.48	2,354.19

In general, the minimum requirements are met. The needs of urban green space as public park based on number of population shows the biggest is in the Kuta Alam district which has population of 49,545 people, thus require minimum of 1.49 hectares of green open space. While the needs of green open space as public park in the district of Kuta Raja is the smallest area in 0.38 ha with population of 12,831 people. Suitability of green space as public park based on number of population with the condition of the existing green space is presented in Table 7.

In Table 8 and 9 below, result of calculation shows the existing condition of green open space in all districts meet the minimum standard of the needs of the urban forest based on population number. Kuta Alam district should provide the biggest space for urban forest, which is about 19.82 hectares. In the existing, only two districts which are Meuraxa and Syiah Kuala have protected forests, but the wide of the area still not fulfilled in accordance with the standards.

Table 8. Urban forest needs based on population

No	District	Population	Min. Std (m^2)	Min. Urban Forest (m^2)	Min. Urban Forest (ha)
1	Meuraxa	18,979	4.0	75,916.00	7.59
2	Jaya Baru	24,481	4.0	97,924.00	9.79
3	Banda Raya	22,961	4.0	91,844.00	9.18
4	Baiturrahman	35,249	4.0	140,996.00	14.10
5	Lueng Bata	24,581	4.0	98,324.00	9.83
6	Kuta Alam	49,545	4.0	198,180.00	19.82
7	Kuta Raja	12,831	4.0	51,324.00	5.13
8	Syiah Kuala	35,702	4.0	142,808.00	14.28
9	Ulee Kareng	25,170	4.0	100,680.00	10.07
	Total	249,499		997,996.00	99.80

Table 9. Difference in the needs of urban forest to the existing condition

No	District	Exist. Urban Open Space (ha)	Min. Urban Forest (ha)	Difference (ha)
1	Meuraxa	323.8	7.59	316.21
2	Jaya Baru	74.9	9.79	65.11
3	Banda Raya	222.0	9.18	212.83
4	Baiturrahman	76.9	14.10	62.80
5	Lueng Bata	132.1	9.83	122.27
6	Kuta Alam	223.7	19.82	203.88
7	Kuta Raja	443.1	5.13	437.97
8	Syiah Kuala	560.4	14.28	546.12
9	Ulee Kareng	289.8	10.07	279.73
	Total	2,346.71	99.80	2,246.91

Discussion

As part of the component in the concept of ecological sustainable city, the existence of urban green structure or green open space in the city became important element supporting the creation of sustainable city. However, the existence of public green open space in the city of Banda Aceh is in the area of 668.948 hectares or 11 % of the area of the city (DKK, 2014). This amount does not yet meet the 20% provisions in the proportion of the public urban green open space to the urban area according Indonesia Spatial Planning Act No. 26 of 2007 (DPU, 2008).

In line with Irwan (2005), the presence of green space is important in controlling and maintaining the integrity and quality of the environment. Control of urban development should be done properly and in balance between development and environmental functions. According to Hakim (2007) and Chiesura (2004) to get green open space deliver its functional and aesthetic characteristics to the city, then the area in minimum size, pattern and structure, as well as the shape and distribution should be taken into consideration in planning and developing it.

Public park and urban forest as part of public green open space is contrast to other public space and open space which in the form of open land and without any plants yet to be built. Public green open space has green elements (vegetation) in any form. Public park and urban forest as public spaces can be enjoyed by the whole community, while the non public or private owned green open spaces and other open spaces are not always able to be used and enjoyed by the whole community.

The result of calculation of public green structure or green open space requirement as public park and urban forest based on city wide and population number mostly can be fulfilled by all districts in the city of Banda Aceh. Public park and urban forest as public green structure requires better planning to keep the balance of urban environmental quality. This is in line with Purnomohadi (2008) and Newman (2008), green open space has primary function as ecological functions and complementary function as the function of social, economic and architectural. As the ecological functions ensure the sustainability of the city, then green open space must be located, sized, and shaped in definite area of the city, such as urban forest to support human life and network of wildlife habitat. Some ecological function of green open space in the city,

among others, are water catchment area, produce oxygen, reduce noise, filter of solid particles that pollute the city's air, absorbing greenhouse gases or acid rain, windbreaks, prevent seawater intrusion, amelioration climate and soil water conservation.

Conclusions

Based on the analysis of urban land use of Banda Aceh in 2010, the results obtained that the city has built up spaces area of 3,789.19 hectares (61.75 %) and the unbuilt spaces or open spaces area of 2,346.71 hectares (38.25 %). Types of land use in the open space that could potentially become as green open space are protected forests, riverside green lines, rice fields, farms, roadside green lines, parks and cemetery with total area of 1,696.77 hectares or about 27.65% of the city area. These amounts are combination of public and private green open spaces.

The result calculations of public green open space requirement as public park and urban forest based on city wide and population number mostly can be fulfilled by all districts. Green open space needs as public park based on population with minimum of 0.3 m2/capita are met by 7 of 9 districts. However, the requirement for minimum of 4 m2/capita green space for urban forest can be fulfilled by all 9 districts. The sufficiency of public green open space and balanced composition of the size and distribution of green space in each district should be maintained to provide the optimum benefits to the city.

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Modeling of Ecologic Urban Green Structure in System Dynamics

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Abstract

Increasing population number while city's land limited, led to the growth of physical development in Banda Aceh is done by converting agricultural land and other open spaces to become built up area. This condition leads to reduction of urban green structure or green open space which will impacted in reducing the role of the ecological functions of green open space in the city. One of the ecological function is CO_2 absorption by vegetation, particularly by number of trees in the urban forest which have high capability in the absorption of CO_2. If decreasing trend of green open space and urban forest keep goes on, while number of energy consumption in the activity of population and numbers of vehicles keep goes up, then it's predicted there will be an increase volume of CO_2 in the city which cannot fully balance by the natural ability of CO_2 absorption by plants, so that will impact in declining health quality in the city of Banda Aceh. This study aims to determine the extent of the urban forest required to absorb CO_2 due to population activities and vehicle numbers in Banda Aceh using system dynamics modeling. The model was built using Powersim 2.5 program, which consisting of interrelated sub systems of population, number of vehicles and the number of plants.
Simulation results from year 2015 to 2025, showed increasing number of population and vehicles, and the needs for the number of plants and urban forest area. Simulation results is made in three scenarios, namely progressive, conservative and sustainable, which may be used as consideration in the arrangement of green open space policy in the city of Banda Aceh.

Keywords : carbon dioxide absorption, urban forest, green open space, powersim

Introduction

After the rehabilitation and reconstruction process of tsunami disaster in 2004, the development of Banda Aceh showed progress in multi sector development where variety of activities grew in the city. As capital city of Aceh province, Banda Aceh serves as center of government activities, center of socio–economic and community services, also trade and industrial. The city has area of approximately 6,136 hectares with growing population of 249,499 people (BPS, 2015). As the population and economic activity growth, varies physical development proceeded rapidly in the city.

One of the most noticeable activities impact due to the rapid physical development of infrastructure in the city of Banda Aceh is decreasing area of urban green open space and increasing gas emissions such as carbon dioxide (CO_2) due to increasing transportation activities and other energy consumption. Increasing levels of CO_2 pollution is not healthy to the city environment and can reduce human health, therefore the concentration of CO_2 in the air should be maintained low. According to Pauliet and Kaliszuk (2005), green open spaces as urban green structures plays important role to support sustainable and healthy urban life.

One way to decrease CO_2 levels in urban areas is to reduce carbon emissions (Dachlan, 2011) and the other way is to build urban forest as part of urban green structures (Li, *et al.*, 2005). Urban forest is the most effective carbon sinks to reduce the increasing carbon emissions in the atmosphere (Irwan, 2005). Photosynthesis process by plants in the urban forest is important process in the carbon cycle and maintaining CO_2 in atmospheric at the same time. This process also plays role in oxygen cycle. To help address natural forest degradation, it is necessary to build urban forest, because of the presence of urban forests is important in neutralizing the effects of air pollution as well as maintaining the quality of the air to keep them clean (Purnomohadi, 2006).

This study aims to determine the extent of the urban forest required to absorb CO_2 due to population activities and vehicle numbers in Banda Aceh using system dynamics modeling. The benefits and practical contribution of this research is that it can be used as consideration for decision makers or policy makers in

planning for the sustainable city of Banda Aceh, especially with regard to the presence of green open space and urban forest.

Methods

This research try to analyze and compile urban forest model in Banda Aceh based on aspect of its ecological function of CO_2 absorption in system dynamics approach using Powersim 2.51 software, which is powerful and easy to use. The approach begins with defining problems dynamically, proceeds through mapping and modeling stages, to steps for building confidence in the model and its policy implications. Model compilation of system dynamics of urban forest divided into population sub–model and urban forest CO_2 absorption sub–model. Based on model of system dynamics, it will show the prediction of each variable behavior in simulation period of 2015–2025.

Powersim software will help to see the behavior of the model created. The stages in making a model of a dynamic system are (a) identification of problem behavior, (b) create a computer model, (c) testing and analysis the models. At the time of running the simulation model, the variables will be interconnected to form a system that can mimic the actual conditions. These variables will be illustrated with some of the symbol, which is the main symbol of the flow symbol and always associated with the level symbol. In this study the condition level is urban forest as part of green open space in city of Banda Aceh. Powersim software will work to build a causal loop diagrams, flow chart, make a graph of time which describes the behavior of the model in the time table.

The systems dynamics model of green open space for the city of Banda Aceh is arranged for several purposes, namely:
a) Understanding the processes that occur in the system. Models must be able to describe the mechanisms of the processes that occur in the system in relation to achieve the research objectives.
b) Prediction. Only quantitative models that can make predictions. In this connection, accuracy of the model becomes important.
c) Support decision making. The model is based on the understanding of the process and has the ability to be used as a predictive tool for planners to assist in the decision making process.

Supporting material used in this study as secondary data collected from several government offices such Master plan of Banda Aceh in 2009–2029 by Bappeda, Banda Aceh in figure 2015 by BPS, and document of green open space management from the Department of Sanitation and Beauty of the city of Banda Aceh (DKK, 2014). It also made direct observations of the use of spaces in the city which include recording images as the primary data. Other secondary data also had been collected from a variety of other related literatures.

Results and Discussion

Conceptualization of System Dynamics Model

According Avianto (2006), the conceptualization of the system in system dynamics model aims to provide an overview of the systems studied in the form of a diagram. Diagram is used in the form of a causal loop diagram. This diagram illustrates the relationship between the components in the system which are interrelated.

Basically the city is formed by several components or elements. Components of urban divided into two main components, namely the physical and non–physical components. Urban constituent components are basically linked interconnections, therefore in the process of structuring and management of urban space should need to pay attention to all components and assume that each of these components are interrelated and are in one unified system.

Urban green structure or green open space is one of the components of the city whose existence is strongly influenced by the constituent components of the city, therefore, to optimize the arrangement of urban green open spaces also need to pay attention to all components of the existing urban areas. Presented in Figure 1 circumference causal diagram (causal loop diagram) of urban green open space system of Banda Aceh.

From the diagram it shows growing population will lead to the increasing demand for land. Increasing levels of land requirement will result in increasing accretion of land which will be use as for housing development and others that in the end will have impact on the reduction of urban green open space. Another activity which affects the green open space and its ecological function are domestic and transportation activities on using energy of fossil fuel which require oxygen and produce CO_2. The availability of urban

green open space and its ecological function has to be prepared properly to balance the ecosystem and keep the city in health.
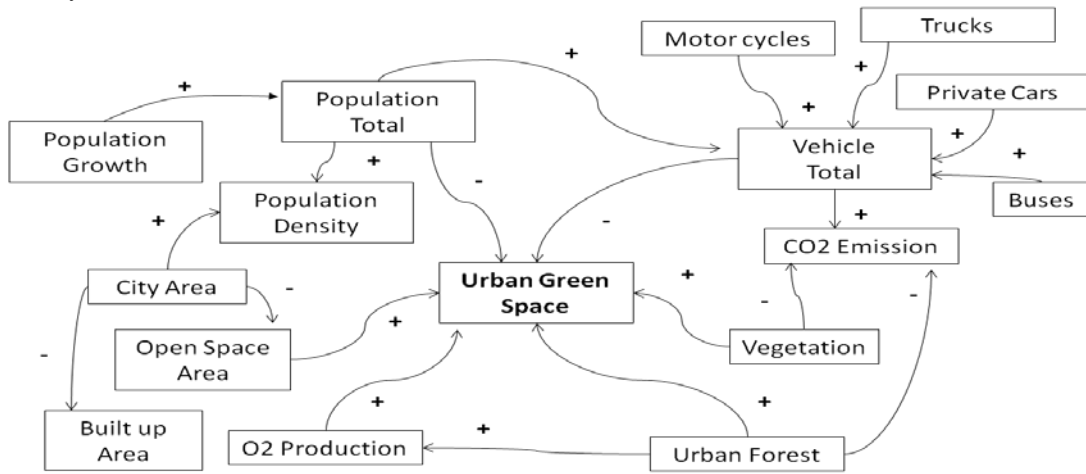

Figure 1. Causal loop diagram of urban green open space system

Model Formulation

Model is built and divided into two sub models which are (a) the population sub–model and (b) urban forest CO_2 absorption sub–model. In the sub–model, it shows the relationship and interconnections between the components that exist. Flow diagram and explanation of the relationship between components in each sub model will be presented in the following pictures.

Population Sub–model

In this model (see Figure 2), the population is considered as a level (accumulation) which can increase and decrease due to certain processes. Technically flow causes an increase or decrease in the level called flow or rate. In this model the process that led to the growth of population due to births and in–migration (immigration) factors, while the rate which reduces the number of population in the city caused by the deaths and out–migration (emigration) factors.
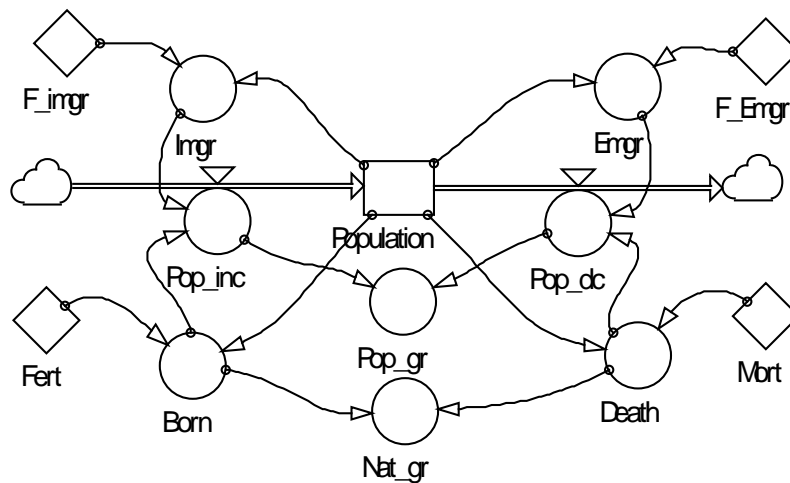
Figure 2. Flow diagram of population sub–model.

Calculation of Carbon Dioxide Absorption

Approximate calculation of CO_2 absorption was conducted to determine the distribution and number of vegetation in each district in the city of Banda Aceh. Results of CO_2 absorption by vegetation will be compared with the amount of CO_2 emissions. Broad values that have been classified in vegetation classes are presented in Table 1. The ability to absorb by vegetation class is known as ability of the existing condition of vegetation to absorb CO_2.

Table 1. CO_2 absorption by vegetation

Green structure vegetation	CO_2 absorption (tons/ha/year)
Plantation	52.3952
Grass	3.2976
Forest	58.2576
Bushes	3.2976

The ability of vegetation to absorb CO_2 by Iverson (Tinambunan, 2006), are: (a) for plantation vegetation is 52.3952 tons of CO_2/ha/year; (b) grass is 3.2976 tons of CO_2/ha/year; (c) forest is 58.2576 tons of CO_2/ha/year; and (d) bushes are 3.2976 tons of CO_2/ha/year. To estimate the CO_2 absorption using secondary data that will be obtained vegetation absorption value for each type of area (such as plantation, grass, forest, bushes) in the districts in the city of Banda Aceh. Calculation of CO2 absorption by vegetation type is presented in Table 2.

Table 2. CO_2 absorption by vegetation in Banda Aceh

No	District	Plantation	Grass	Forest	Bushes	Total (tons)
1	Meuraxa	1,019.61	23.08	116.52	206.10	1,365.31
2	Jaya Baru	597.31	–	–	209.40	806.70
3	Banda Raya	1,309.88	–	–	649.63	1,959.51
4	Baiturrahman	–	–	–	87.39	87.39
5	Lueng Bata	1,257.48	3.30	–	77.49	1,338.28
6	Kuta Alam	–	–	–	13.19	13.19
7	Kuta Raja	2,910.03	–	–	–	2,910.03
8	Syiah Kuala	7,602.54	–	233.03	98.93	7,934.50
9	Ulee Kareng	9,630.24	3.30	–	346.25	9,979.78
	Total	24,327.09	29.68	349.55	1,688.37	26,394.69

Based on calculations in Table 2, the maximum CO_2 absorption by the vegetation found in the Ulee Kareng district, about 9,979.78 tons of CO_2. Greatest absorption due to the amount of vegetated area in this district is quite extensive. While the smallest absorption found in Kuta Alam district in the amount of 13.19 tons of CO_2.

Estimated total amount of CO_2 that can be absorbed by vegetation type based on the existing condition of vegetation in the city of Banda Aceh is approximately 26,394.69 tons. Two districts which are located in the city center: Kuta Alam and Baiturrahman have less absorption, due to very small area of vegetation growth.

Value of total CO_2 emissions are estimated based on the energy used in the city of Banda Aceh. Energy is calculated by tabulating the data derived from the use of electricity, kerosene, gasoline and diesel. Total value is obtained based on the value of CO_2 calculated in accordance with Table 3 and 4.

In Table 3 it can be seen that the amount of CO_2 emissions in the city of Banda Aceh derived from the consumption of electricity, kerosene, gasoline and diesel was approximately 109,015.42 tons. CO_2 emissions that most of it comes from the source of electricity production in the amount of 108,328.79 tons.

Table 3. CO_2 emissions in the city of Banda Aceh

Source	Capacity (kwh)/ Consumption (ltr)	Emission factor (gr/Kwh–gr/ltr)	CO_2 (gr)	CO_2 (tons)
Electricity	238,609,598	454.00	108,328,757,492	108,328.76
Kerosene	38,171,000	2.52	96,190,920	96.19
Gasoline	111,110,000	2.30	255,553,000	255.55
Diesel	124,045,000	2.70	334,921,500	334.92
Total				109,015.42

Difference in CO_2 emissions generated and the ability of vegetation absorption obtained from the classification of the type of vegetation to absorb CO_2 emissions are presented in Table 4.

Table 4. Difference in CO_2 emissions to CO_2 absorption by vegetation

Region	CO_2 emission (tons)	CO_2 absorption by vegetation (tons)	Difference (tons)
City of Banda Aceh	109,015.42	26,394.69	−82,620.74

The results of calculating the difference in absorption of CO_2 by vegetation to CO_2 emissions in the city of Banda Aceh, obtained the high existing lack of green space ability in the absorption of CO_2 which is about 82,620.74 tons due to the lack of vegetation in the city.

Urban Forest CO_2 Absorption Submodel

In this model (see Figure 3), urban forest is considered as variable rate to variable decision systems which are regulated by one or more policy structures. In this model the process that led to the needs for urban forest and its vegetation as an absorber of CO_2 is to offset the amount of CO_2 emissions from domestic activities in the use of electricity, gasoline, diesel and kerosene.
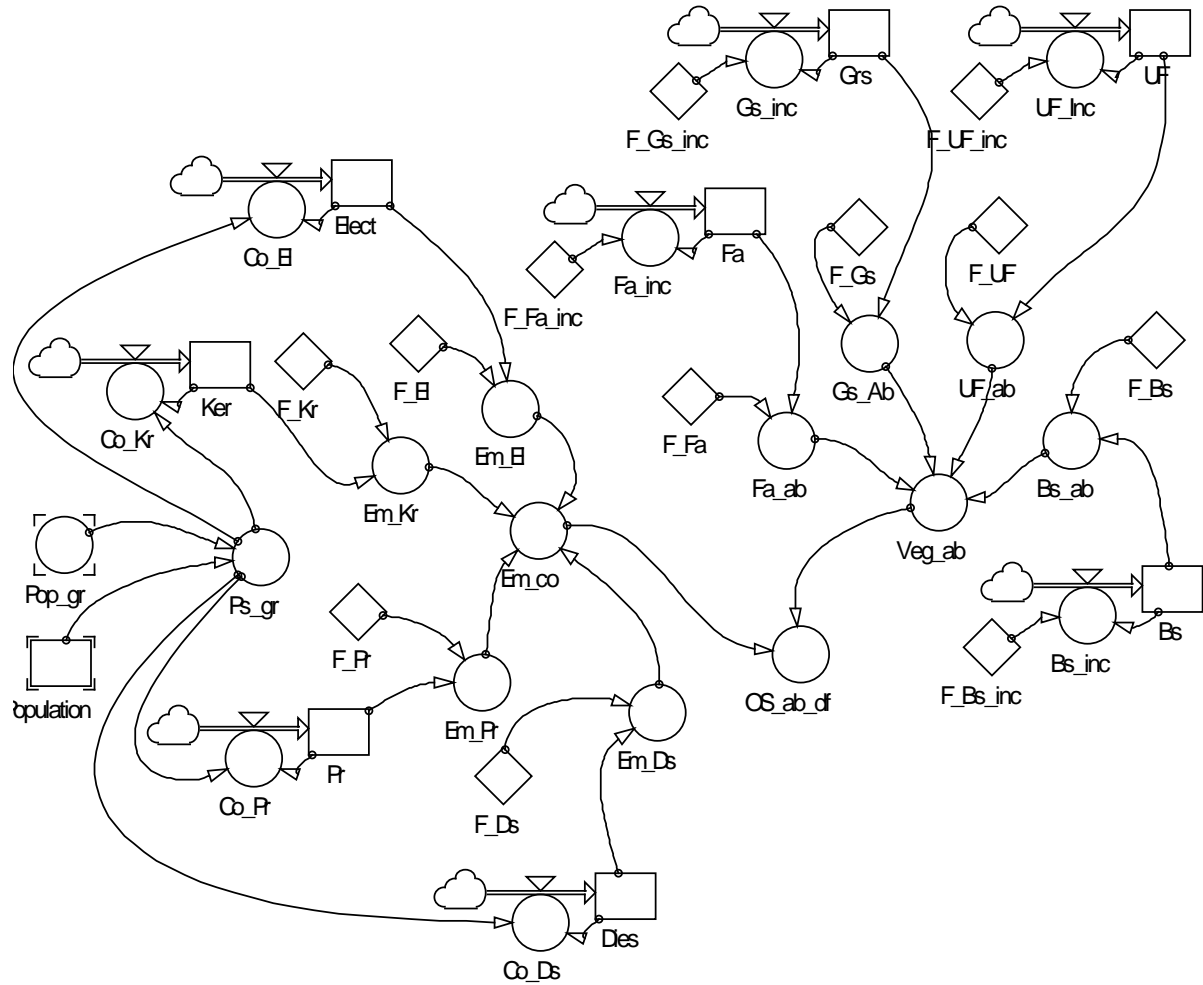

Figure 3. Flow diagram of UF–CO_2 absorption sub–model

Analysis of Model Behavior

Analysis of the model behavior is an attempt to understand the behavior of the system as a result of the assumptions in the model. Understanding models by computer simulation will inform the behavior of all variables in the model with respect to time.

Population Sub–model Behavior

Based on the results of simulations carried out on the population sub model, increasing numbers of population in the city of Banda Aceh, from 249,499 people in the beginning of the simulation year (2015), increase to 275,602 people by the end of the simulation year (2025). The following graph is presented in Figure 4, shows changes in the population of the city of Banda Aceh during the period of the simulation.
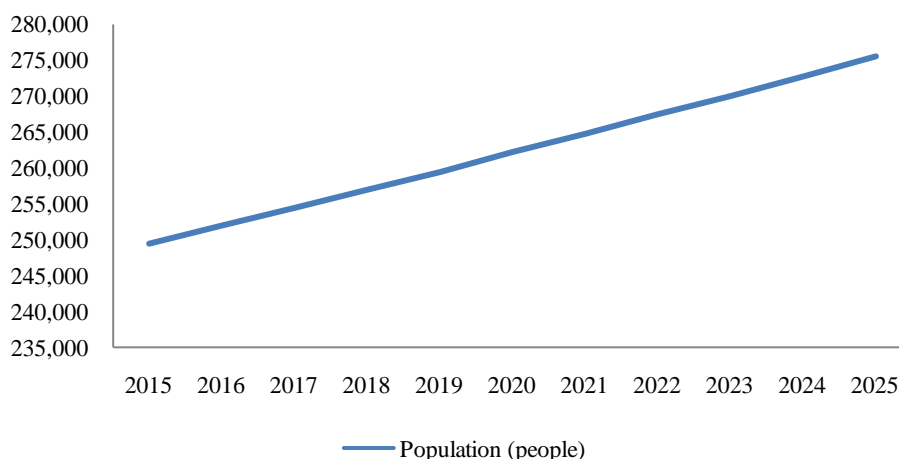
Figure 4. Population Growth

Urban Forest CO$_2$ Absorption Sub–model

The needs for urban forest as part of urban green open space to absorb CO$_2$ emissions from domestic activities in the use of electricity, gasoline, diesel and kerosene. Based on the results of simulations performed, it shows increasing needs of urban green open space. CO$_2$ emission rise from 109,015.42 tons in 2015 to 120,420.84 tons in 2025, while the absorption capacity of the existing vegetation only 26,394.69 tons in 2015 and 32,174.98 tons in 2025. Assuming the ability of CO$_2$ absorption by urban forest in urban green open space is 800 tons/ha (Dachlan, 2011), then the needs of green open space should be 150.52 ha of urban forest at the end of the simulation in 2025 to balance the CO$_2$ emissions rate (see Figure 5).
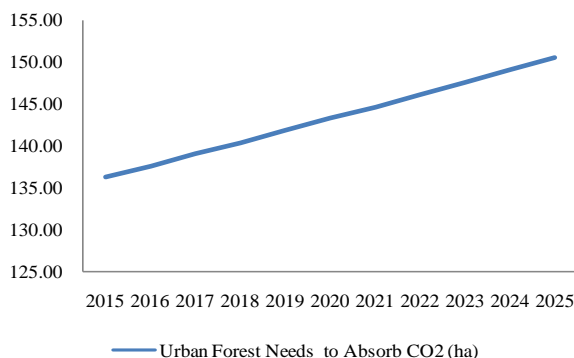

Figure 5. Urban Forest Needs to absorb CO$_2$

Based on the simulation, results shows increasing needs for the amount of vegetation in urban forest and especially the tree that has high ability to absorb CO$_2$. However, due to the small rate in the growing urban green space, resulting insufficiency of oxygen production and vegetation ability to absorb CO$_2$ emissions. The urban forest need to be planned for the adequacy of its wide and types of vegetation that has high ability to absorb CO$_2$.

Table 6. Intervention varibles of three scenarios

Variable	Progressive	Sustainable	Conservative
Population	Population growth rate increase by 1%	Population growth rate increase by 0.5%	Population growth rate increase by 1%
Urban Forest	Green space increase by 0.1%	Green space increase by 0.5%	Green space increase by 0.1%
Vegetation	Composition 1 Trembesi (40%), Mahoni (20%), Angsana (30%), Asam (10%)	Composition 2 Trembesi (50%), Mahoni (20%), Angsana (20%), Asam (10%)	Composition 3 Trembesi (10%), Mahoni (10%), Angsana (60%), Asam (20%)

Policy Analysis

Policy analysis was started by establishing scenarios. Three scenarios were applied for urban forest development simulation. Intervention variables applied are presented in Table 6 and vegetation composition in urban forest is presented in Table 7.

Table 7. Vegetation composition in urban forest

Local name	Scientific name	CO_2 absorption (kg/tree/year)	Absorption availability
Trembesi	Samanea saman	28,448.39	High
Mahoni	Swettiana mahagoni	295.739	Medium
Angsana	Pterocarpus indicus	11.1226	Low
Asam	Tamarindus indica	1.4931	Very Low

Scenario simulation (Table 8) showed that for all scenarios it is difficult to maintain urban forest existence. The most realistic scenario is sustainable scenario. A strong policy should be created to maintain urban green space and urban forest existence.

Table 8. Result of three scenarios simulation on population, urban forest and CO_2 absorption

Variable	Year	Scenario		
		Progressive	Sustainable	Conservative
Population Growth (people)	2015	249,499	249,499	249,499
	2025	275,602	262,258	275,602
Urban Forest Growth (ha)	2015	25.39	25.39	25.39
	2025	41.36	65.86	30.95
Vegetation Needs to Absorb CO_2 (ha)	2015	27.47	34.30	136.20
	2025	30.35	36.05	150.45

Conclusions

The presence of urban forest as element of the natural environment plays an important role in maintaining the quality of city life. The concept of ecology green structure in the city of Banda Aceh attempts to achieve ecologically healthy city. The needs of urban forest as part of urban green structure appropriate to ecological functions of CO_2 absorption which known from the calculation are:

a. Urban forest requirements based on the role of existing vegetations as CO_2 absorber there is a lack of 82,620.74 tons due to the lack of vegetation in the absorption of CO_2.

b. Vegetation composition should be planned wisely to avoid superfluous space, as the conservative scenario shows maximum area needs for vegetation in urban forest to absorb CO_2 in the area of 150.45 hectares in 2025 to balance the CO_2 emissions rate.

c. Land use control should be taken seriously by the government so that the presence of urban forest in the city will not degrade in the quality and quantity.

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The Twentieth Century Architecture of Banda Aceh: Researching Identity and Strengthening Colonial Authority

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Abstract

Aceh, one of provinces in Indonesia, was occupied by the Dutch from 1874–1942. Within such a short period, the Dutch has built the new city, called Kuta Raja, which is now known as Banda Aceh city. This paper aims to examine how the Dutch–colonial administration attempted to construct a "proper" direction in creating architectural identity of the Indies (Indo–European) in the twentieth century. The paper focuses on architectural developments in Banda Aceh in the twentieth century. During this time, the Dutch government, with its centre in Batavia, started to raise the question of the Indish identity in its colonies, including Aceh. This marked a shift in the direction of thinking and knowledge production of architecture which was accompanied by a new mode of architectural representations to express the Indies (Indonesia and Dutch). The methology of this study is qualitative descriptive. The collected data is analized through library reseach and field observations. In doing this study, the paper shows that the socio–political scenes in colonial time have influenced architectural production in the city of Banda Aceh in order to articulate a unique caracteristics of Indies.

Keywords : Indies architecture, identity, twentieth century, colonial period.

Introductions

The Dutch troops has tried to come to Aceh to invade the region several times, and were finally able to capture the capital city and seize the royal palace in 1874. During the Dutch occupation, the Acehnese persistently resisted the presence of Europeans in their region until the Dutch left Aceh in 1942. This led the Dutch to spend their energy and efforts on warfare rather than on development. Regarding this condition, the development of the city during the Dutch period was developed in the first quarter of the twentieth century, several decades after the Dutch occupied Aceh. The representation of the 1920s architectural buildings in Aceh were similar to those buildings in other places of the Dutch colony in the archipellago. Its architectural style was known as Indies architecture. The emergence of such a style coincided with the debate on the vision of the new plural Indo–European society, known as Indies society. The main purpose was, thus, to create appropriate direction of Indies architectural identity.

This paper, thus, aims to examine the efforts of the Dutch–colonial administration in trying to construct a "proper" direction to create architectural identity of the Indies society. This showed the amendment of thinking and knowledge by a new mode of architectural representations. The typical Indies architecture demonstrates the architects' dissatisfaction with the neoclassical style, characterised by monumental architectural forms and symmetrical formal arrangements (Sukada, 1996). The study focuses on the developments in the built environment in the early twentieth century under Dutch colonialism. In order to accomplish the paper, a number of written sources on the twentieth cwntury architectural theory and history of the Indies as well as political rules are reviewed. In additions, field survey in order to observe architectural buildings are conducted. In doing this, the study show how the political effort of the Dutch government influenced architectural representation in order to empower the colonial authority in Indonesia, including Aceh.

Historical Background

The advent of twentieth centuries witnesses the rise of national conciousness by Indonesian nationalists who struggle for Indonesian independence, under the banner of nationalism. They generates 'subversive action' against the colonial rule by raising people's awareness of national bonds that could generate a new

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spirit and new powers. The climax of this movement delivered the Youth Pledge (Sumpah Pemuda) Congress in October 28, 1928.In addition to the notion of nationalism, the beginning of the twentieth century also marked the segmentation of Indies society on the basis of ethnic background, region and religion (Kusno, 2012; Hasan, 2010).

Having had the impact of modernization, and dealing with the social mix that emerged among Indonesians and the Dutch , the local people began to ignorant of their tradition. Concerning this, the colonial government believed that there was a need for 'colonial tutelage'and thus introduced the Ethical Policy (Hasan, 2010). Kusno (2012), more over, argues that the policy was aimed at controlling the 'proper direction' of social change in the plural Indies societies, in order to achieve social integration and to build 'cultural unity. Another concern of the Dutch was to unite the Indonesian and Western traditions "with the Western element as the major impetus to a positive promotion of change."[1] The ultimate outcome of this was the construction of the 'Tropical Netherlands.'[2]

This cultural synthesis was strongly linked to political interests: it was the Dutch attempt to hinder the development of Indonesian nationalism.

Ethical Policy and empowering colonial rule

In the beginning of twenty century, the dutch colonial introduced the policy, so called the Ethical policy. The establishment of the Ethical Policy coincided with the development of national consciousness of Indonesian people. The ethical policy, in fact, lead to define the nucleous of the "Indies–ness" that unite the plural society–Indonesian and Dutch. Uniting this two cultural backgrounds, however, became problematic when it was connected to a political interrest that mediated the defining of cultural identity of the Indies society. The colonial government paid special attention to make people learn their own culrure and improving their level of education.

In fact, the implimentation of the ethical policy attracted more Europeans, who either lived in or ouside the Indies, to live in the Indies (Doorn, 1987). The Colonial government, thus, could create their authority as a great place for a world market. Regarding this, There is a need to improve "the living standard of their colony including the provision of communication, stability and safety."(Kusno, 2000)

Architectural identity of the Indies

At the beginning of 1920s, the debate on the architectural identity in relation to the process of cultural integration in the indies society was intensified. Such an effort coincided with the debate, delivered by the colonial government, on the vision of the new plural Indies society. The main purpose is to create 'appropriate direction' of the production of Indies (Indo–European) architecture within which its concept support the process of cultural integration of Indies Society. As the debate over the merits of the Ethical Policy of the new society intensified, views on the possible development of an Indo–European architecture began to take shape.[3]

The two prominents architectural figures of the Indies architectural movement were H. Maclaine Pont (1884–1971) and Thomas Karsten (1884–1945). These architects, through their architectural works, showed their response to contemporary aspiration and moral obligation to exhibit Indonesian–ness. They concerned particularly with cultivating native architecture, particularly the Javanese vernacular building (Sukada, 1996). Concerning this, there were two main views; one emphasized on rethinking the significant of the surviving Javanese –traditional architecture, meanwhile the other insisted on discovering the cobination of Western architecture and ancient Hindu–Javanese architecture. (Hasan, 2010).

In their works, they searched for aspects of western architecture that were suitable for local–javanese architecture, and examined its architecture using the principle of modern rational approaches (Hasan, 2007). In this regards, special attention had been paid to local conditions, primarily climate, labour and material. In additions, the architectural form as well as the aesthetic of the javanese buildings were also became the architects' concideration.Thomas Karsten and H. Maclaine Pond who provide such insights toward the debate on the Indies (Indo–European) architectural style, can be seen as a dirct out come of the Ethical Policy. Its architural style that reveals cultural identity of plural Indies society became the spirit of that period.

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[1]   Sudradjat, "A Study of Indonesian Architectural History," 157.
[2]   Doorn, "A Divided Society: Segmentation and Mediation in Late–Colonial Indonesia," 13.
[3]   Doorn, "A Divided Society: Segmentation and Mediation in Late–Colonial Indonesia."

The Dutch Legacy in Architecture and Urban Planning in Aceh in Aceh

The colonial architecture of the early twentieth century of Aceh included private and public buildings. As in Java, most buildings[4] were built in responding to the tropical conditions. Only a fiew buildings of this decade were built following the western tradition, which was mostly copied the prevailing neoclassical style. The attempts to adapt to the local climate can be seen in a number of buildings built in the second decade of twentieth century. The architects working in this new style found the nineteenth–century neoclassical form, the cubist form, flat roofs, and towers to be inappropriate to the hot and humid tropical climate (Hasan, 2010).

The building that is now used for Aceh's regional office of the Central Bank of Indonesia demonstrates a starting point in adapting to the local climate, by providing cross–ventilation and reducing direct solar radiation (Figure 1). Other buildings of the same period presenting a growing sensitivity to local conditions and traditional forms are the military hospital in Kuta Alam on the side of Aceh River (Figure 2). This building is placed on the eastern side of the river, whereas Atjeh Hotel and Atjeh Club, the Dutch assembly room, were located on the western side, across the great mosque of Baitur–Rahman (Figure 3).

Figure 1. The Central Bank of Indonesia: A 'New Indies Style' Building (source: Author's collection)

Figure 2. The military hospital in 1962 (source: Winkler's collection)

In addition to the public buildings, there remain some residential buildings in Banda Aceh built during this period. Generally, these buildings were raised about one to one and a half meters above the ground. This typology was dissimilar to that of the Javanese colonial houses, which were generally built of stone and on the ground. Raising the floor might have been to avoid flooding during the rainy season. The early twentieh century houses display some common features of the Indies–style country houses (Figure 4 and 5). The house type is similar to the house built in Java. However, while in Java the houses were built of stone and on the ground, in Aceh such buildings were built of wood. The house reveals special attention to local conditions, primarily climate, labour and material. Moreover, the Dutch architects conciderated on the architectural form

as well as the aesthetic of the local–traditional house. The houses have large verandas at the front and the floorsare raised above the ground. The concept of Acehnese traditional house was adapted by the Dutch architects.

Figure 3. Hotel Aceh in 1930 (source: Collection of the Centre of Documentation and Information Aceh)

The type of house construction allowed cooling breezes to pass underneath while it kept the dwelling high enough to avoid flooding during the rainy season. This type of house became the main model emulated throughout Banda Aceh during the Dutch occupation. Having had verandahs and raised the floors allow the cool moist air to be drawn up through the slatted floor and verandah to reduce the hot currents created from heated roof space.

Figure 4. A colonial residential building in Banda Aceh (source: Author's collection)

Figure 5. A colonial residential building in Banda Aceh (source: Author's collection)

Conclusions

The penetration of modernity into Indonesia had the impact on local transformation in the field of architecture. As part of Indies society that had been involved with cultural mixed, the colonial government has tried to rethink of architectural production of Aceh whithin the concept of tropical Netherland that applied throughout the archipellago.Adapting to local conditions was an approach followed by the Dutch architects in order to respond to local climate as well as to appear more relevant to the subjects of their colonies. The sensitivity towards local conditions relates to the concept of the Ethical Policy. The policy that was initiated by the Dutch , based on the mergency of crossed cultural issue, with the purpose of the Indonesian and Dutch traditions in the "tropical Netherlands."

In a sense, the Dutch invented Indies architecture as a medium to calm down the Acehnese people against the foreignerrs of their colonial presence so that they can protect their colonial interests from possible intervention by the locals. The'Colonial benevolence' in creating such an architectural concept became part the Dutch colonial's strategy to gain their propitiation toward their colony and secured their authority in Aceh.

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Effectiveness of Tsunami Evacuation Building as a Tsunami Disaster Mitigation Effort in Banda Aceh

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Abstract

About 60% of the city of Banda Aceh was hit by the tsunami at the end of 2004. Now, after the 2004 tsunami disaster, most vulnerable people back to inhabit coastal areas in the lowlands. The need for tsunami evacuation buildings are inevitable, such as the evacuation place to mitigate the earthquake and tsunami in the future. There are 5 tsunami evacuation buildings was built after the disaster. With regard to the existence of the tsunami evacuation buildings are necessary to do the research. This research suggests problems with the tsunami evacuation building to find the value of its effectiveness in mitigation of tsunami disaster efforts. In addition, it is to find out how far the tsunami evacuation building function right on target. The goal is to uncover the effectiveness of tsunami evacuation buildings in an effort to mitigate the tsunami in Banda Aceh, as well as to maximize the functions of tsunami evacuation buildings, either during the tsunami or during the common day. In this research, the quantitative method was used to find the value of the effectiveness of existing tsunami evacuation building. Field data collection effort as completely as possible by observation, interviews and questionnaires to divide the population. The data was then analyzed and discussed with the measure criteria of strength, capacity, accessibility, eligibility and visibility of tsunami evacuation buildings. The results show that of the five tsunami evacuation buildings in Banda Aceh, the Aceh Tsunami Museum is building with the highest level of effectiveness, followed by the Community Building/Escape Building the Lambung Village, the Office of TDRMC–Unsyiah, the Community Building/Escape Building in Alue of Deah Tengoh Village, and the Community Building/Escape Building in Deah Glumpang Village. However, the five tsunami evacuation buildings, especially in Meuraxa District, only able to accommodate about 1/4 (± 4500) population of 21,000 inhabitants, excluding the population in other districts. Therefore, it is necessary the number of tsunami evacuation buildings with the concept of multi–functional building.

Keywords: tsunami evacuation building, mitigation of tsunami disaster, Banda Aceh.

Introduction

Nearly 60% of the city of Banda Aceh was hit by the tsunami on December 26th 2004. Because of limited knowledge and awareness, the disaster has caused hundreds of thousands of victims. Now, after the disaster of 2004, the population inhabiting the coastal areas is back to the lowlands. The city which is located at the coastal areas is vulnerable of earthquake and tsunami. Therefore, we need the mitigation measures to minimize the number of victims in the future. The needs for tsunami evacuation buildings as the evacuation was inevitable as the tsunami disaster mitigation efforts in the future.

The 'Tsunami Evacuation Buildings' include vertical evacuation rescue directed to citizens with disabilities as to save themselves when the tsunami happen (FEMA 646a, 2009). Types of Vertical Evacuation, according to FEMA 646a, 2009, are: natural or artificial highland, parking buildings, public facilities building, commercial buildings, schools, existing buildings. Tsunami rescue buildings (tsunami evacuation building) is the perfect solution for tsunami mitigation.

There are five tsunami evacuation buildings built with a special post–disaster design, namely: The Escape Building of Gampong Alue Deah Tengoh, The Escape Building of Gampong Deah Glumpang, The Escape Building of Gampong Lambung, TDRMC–Unsyiah Office and Tsunami Museum. In relation to their

existence, tsunami evacuation buildings is deemed to be investigated to measure the effectiveness of each of these buildings.The questions of the research based on the existence of 'tsunami evacuation buildings' are how effective the tsunami evacuation buildings within the tsunami hazard area in Banda Aceh as mitigation plan are and how far the Tsunami Evacuation Buildings that exist today can be functioned at any time.

The 'Tsunami Evacuation Buildings' include vertical evacuation rescue directed to citizens with disabilities as to save themselves when the tsunami happened (FEMA 646a, 2009). Types of Vertical Evacuation, according to FEMA 646a, 2009, are: natural or artificial highland, parking buildings, public facilities building, commercial buildings, schools, existing buildings. Tsunami rescue buildings (tsunami evacuation building) is the perfect solution for tsunami mitigation.The aim of this study was conducted to answer the research questions based on the issues that have been mentioned before, including;

- Uncover the effectiveness of Tsunami evacuation buildings as one of the mitigation efforts to the tsunami disaster in Banda Aceh.
- Maximize the function of the Tsunami evacuation buildings which became an integral part in the midst of society, both during the tsunami and the normal condition in Banda Aceh.

Methodology

The method in this study starts with a literature reviews with the initial preparations in the form of preliminary observations and supporting data as secondary data. These data form the basis before doing research into the field.

Field observations, interviews with authorities and experts, and also gather information from population in tsunami vulnerable areas in the region 'Banda Aceh' is an important data which became the primary data to be discussed and analyzed. Using the steps, the methods that is used will have the desired phase. The assessment of tsunami evacuation buildings with focus on the effectiveness of its saving and function to the surrounding environment and the presence of local residents.

This research is quantitative research which is to find the value of the effectiveness of existing rescue buildings. The collection of the data is provided as informative as possible through observations, interviews and questioners to population.

The location of this research is in the area of Banda Aceh. Based on data from the 2004 tsunami, almost 2/3 of the mainland city of Banda Aceh was hit by the tsunami. The result is due to the topography of the city of Banda Aceh which is the lowlands. Banda Aceh has 6 sub–districts in zones which are vulnerable to tsunami threat. They are Meuraxa, Kuta Raja, Kuta Alam, Syiah Kuala, Jaya Baru, and Baiturrahman. Due to time constraints and cost–owned study, the researchers chose to determine the location of the sample with purposive sampling technique. The location is selected in the district that has a level of accuracy of the data that can be represented as a whole. The location with a high degree of variation of the variables that affect the study set is in Meuraxa. The selection is based on consideration of: being in a high–risk zone, the topography is relatively the same as the other districts, high population density, variations in land use and the presence of the rescue buildings. These considerations become important points to this study site selection. The accuracy of site selection research in mitigation efforts in the region of Banda Aceh should be a model of reference for other sub–districts.

The object of the study are five Tsunami evacuation building located in Meraxa sub–districts: Gampong Alue Deah Tengoh Escape Building, Gampong Deah Glumpang Escape Building, Gampong Lambung Escape Building, TDRMC Office – UNSYIAH and Aceh Tsunami Museum.

Research Materials

The materials for research are maps, demographic data, photos and images of buildings existing savior, and questionnaire data as well as data from field observations.

Research Process and Data Collection

The data collection techniques used in this study are the observation, interviews and questionnaires. The research was carried out in several stages as described in Figure 1. The field data collection was conducted as a primary data. Data collection was done by observation, interviews both structured and unstructured, and collection of data from the questionnaire prepared in this study. Observations were carried out starting with finding an evacuation building representative in this study. The next step was to identify facts in the buildings. Interviews were conducted by collecting information from the parties who are experts in their field that were involved in the planning, building up and playing an active role for the existence of a rescue building in the city of Banda Aceh.

The data from the observation, interview and questionnaire were conducted as field facts. The results were obtained by measuring the discussion/simple assessment of the criteria of which consists of the power, capacity, accessibility, visibility and eligibility of evacuation buildings.
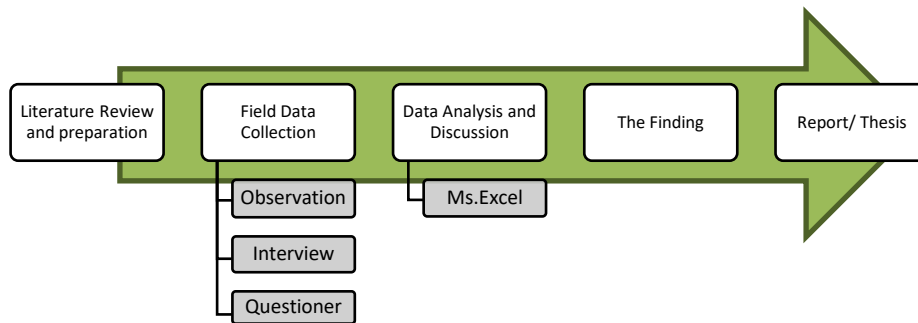
Figure 1. Diagram of the process of the research

Research Variables

Variables are grouped according to their needs. After statisticalized, the data were tabulated with other variables in other districts. Variables that influence the function of the building are physical and structural conditions, treatment and management, maintenance and management, accessibility of achievement (evacuation path), the distance of the building towards the direction of the tsunami, the distance to the achievement of the building, accommodating capacity, the height of the building to the prediction of tsunami, residents familiar with the building evacuation routes and local rescuers and other evacuation building supporting facilities.

Results and Discussion

Data were analyzed and discussed by measuring criteria for strength, capacity, accessibility, eligibility and visibility of the Tsunami Evacuation Building. Analysis was performed by using the data finding in the field and making a simple statistical count by utilizing software Ms. Excel.

Banda Aceh has 61.36 km2 area, which is directly adjacent to the waterway on the North side, Aceh Besar in the South and East side, while on the west side is the Indian Ocean. Geographically located between 050 16 '15' '– 050 36' 16" North latitude and 950 16 '15" – 950 22' 35" East Longitude. The topography is relatively gentle with average height – 0.80 m above sea level. Banda Aceh has 9 districts with 90 village (village). 9 sub–districts are Meuraxa, Jaya Baru, Banda Raya, Baiturrahman, Lueng Bata, Kuta Alam, Kuta Raja, Syiah Kuala and Ulee Kareng. The total population of the city of Banda Aceh is amounted to 238 784 inhabitants in mid–year 2012. The population of Meuraxa sex ratio amounted to 17 614 by 9530 souls male and 8,084 female. Average population density is 1,101 inhabitants/village or 2,406 people per km2 (BPS, 2013).

In this study, the research area set out in Meuraxa, which consists of 16 village/rural sub–district with an area of 7.26 km2, or 11.83% of the total area of Banda Aceh. The villages in this district consists of Surien, Asoe Nanggroe, Blang, Lamjabat, Baro, Punge Jurong, Lampaseh Aceh, Punge Ujong, Cot Lamkueueh, Gampong Pie, UleeLheue, Deah Glumpang, Lambung, Blang Oi, Alue Deah Tengoh and Deah Baro.

Banda Aceh with its susceptibility to earthquake and tsunami is located adjacent to subduction zones, which is about 200–250 kilometers with high seismic activity. Therefore, the area should have buildings with vertical evacuation alternatives. The evacuation buildings are in great importance for the city of Banda Aceh, especially in Meuraxa as the location of observation included in the category that desperately in needs of evacuation building, principally due to several factors, including:

- Topographic which only has an average height of land about 80 cm from the surface of the sea.
- The population density in tsunami hazard zone is very high. Either the local residents or visitors is at high risk, especially in the area of Ulee Lheu which is a harbor transporting passenger from Banda Aceh to Sabang.

Banda Aceh, especially in Meuraxa has 4 evacuation building which was built after the earthquake and tsunami of 26th December 2004. The Evacuation Building as the object of the study also includes one evacuation building at Tsunami Museum, which is in the Village of Suka Makmur Sub–district of Baiturrahman that still adjacent to Meuraxa. Buildings was built by JICA rescuers are located in alue Deah Tengoh, Deah Glumpang and Lambung. The three building which was carried by the studies have included another village around the building layout. There are three villages which became the location of the building

JICA evacuation building, but it also embodies the village around it such as Gampong Deah Baro, a fraction of Gampong Pie and Blang Oi. The evacuation building at TDMRC includes Gampong Pie and Ulee Lheu. Tsunami Museum became a place for the evacuation of residents of the surrounding area and the refugees who have bottleneck tip at Sultan Iskandar Muda street.

Paths has been provided to achieve the evacuation building. During the small earthquake and tsunami at 12th April 2012, the evacuation of the region to the evacuation building was still panic. In the time of evacuation, the bottlenecks paths are inevitable. The population growth after previous disasters made existing escape road yet to find a solution for such evacuation. Banda Aceh is relatively flat topography. Tsunami horizontal evacuation to stay away from the beach shortly after the big quake occurred is difficult to apply as a whole due to the density and limited evacuation path.

Simulations was held several times. One of them was held in order to lay the existence of vertical evacuation of the tsunami evacuation building in Banda Aceh. Simulation is expected to be implemented on a regular basis to ensure the readiness of the population to face the tsunami disaster in the future.
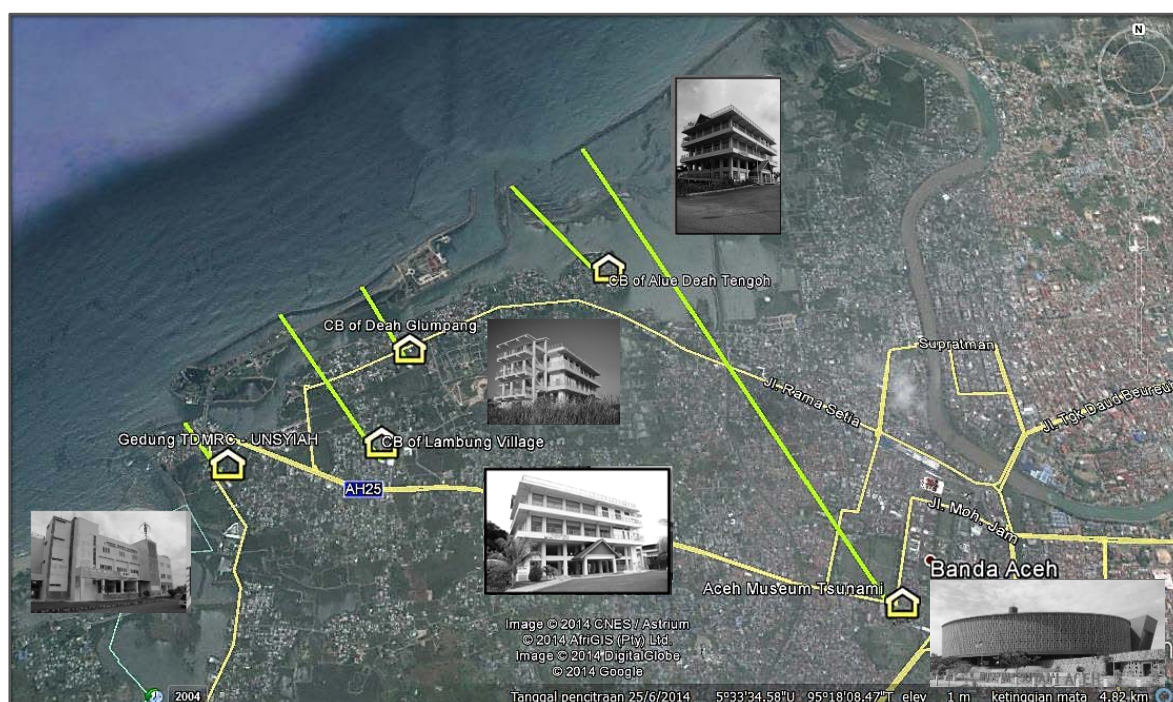

Figure 2. Satellite imagery distancefive of tsunami evacuation buildings with directions coming tsunami in Banda Aceh (Source: Google Earth with editing)

The findings were obtained from capacity of each evacuation building located at five location mentioned before. These results illustrate that of the nearly 21,000 residents Meuraxa district until 2014, only 1/4 (± 4500) population can be accommodated at the moment when the tsunami evacuation occurs in the future. The readiness of vertical evacuation in mitigation efforts in areas that are included in the dangerous zone is still insufficient.

Analysis and Discussion Tsunami Evacuation Building

There are 4 units of Evacuation Building (EB) located in the area of tsunami Meuraxa. There are 3 Evacuation Buildings named as Community Building (CB). Community building (CB) was a Japan people aids which were typically constructed. Each Community Building (CB) are located in the Village Alue Deah Tengoh, Gampong Deah Geulumpang and in Gampong Lambung. Another Evacuation Building was built by Tsunami Disaster Research Management Center (TDMRC) Syiah Kuala University which is located in the Gampong Pie. One of the Evacuation Building was built in the form of a tsunami museum located in the Sub–district Baiturrahman which is immediately adjacent to Meuraxa. All evacuation buildings were built after the earthquake and tsunami of 26 December 2004 in Banda Aceh. From the results of field observations, interviews and opinion of the population indicates that the function of the entire Tsunami Evacuation Buildings have multi–functional concept.

With multi–function concepts, the buildings were planned for the evacuation when Tsunami comes again. For the pre–disaster state, each building works as intended. Evacuation buildings has become an

important requirement for the region with relatively flat topography and with such a high risk of tsunami Banda Aceh.

The assessment were carried out on the tsunami evacuation building based on criteria of the power, the capacity, the accessibility, the eligibility and the visibility. These measurements were carried out to find the effectiveness of Evacuation Buildings against the tsunami disaster mitigation. Criteria for evacuation building includes structural strength, shape and stability of the building. Capacity of evacuation building became widespread assessment included the building itself and the capacity in the time of the disaster later. Accessibility includes assessment of vertical circulation of evacuation building and its simple access by reviewing the escape road. Eligibility (feasibility) into elements assessed further by reviewing the daily functions of the building outside its special function as a tsunami vertical evacuation and also an assessment of the feasibility of infrastructure in the building.

The results were obtained by giving a numerical weighting to determine the effectiveness of the Evacuation building. Five Evacuation buildings effectiveness in Banda Aceh and their measurement shown in Table 1. The results mentioned in table 1 has represented the presence of other buildings. Why do the research only study five evacuation building? Because five Evacuation Building had been planned and designed exclusively from the outset as a means of saving from the tsunami. Assessing the effectiveness of the five buildings used qualitative data that has been converted into quantitative scoring. Scoring is divided into 3 simple assessment. A value of 1 means less good, 2 means good value and a value of 3 means very good. Through the assessment the effectiveness of Evacuation Building among the five buildings can be found objectively.

The results of measurements of each criteria: strength, capacity, accessibility, visibility, eligibility of Evacuation Building showed that the Aceh Tsunami Museum scored top marks with weight 14, followed by Community Building/Escape Building Gampong hull weighs 13 value, TDRMC Office – Unsyiah positioned on the third with a value of 11. Community building/Escape Building Gampong Alue Deah Tengoh scored 10 and the last Community building/Escape Building Gampong got the lowest score with a score of 8. Aceh Tsunami Museum is Evacuation Building with the highest level of effectiveness among 4 other buildings.

Table 1. Results of assessment of the effectiveness of building evacuation (BP) in the tsunami disaster mitigation in Banda Aceh

	Tsunami Evacuation Buildings				
	CB - ADT	CB - DG	CB Lambung	TDMRC-Unsyiah	MTA
Strength	3	3	3	3	3
Capacity	2	2	2	1	3
Accessibility	2	1	3	2	2
Eligibility	1	1	2	2	3
Visibility	2	1	3	3	3
Amount	10	8	13	11	14

Assessment criteria:
Value 1: poorly
Value 2: good
Value 3: very good

➤ Strength : analysis of the structure and building construction savior
➤ Capacity : analysis of the broad and capacity building lifesaver
   Accessibility : an analysis of vertical circulation within the building and to the achievement of the savior
➤ Eligibility : an analysis of the feasibility of the function; the condition of facilities and infrastructure building savior
➤ Visibility : analysis of the ability of residents / non-residents to mudh see and remember building a lifesaver.
➤ CB : Community Building Building or known savior Escape Building
➤ ADT : Alue Deah Tengoh Village
➤ DG : Deah Geulumpang Village
➤ TDMRC – Unsyiah : Tsunami Disaster Management Research Center - Syiah Kuala University Office
➤ MTA : Aceh Tsunami Museum

Conclusion

The results showed that among the five Tsunami evacuation building in Banda Aceh, Aceh Tsunami Museum has the highest level of effectiveness, followed by Community Building/Escape Building Gampong Lambung, TDRMC Office – Unsyiah, Community Building/Escape Building Gampongalue Deah Tengoh, Community Building/Escape Building Gampong Deah Glumpang. The measurement results of the criteria is in strength, capacity, accessibility, visibility and eligibility tsunami evacuation building showed Aceh Tsunami Museum has the highest level of effectiveness among 4 other buildings.

The presence of evacuation building in Banda Aceh is very important. Therefore, the effectiveness of evacuation building should be able to answer the needs of rescue evacuation if a tsunami occurs again.

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The Role of Bus Rapid Transit, Trans Mebidang in overcoming the Congestion in Medan

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Abstract

The rapid economic development make the amount of movement in urban communities also increased thus demanding additional means of transport to meet the transport needs of the community. Public transportation is the main solution suggested for urban mass transportation in order to reduce congestion due to the number of vehicles on the road. Similarly, the presence of Bus Rapid Transit Trans Mebidang provided by the government to serve the route Medan–Binjai–Deli Serdang are expected to provide satisfaction for the community in terms of services. The purpose of this study was to determine the role of Bus Rapid Transit Trans Mebidang in overcoming the congestion in Medan. This research used analytical research methodology with descriptive approach. The operation of the bus rapid transit Trans Mebidang is able to attract people to use them because the quality of service provided is better than other public transport. This of course resulted in a decline in the use of private vehicles although not significant and the level of congestion on the main arterial roads in the city of Medan is still going on.

Keywords : BRT and Congestion.

Introduction

Medan as the Capital of North Sumatra Province is the main goal for the trip nearby towns like Binjai and Deli Serdang. Medan become a travel destination for economic activity such as work or other business activities. The rapid economic development is in line with the growth of transport caused by the increased number of movements of people in Medan. Thus increasing the activity of the community is also demanding additional transportation facilities both public and private transport.

The importance of transport for the development of a city must be followed by the quality of transport services especially public transport. Where public transport is the main solution for the transport of Medan in overcoming the congestion in the midst of people who prefer to use private transport in their activities.

Some of the problems faced in realizing the maximum use of public transportation is when a trip using public transportation takes much longer than using private transport, the absence of a fixed schedule and limited public transport routes that are reachable (Tamin, 2000).These problems resulted the citizens in urban areas prefer to use private vehicles to carry out all the activities because it is considered more efficient and effective. On the other hand the demand for private vehicle ownership in urban areas increased, thereby increasing traffic congestion in Medan because the roads are not able to accommodate the entire number of existing vehicles.

Basically, the perception of people in using public transport is public transport safety and comfort is assured, accuracy and regularity of operations schedule, the cost of transport is affordable and speed to the destination. To realize the public perception as users of public transport services, the government provides Bus Rapid Trans Mebidang order to meet the transport needs Mebidang.

Bus Rapid Transit Trans Mebidang is expected to be able to give satisfaction to the community so that people want to change the using of public transport and leave their private vehicles so that the figure congestion is also reduced.

Literature Review

Transportation stakeholders face many challenges in providing transport services that satisfy customer demand (Mahmoud, *et al.*, 2011). Quality can be defined as satisfying the needs of customers hope (Shen, *et al.*, 2000). When the quality of a service is not in line with expectations, then there is a tendency passengers to leave the transportation modes. Quality of service is one of the most important factors in improving the use of the public transport system (Erdogan, *et al.*, 2013; Botzoris, *et al.*, 2015). The concept of service and intangibility services is one of quality measurement (Joseph, *et al.*, 2005), quality of service is defined as an overall assessment of the service by the customer (Eshghi, *et al.*, 2008).

Quality of service is composed of six dimensions: tangibles (appearance of physical facilities, equipment, personnel) (Ilhaamie, 2010); reliability (ability to perform the promised service accurately) (Sullivan, 2007; David & Heinelle, 2003); responsiveness (willingness to help customers and provide prompt service) (Nutsugbodo, 2013); insurance (the knowledge and courtesy of employees thereby increasing trust and confidence of customers) (Pizam, 2010; Loke, *et al.*, 2011); empathy (caring and attentive to the customer's company) (Pakdil and Feride, 2014); and the last is a comfort (Mazulla and Laura, 2006; Das, *et al.*, 2013).

Quality of service can be viewed from four directions: from the passenger side, the vehicle performance (including the human operator), the leading provider of transportation services and government (Simona, 2010). Quality of service is a decisive factor for the company's services to gain a comparative advantage (Stopka, *et al.*, 2015). That is, the state of the quality of service becomes a major factor to be considered by the services company to be able to retain the services to be used continuously. The quality of services also includes bus fare (Aidoo, *et al.*, 2013). Public transport services must understand the responsibility of providing a reliable and consistent service to passengers in order to produce a better quality of service (Randheer, *et al.*, 2011).

Research methods

This research is descriptive analysis approach where the data obtained will be analyzed by describing the data that has been collected in order to gain understanding, develop existing theories and develop the existing realities are more complex. Based on Miles and Huberman (2009) after the data obtained has the validity of the data, it will be analyzed by the stages of data collection, data reduction, data presentation, and finally conclude the study.

Data were obtained from direct observation and interviews with the users of Rapid Bus Transit Trans Mebidang by using questionnaire. All of the questionnaires were made with closed–type questions to measure the perceived quality of the bus service by passengers is indicated as 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = disagree and 5 = strongly disagree.

From the data obtained will be made after the conclusion of the study were analyzed by a picture obtained from the responses of passengers Bus Rapid Transit Trans Mebidang on this bus service performance in providing services so as to encourage people to switch from private vehicles to public transport.

Results and Discussion

The economic development in Medan as a travel destination of Medan, Binjai and Deli Serdang demanding more efficient economic activity, especially transportation. This development requires people to perform activities such as work to be able to get to their destination on time. In the traveling, communities are given many choices of transport modes such as public transport and private vehicles.

Public transport should be a solution to overcome the density of the vehicle because it can carry a lot of people with different purposes according to the route of that public transport. But the reality of mode choice of transportation in Mebidang is still dominated by private vehicle, namely 75.9%, 56.6% of motorcycles and private cars 19.3% while public transport is only 20.6%. This situation will impact on the high volume of vehicles in the road so that the road that number is not increasing will not be enough to accommodate the number of existing vehicles so that congestion cannot be avoided anymore.

The existence of Bus Rapid Transit Trans Mebidang expected to reduce the volume of private vehicles because communities will change the transport modes choice to this public transport. Bus Rapid Transit Trans Mebidang is presented to overcome the congestion that occur as a result of the high volume of private vehicles by providing comfort travel services.

Bus Rapid Transit Trans Mebidang serve two corridors, namely corridors Medan–Binjai along 23 km and takes about 90 minutes from Terminal Binjai, Soekarno–Hatta Street, Gatot Subroto Street, Iskandar Muda Street, Gajah Mada Street, S. Parman Street, Raden Saleh Street, Town Hall Street, Station Street, MT Haryono Street, Sutomo Street and Market Center (Medan). Second corridor is Medan–Deli Serdang along 32 km and takes about 100 minutes from Market Center (Medan), Sutomo Street, Perintis Kemerdekaan Street, Mohammad Yamin Street, Station Street, MT Haryono Street, Cirebon Street, Singamangaraja Street, Medan Street and terminal Lubukpakam.

No	Bus services	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Insurance Dimension					
1	Drivers are polite	31,9%	58,7%	1,4%	6,5%	1,4%
2	Security at station / stop guaranteed	15,9%	80,4%	1,4%	1,4%	0,7%
3	Security in public transport guaranteed	82,6%	15,9%	1,4%	–	–
4	Drivers are able to answer passenger questions	46,4%	50%	1,4%	1,4%	0,7%
	Empathy Dimension					
1	Drivers care to passengers	46,4%	49,3%	1,4%	2,2%	0,7%
2	Drivers understands the passengers' question	31,9%	60,7%	–	1,4%	–
3	Drivers provide help for passengers	29%	66,7%	2,2%	2,2%	–
	Reliability Dimension					
1	Time waiting for a bus is consistent		62,3%	–	36,2%	1,4%
2	Bus travel time consistent	15,2%	59,4%	–	23,9%	1,4%
3	Complaint handling system available	16,7%	79%	1,4%	2,9%	–
	Responsive Dimension					
1	The driver responsive to the needs of passengers	47,1%	43,5%	–	7,2%	2,2%
2	Fast and precise service is available	7%	73,9%	–	24,6%	7%
	Tangible Dimension					
1	Information on terminal / stop clear	71%	–	8,7%	20,3%	–
2	Cleanliness in the bus awake	2,2%	61,6%	6,5%	29,7%	–
3	Appearance of terminal modern	2,9%	83,3%	–	13,8%	–
4	Bus stop clean	7%	73,9%	–	24,6%	7%
5	Appearance bus attractive	58%	42%	–	–	–
6	Drivers tidy and clean	62,3%	43%	–	4,3%	–
7	First aid facilities available	–	–	–	83,3%	16,7%
	Comfort dimension					
1	Available seat	17,4%	24,6%	15,9%	42%	–
2	seating is comfortable	17,7%	83,3%	–	–	–
3	The driver of traffic rules	29%	63%	–	8%	–
4	Bus uses AC	66,7%	33,3%	–	–	–

Source: Survey

The results above indicate that the service of Bus Rapid Transit Trans Mebidang by the dimensions of insurance, empathy, reliability, responsiveness, tangible and comfort respond positively to the services provided. From the dimensions of insurance is obtained that the average percentage of respondents with 44.2% and 51.25% argued strongly agree and agree that the services provided provide security for the safety of the passengers. Furthermore, the dimensions of empathy where this dimension is to show how concern the driver to the passenger showed that respondents also give positive response to the bus service in terms of empathy with the average percentage of 35.7% and 58.9% believe strongly agree and agree that the bus driver care to passenger.

This reliability dimension concerns the consistency of service to the waiting time and travel time of buses as well as the availability in the handling of complaints. From the survey results showed that the waiting time 62.3% of respondents agree that the time waiting for buses consistent and timely, and for bus travel time 59.4% of respondents found the bus travel time consistently and precisely to the destination, while 23.9% respondents found inconsistent bus travel time or longer to get than the specified time. It caused by congestion that occur unpredictable while traveling, for example as a result of traffic accidents or other conditions. As for the system of handling complaints about 73.90% of the respondents found the complaint handling system available on the bus indicated by availability of telephone number to contact if passenger complaints.

The survey results on the responsive dimension of Bus Rapid Transit Trans Mebidang services show that 27% and 58.7% of respondents strongly agree and agree that the driver is responsive to the needs of passengers and the service is fast and precise available for complaints of passengers in the bus. Tangible dimension in bus Mebidang also showed a positive response from the respondent. This is evident from the average respondent argued strongly agree and agree to the terms of tangible bus service satisfactory with the

percentage of 32% and 43.3%. Tangible dimension looks satisfactory in terms of the information in the terminal / bus stops clear, cleanliness in the bus stop and maintained so that the passengers comfortable, the bus looks modern and attractive than other buses, and the driver are also tidy and clean. Just in terms of the availability of first aid facilities inside the bus, approximately 83.30% and 16.70% of respondents disagree and strongly disagree that first aid boxes are available in the bus.

The government's aim to provide Bus Rapid Transit Trans Mebidang is to attract people to use public transport and leave the old habits of using private vehicles. The concept of Bus Rapid Transit Trans Mebidang made according to the wishes of passengers so that passengers feel comfortable and sustainably use this bus because it was considered as efficient to use private vehicles. From the above survey results found that the average respondent / passenger agrees with the level of outstanding service provided Bus Rapid Transit Trans Mebidang seen from six dimensions. The existence Bus Trans Mebidang this will certainly affect the public interest in using public transport, especially Bus Rapid Transit Trans Mebidang so that the volume of private vehicles will be reduced and in line with that, the congestion will be reduced.

Conclusion

By operating the Bus Rapid Transit Trans Mebidang with good services can give satisfaction to the passengers in terms of comfort, safety and consistency of time. For the Bus Rapid Transit Mebidang comes with the aim of providing good public transport services so that people would like to use these shuttles constantly and leave their personal vehicle.

The results showed that the passenger responded positively to the services provided by Bus Rapid Transit Mebidang. This service is tailored to the wishes of public transport passengers who expect public transport to provide comfort and security as well as using private transport. With the operation of the Bus Rapid Transit Trans Mebidang able to attract people to use it because the quality of service provided is better than other public transport resulting in decreased use of private vehicles although not significant and the level of congestion on the main arterial roads in Medan is still going on.

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Cooling Rate Investigation and The Influence of Pouring Temperature on Hardness Properties of As–Cast Aluminium Alloys

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Abstract

This experiment investigated the cooling curve behavior and the effect of variation pouring temperature on three aluminum alloy by casting process. Three aluminum alloys are Al–1.37Zn–1.19Si, Al–1.66Si–1.35Zn, and Al–2.81Zn–2.6Si derived from melting and alloying a pure aluminum with ADC12 (Al–Si) ingot. Cooling curve recorded from two alloys are Al–1.37Zn–1.19Si and Al–1.66Si–1.35Zn with pouring temperature at 710 ^{o}C. Pouring temperatures was varied by three variations that are 710, 760, and 810 ^{o}C, while the mold temperature kept constant at 220 ^{o}C. The result shows, a freezing range of Al–1.37Zn–1.19Si is 643–348 ^{o}C and Al–1.66Si–1.35Zn is 621–401 ^{o}C with pouring temperature at 710 ^{o}C for both alloys. Then cooling rate obtained for Al–1.37Zn–1.19Si is 55.56 ^{o}C/S, and Al–1.66Si–1.35Zn is 30.09 ^{o}C/S. The hardness index is increasing first then decrease, with increasing of pouring temperature on Al–1.37Zn–1.19Si and 1.66Si–1.35Zn alloys. While on Al–1.66Si–1.35Zn alloy, the hardness value is improving with increasing of pouring temperature.

Keywords : Metal casting, metallurgy, cooling curve, cooling rate, aluminum alloy, hardness.

Introduction

Aluminum alloys have widely used in automotive manufacturing, aerospace component manufacturing and advanced military applications (Wang, *et al.* 2014). They have a high strength to weight ratio, excellent cast ability, high corrosion resistance, low coefficient of thermal expansion, and good wear resistance (Fang, *et al.*, 2014). Metal casting is a process for fabricating structure components, but a disadvantage of this technique is lower mechanical properties than base material before melted. Pouring temperature is one of the casting parameters that affecting on material properties (Kaiser, *et al.*, 2013). Foundry variable such as mold material and pouring temperature has affected on increasing casting quality of LM25 aluminum alloy (Kabir, *et al.*, 2014). Study on the impact of cooling rate on solidification behavior in casting Mg−10Gd−3Y−0.4Zr alloy using sand mold has been done by Pang, *et al.* (2015). The influence of cooling rate on mechanical properties of aluminum alloys has been widely investigated (Amin and Mufti, 2012; Akili, *et al.*, 2014). Study on a cooling curve during solidification and hardness during recycled Al–Zn aluminum alloy by metal casting process has been done by Akhyar and Husaini (2016). The effect of cooling rate on microstructure and solidification parameter of Al–7Si−0.3Mg−0.15Fe alloy was investigated (Pang, *et al.*, 2013), the result shows hardness enhances with the increased cooling rate.

Influence of mischmetal as a modifier, heat treatment and cooling rate on hardness properties of non–modified and modified by Sr for A319.1, A356.2 and A413.1 as–cast alloys has been studied. There are two cooling rates were used to estimate hardness levels (~85 and ~110–115 BHN) in commercial alloys. The result displayed hardness indexes were higher at high cooling rates if compared with low cooling rates of the as–cast alloys. Non–modified or no Sr addition alloys showed slightly higher hardness levels beside the Sr–modified alloys, and the hardness index also decreased with added mischmetal for both cooling rates. An interaction between mischmetal with the alloying elements Cu and Mg were forming the various intermetallic phases may be attributed reducing the hardness values. Increasing of those elements followed by decreasing the formation volume fraction of the precipitation–hardening phases (Al_2Cu and Mg_2Si phases) on the A319.1 and A356.2 alloys, subsequently reducing the hardness (Sebaie, *et al.*, 2008).

The literature survey revealed that effect of pouring temperature on metal hardness properties and cooling rate behavior had not been documented. Therefore, the main objective of this study is to investigate

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the cooling curve behavior on Al–1.37Zn–1.19Si and Al–1.66Si–1.35Zn during solidification. The effect of different pouring temperature ranging from 710–810 ^{o}C on hardness material properties of cast sample is discussed. Three alloys, namely Al–1.37Zn–1.19Si, Al–1.66Si–1.35Zn, and Al–2.81Zn–2.6Si are used for producing cast–samples from melting pure aluminum and ADC12 (Al–Si).

Material and Method

Material

Al–1.37Zn–1.19Si, Al–1.66Si–1.35Zn, and Al–2.81Zn–2.6Si alloys were prepared by casting metallurgy process. Pure aluminum and ADC12 were taken as the starting raw material as shown in Table 1. The chemical composition of the alloys, analyzes by spectroscopy's metal standard. The chemical compositions (wt.%) of the alloys used in this experiment are shown in Table 2. Induction furnace used for melting aluminum alloys and cast into a permanent mold with the diameter is 9.5 mm. A steel mold was preheated with temperature of 220 ^{o}C.

Table 1 Base materials used for alloying metal (wt.%)

alloying metal	Si	Fe	Cu	Mn	Ti	Cr	Pb	Sn	Ni	Zn	Al
Pure Al	0.24	0.53	0.13	0.07	0.01	0.004	0.7	0.01	0.007	1.65	97.26
ADC12	10.56	0.78	1.71	0.15	0.02	0.029	0.05	0.19	0.05	0.83	85.6

Table 2. Chemical composition of cast–sample (wt%)

Cast–sample	Si	Fe	Cu	Mn	Mg	Ti	Cr	Ni	Zn	Al
Al–1.37Zn–1.19Si	1.19	0.62	0.3	0.06	0.01	0.02	0.006	0.009	1.37	Bal.
Al–1.66Si–1.35Zn	1.66	0.71	0.39	0.07	0.01	0.02	0.008	0.011	1.35	Bal.
Al–2.81Zn–2.6Si	2.6	1.41	0.87	0.09	0.01	0.02	0.013	0.029	2.81	Bal.

Methods

To characterize the influence of the pouring temperature on the hardness properties, the casting temperature of three alloys were chosen as 710, 760 and 810 ^{o}C, respectively. A thermocouple K–type was inserted into steel mold for recording cooling temperature during solidification of Al–1.37Zn–1.19Si and Al–1.66Si–1.35Zn alloys with pouring temperature at 710 ^{o}C. The cast samples were grind using SiC paper and polished using a standard technique. Hardness value from the alloys was performed using a Brinell test on a section perpendicular of cast sample with five point indentations (Figure 1).
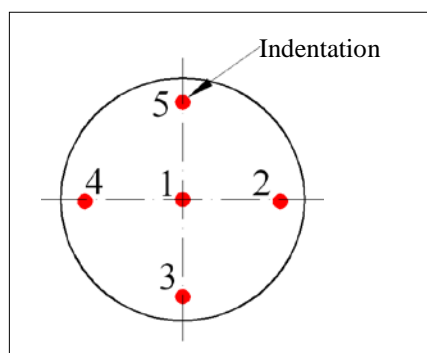

Figure 1. Five location indented on cross section of cast–sample

Results and Discussion

Cooling Curve/Rate

Figure 2 shows cooling and first derivative curve on Al–1.37Zn–1.19Si alloy for pouring temperature at 710 ^{o}C. The solidification curves indicate that thermocouples data recorded from a particular range of solidifications. The first peak of derivatives curve shows the liquids temperature about 643 ^{o}C (primary α–Al formation). The second peak on derivatives curve denotes the solidus temperature around 348 ^{o}C. The liquids temperature is 621 ^{o}C, and the solidus temperature is 401 ^{o}C from cooling and first derivative curve with pouring temperature at 710 ^{o}C on Al–1.66Si–1.35Zn alloy, as shown in Figure 3. The freezing range for Al–

1.37Zn–1.19Si with casting temperature at 710 ^{o}C ranges about 643 – 348 ^{o}C and freezing range for Al–1.66Si–1.35Zn with pouring temperature at 710 ^{o}C ranges from 621 to 401 ^{o}C. Cooling rate for Al–1.37Zn–1.19Si is 55.56 ^{o}C/S and Al–1.66Si–1.35Zn is 30.09 ^{o}C/S. Cooling rate as a thermodynamic parameter is significantly affected by the pouring temperature, and it would decrease with increasing of pouring temperature (Pang, *et al.* 2015).
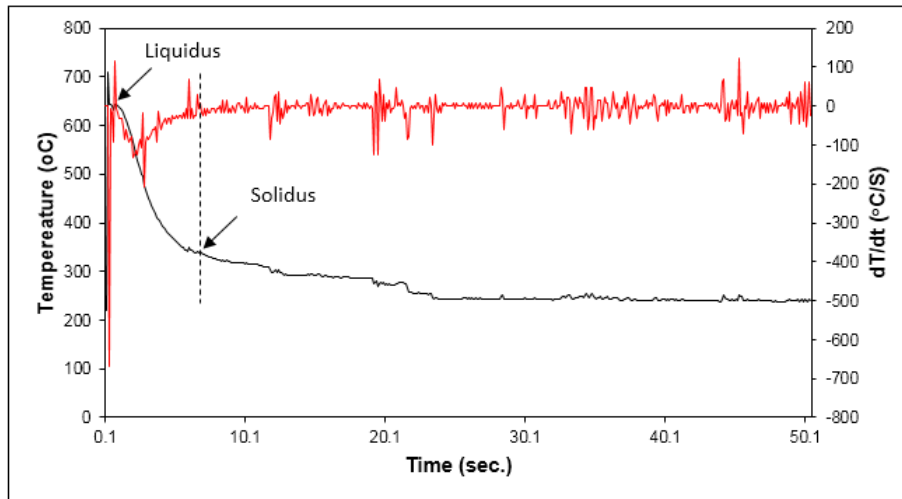

Figure 2. Cooling curves and the first derivative on Al–1.37Zn–1.19Si alloy with poured at 710 ^{o}C.
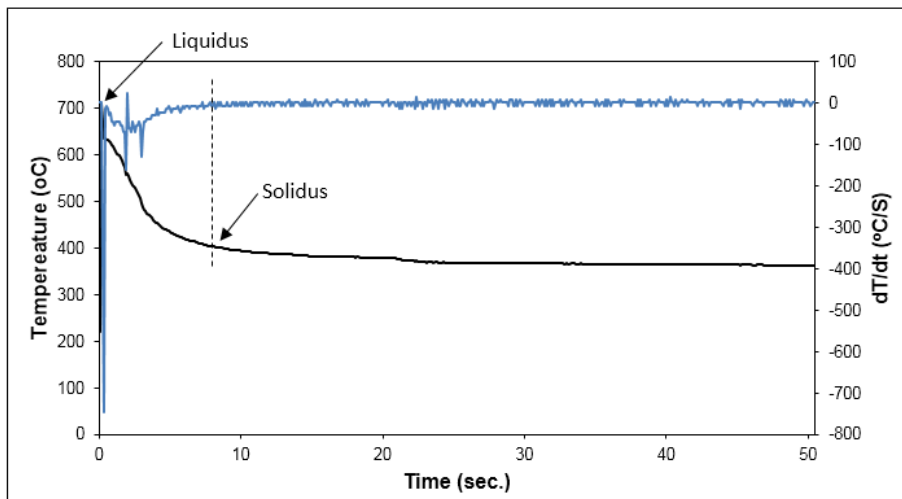
Figure 3. Cooling curves and the first derivative on Al–1.66Si–1.35Zn alloy with poured at 710 ^{o}C.

Hardness Material

Hardness properties of the cast–sample that produced with different pouring temperatures were observed, the result shown in Figure 4. The hardness value maximum on Al–1.37Zn–1.19Si alloy is 42.88 BHN at 760 ^{o}C of pouring temperature. The hardness index has a maximum on Al–1.66Si–1.35Zn alloy is 50.04 BHN at 760 ^{o}C of pouring temperature. It can be seen that the hardness index is increasing first and then decrease with increasing of pouring temperature. A Slightly difference on Al–2.81Zn–2.6Si alloy, the hardness index is increased with increasing pouring temperature and reach maximum at 62.83 BHN at 810 ^{o}C of pouring temperature. According to Kaiser, *et al.* (2013), the hardness increase in alloy with increasing cooling rate during solidification. Hardness average value is rising from 490 H_v at slow cooling rates to 520 H_v for metal casting with rapidly cooled.

According to the result shows that pouring temperature has affected on hardness material properties. Moreover, the variation of metal compositions has effected to the hardness index. Increases cooling rate would be increasing hardness properties of material. Increases cooling rate frequently change grain microstructure become finer, and that would follow by increasing the solid solubility in solid solution. If the solid solubility alloying elements is weak, then the grain size become smoother so increased hardness metal. A regular structure has better of hardness properties than random structure, and this is because of higher internal stress. That internal stress is inversely proportional to mechanical properties. A high pouring

temperature frequently increases the nucleation spots in the superheat melt and refine the microstructure (Kabir, *et al.* 2014). The refined microstructure improved the hardness of the alloy, implying that SDAS of cast–sample have an influence on hardness (Hu, *et al.*, 2012).
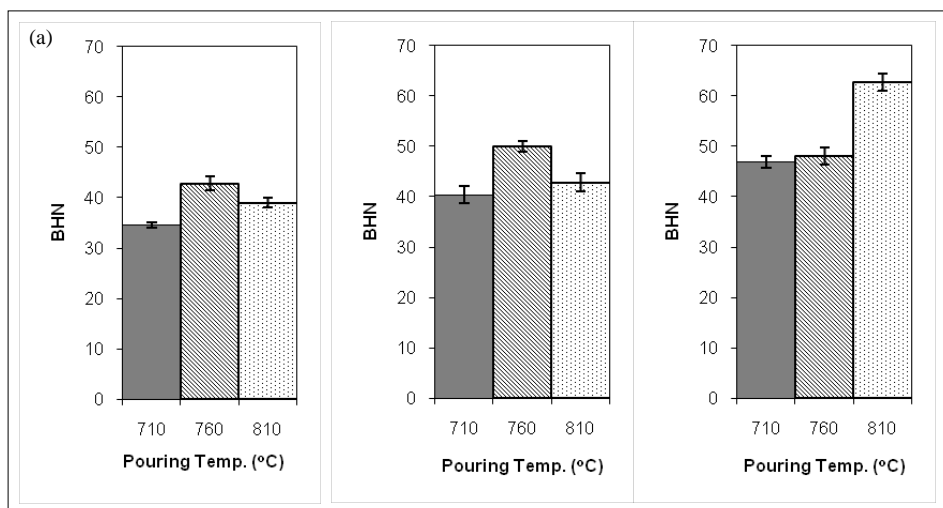

Figure 4. Hardness value with different pouring temperature on (a) Al–1.37Zn–1.19Si; (b) Al–1.66Si–1.35Zn; and (c) Al–2.81Zn–2.6Si alloys.

Conclusions

The conclusion of this experiment show, the freezing temperature of Al–1.37Zn–1.19Si is starting from 643 °C until 348 °C with pouring temperature at 710 °C, while freezing range of Al–1.66Si–1.35Zn is starting with 621 °C to 401 °C at 710 °C of pouring temperature. However, the cooling rate could define for Al–1.37Zn–1.19Si is 55.56 °C/S and Al–1.66Si–1.35Zn is 30.09 °C/S. The hardness value is increasing first then decrease, with increasing of pouring temperature on Al–1.37Zn–1.19Si and 1.66Si–1.35Zn alloys. The slight difference with Al–1.66Si–1.35Zn alloy, the hardness value is increase with increasing of pouring temperature.

Acknowledgements

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Performance Investigation and Development of Solar Dryer Tunnel Type Apparatus of Cocoa

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Abstract

The reduction in water levels in cocoa is an essential step to maintaining quality. It can be done by direct sun–drying or with drying apparatus. The development of solar dryer with tunnel type is introduced in this paper then followed by an experimental investigation of drying cocoa to compare the performance of drying apparatus with open sun drying. Solar energy converted into heat by solar collector then turbine ventilator installed at the end of drying tunnel to force heat air convection inside drying chamber. Solar collector width and length are 200 and 150 m, respectively. Drying cocoa by using drying tunnel shape apparatus need 8.5 hours or one day to reduce the moisture content from 55–60% to 5.62%, while traditional drying time takes 25.5 hours or three days for reach 5.76 % moisture content. The advantages of using this drying tunnel are to protect from the wind, rain, fungi, dust particle, animal feces, microbes and other contamination during drying cocoa, thus affecting the drying time and product quality.

Keywords : Solar drying, solar collector, natural drying, forced drying, dried cocoa.

Introduction

Preservation of cocoa beans usually done by traditional drying and using solar dryer apparatus. Farmer is commonly drying cocoa bean by naturally under direct sunlight with spread out on mats or concrete floor. It usually takes 3–4 days to obtain cocoa dried when the weather is sunny, but it would be problems if the weather is cloudy or rainy. Besides required long drying time with traditionally also have another problem concerning contaminated with dust and bugs.

Mathematical modeling and validation with an experimental investigation for drying kinetics of white mulberry under microwave treatment have been studied. Microwave power level varied with 90, 180, 360, 600 and 800 W. The result shows moisture content reduced from 3.79 to 0.25 (g water/g dry matter), drying time reduced by 88% with 800 W of power level (Evin, 2010). Study of ear–corn drying techniques (sun drying, solar passive ear–corn drying, and heated–air ear–corn drying) has been investigated by comparative performance of those techniques (Iqbal and Ahmad, 2014). Current research on the applied indirect solar dryers was intensively reviewed (Phadke, et al., 2015). The numerical study heat transfer in the air–heating flat–plate solar collector for optimal homotopy asymptotic method (OHAM) and homotopy perturbation method (HPM) application to find approximate of nonlinear differential has been provided. The results show HPM more accurate than OHAM. Increasing dimension of width and length of collector would be decreasing thermal efficiency while increasing air mass flow rates improve it (Ghasemi, et al., 2013).

Design–construction of forced and natural convection solar vegetable dryer for food preservation with heat storage was investigated (Babagana, et al., 2012). The thin layer drying characteristics of chilly red leaves using both open air and in a solar drying was studied (Subahana, et al., 2014). A mixed–mode solar drying with forced convection has been constructed, and open sun drying conducted to compare the performance of drying apparatus. Grapes with 3 kg loaded on it with initial moisture is 81.4%, then final moisture content is 18.6% and achieved within 4 days while open sun drying required 8 days. The temperature at absorber plate reached 69.2 $^{\circ}$C under unload and 64.1 $^{\circ}$C with load conditions. The drying apparatus has designed and constructed with 1.03 m2 as maximum area (Pardhi and Bhagoria, 2013). An experimental study for open–sun and solar heat collector in drying apparatus investigated. Bilimbi (*Averrhoabilimbi, L.*) used as material to produce asam sunti (asam sunti is Aceh–Indonesia local name dry bilimbi). Sunlight intensity and temperatures on several locations inside of drying apparatus have observed. The result shows, maximum temperature obtained at the solar collector is 67 $^{\circ}$C. Drying apparatus has significantly reduced of drying times compare with traditional open sun drying, and it is 24 hours (three days)

and 40 hours (five days), respectively (Harun, *et al.*, 2016). Influence of solar drying on the nutrition content of selected indigenous leafy vegetable is investigated. Five local consumed indigenous vegetables in Ghana are Cocoyam leaves (kontomire: local name), "Ayoyo" water leaves, Moringa leaves and "Bitter leaves" used as material to dried in chopped shape. The experiment conducted with five locally constructed solar panels labeled A, B, C, D and E (control). The result found, Products dried better in the solar panels than in the control due to the protective covering of the panels that prevent unfriendly weather conditions during the drying periods (Seidu, *et al.*, 2012). The suitability of processing sweet potato into chips using locally constructed solar panels studied. Observation showed the potato are well dried and could store for longer times. Solar dryers have the best performance on drying potato chips, and it is effective in drying and void of contamination of products (Seidu, *et al.*, 2012).

Solar tunnel drying apparatus developed, and experimental study discusses in this paper from drying cocoa. The main objective of this experimental is to observe ambient temperature that used for the open–sun traditional system, investigate temperature inside of solar tunnel drying system, evaluate drying time for both drying systems are open–sun and solar tunnel drying apparatus, compare drying time for both drying system.

Material and Method

Developed Solar Tunnel Drying

In this experiment, solar dryer developed for drying cocoa with tunnel shape has a simple construction divided into several parts as shown in Figure 1. The collector plate absorbs solar emission and another part of dryer apparatus then stored after that converted into heat energy which is used to raise air temperature in drying chamber, not all light emission absorbed but some of them reflected into the drying chamber. Material solar collector made from an aluminum plate and to improve ability to absorb heat energy from sun emission then surface collector painted with black color. The solar collector would be raising air temperature from 41 $^{\circ}$C until 74 $^{\circ}$C in drying tunnel. Drying column is a chamber with the shape like a tunnel for placed material to be dried. It made from wood, steel frame and aluminum plate without painting as wall drying chamber.

Heat air temperature generated from this apparatus is higher than the ambient air temperature. Good air circulation is needed to keep moisture in the chamber. Turbine ventilator assembled at the end of drying tunnel functioning to force heat air that containing water vapor from cocoa in the drying chamber to come out through exhaust by spin on its axis. It rotates by pushing from the wind on turbine blades and made from aluminum. If the ventilator turbine does not rotate in properly the heat air still can be out with lower acceleration. Limestone chamber located at intake air, it is functioning to reduce water content from the air than before getting into the drying tunnel. Equipment that has been used to collect data are K–type thermometer used to monitor temperature during experimental, stopwatch, digital scale.
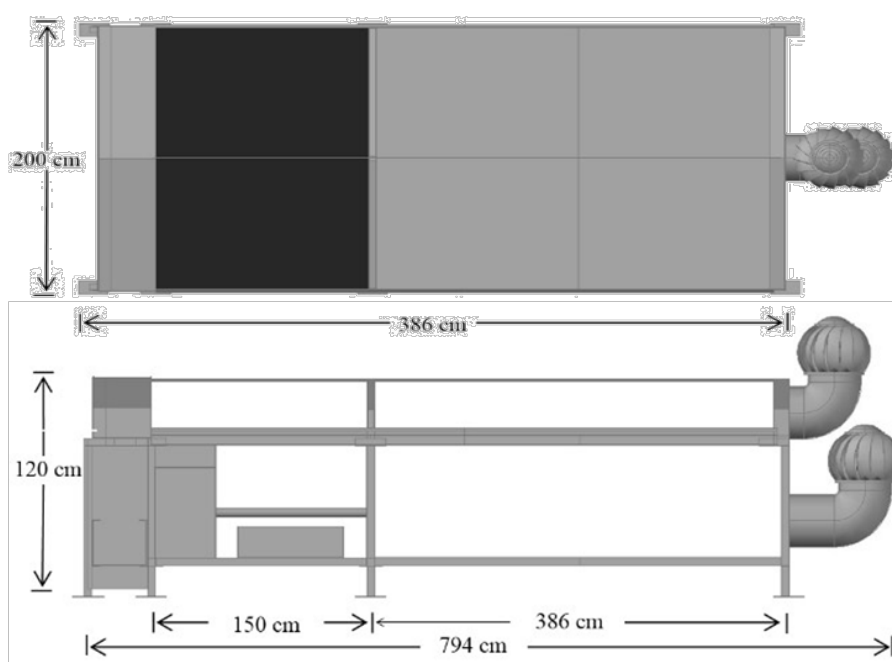

Figure 1. Schematic of drying apparatus with tunnel shape: top view (top) and front view (bottom).

Data Measurement

Two types of experiment condition were traditional sun drying and tunnel shape of drying system with equipped by turbine ventilator, which is open location and no shaded by tree and building for maximal drying. Cocoa bean as material to be dried and fermented before placed into a double drying tunnel with initial weight is 100 gram each, and it obtained from Saree–Aceh Besar District, Indonesia. Data temperature recorded at several points as shown in Figure 2 and collected every 30 min started from 09:00 – 17:30 WIB (West Indonesian time region) for both drying systems. Drying apparatus divided into two column for data collection. Column 1 is close to heat source or solar collector) and column 2 nearby outlet/exhaust drying apparatus.
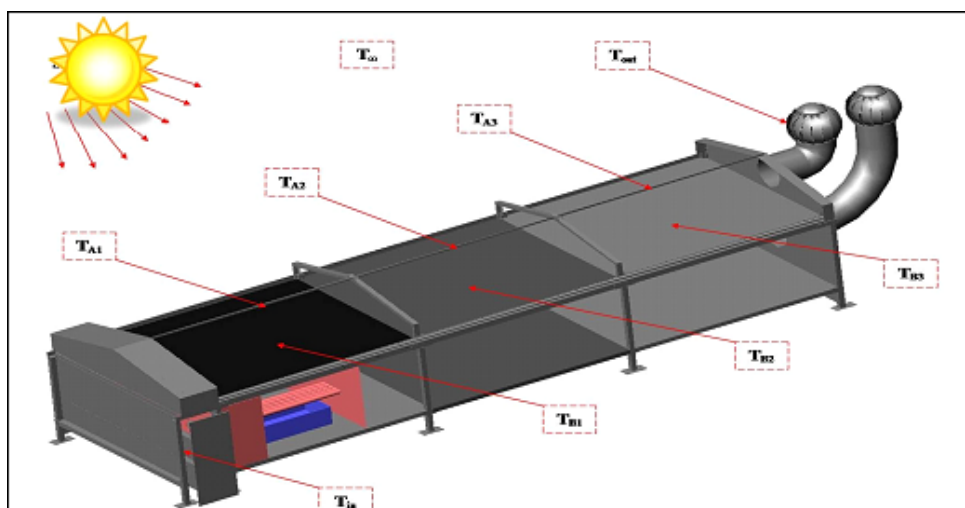
Figure 2. Temperatures data recorded by thermocouple

Location of data temperature are as followed:

T_∞ : Ambient air temperature
T_{in} : Intake air temperature
T_{A1} : Collector column temperature
T_{A2} : Drying column temperature I
T_{A3} : Drying column temperature II
T_{B1} : Collector plate temperature
T_{B2} : Plate column drying temperature I
T_{B3} : Plate column drying temperature II
T_{out} : T_{out} = exhausting air temperature.

Results and Discussion

Temperature Distribution

Figure 3a shows temperature distribution inside drying tunnel shape apparatus (data temperature starting recorded from inlet until exhaust) and temperature ambient without cocoa drying (empty). Temperature ambient and intake not a significant increase, but for other temperature at the beginning show increase then fluctuates started from 10:00 – 13:00 WIB, then temperature decrease with increasing drying time. Temperature maximum is 78 ^{o}C at 14:00 WIB it recorded in plate collector (TB1). Temperature ambient maximum is 38 ^{o}C with the range of drying time started at 14:00–15:30 WIB.

Heat distribution with cocoa as material to be dried using the solar dryer with tunnel shape shown in Figure 3b. Ambient temperature shows not a significant change, and it is 30 ^{o}C at 09:00 WIB (that collected at the beginning of the experiment). Maximum temperature about 35 ^{o}C at 12:00 – 12:30 WIB then 29 ^{o}C at 17:30 WIB (at the end of data collected for the first–day experiment). Temperature maximum in 79 ^{o}C and recorded from plate collector at 13:30 – 14:30. Ambient temperature recorded for open sun drying and also used to compare with the temperature inside of drying chamber apparatus. Temperatures inside of tunnel drying show increase at beginning then reach the maximum at noon after that decreases with increasing interval of drying time.
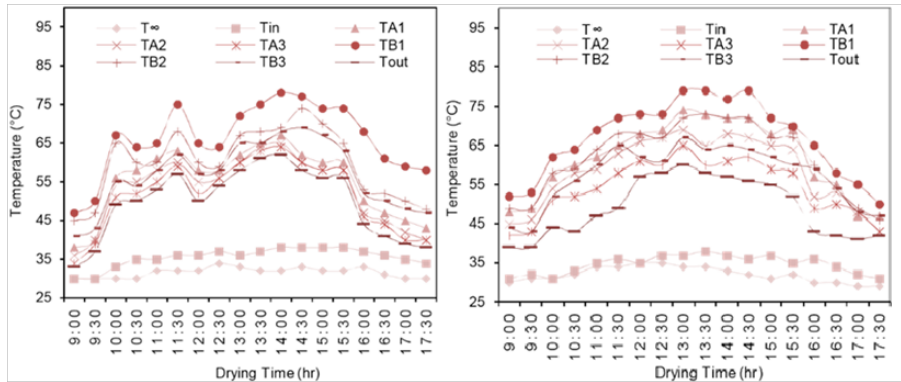
Figure 3. Heat distribution in drying apparatus: without load (left) and with cocoa for drying (right).

Drying Time

Cocoa weight vs. drying time is significant reduced after drying with the solar tunnel as shown in Figure 4a. The initial weight of cocoa is 100 grams (at 09:00 WIB) and after drying with solar dryer about 45 grams (at 17:30 WIB). Cocoa for the tray I and II do not significant shows different of weight. The results shows cocoa weight vs. drying time for open sun drying. It is required three days to reach about 45 gram of cocoa weight. Water content of cocoa bean with open–sun and drying with solar drying apparatus for three days data collection (Figure 4b). The final product of cocoa dried shown in Figure 5.

Temperature distribution shows increased at the beginning of the experiment and reach the maximum at noon, and then temperature decreased with increasing of drying time. Maximum temperature improve at noon, it is because of highest light sun intensity obtained around 13:00 – 14:30 WIB base on investigated by Harun, et al. (2016). Fluctuated temperature shows in drying tunnel apparatus that affected by the brightness of sun conditions.

Results show only one day required for drying cocoa using solar tunnel apparatus if comparing with open sun drying (traditional drying) needed three days to reach the same weight of cocoa. Tunnel shape of the drying chamber and turbine ventilator have significantly affected on drying time. Force heat convection applied on those parts of drying apparatus. Transparent glass covered drying systems to keep heat in drying chamber. Normal air enters from intake ventilation to limestone column, then air moisture reduced using limestone (limestone can absorb water vapor). Heat from sunlight absorbs by solar collector then increasing air temperature above (collector chamber) after that heat air flow through cocoa bean in tunnel drying chamber by rotate turbine ventilator (affected by the wind).
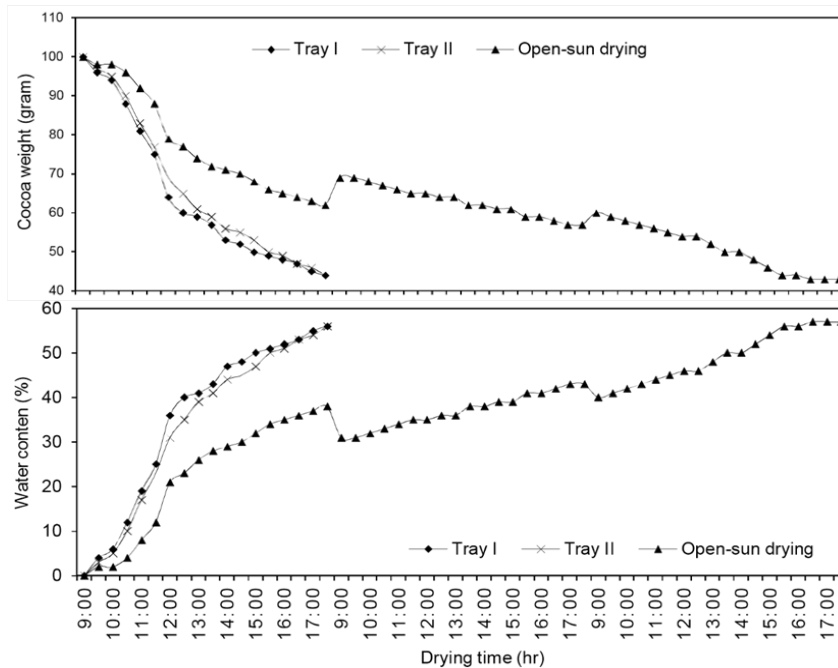

Figure 4. Drying condition with tunnel solar dryer apparatus and compare with open–sun drying for three days of drying times: weight cocoa (top), and water content of cocoa (bottom).

Figure 5.Cocoa bean after drying: (a) column I, (b) column II, and (c) traditional drying.

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Conclusions

This article develops and investigates of solar tunnel dryer apparatus for cocoa bean as dried material then compare with traditional open sun drying. The conclusion can be drawn as followed:
1. Ambient temperature does not significant increases with increasing drying time.
2. Solar tunnel dryer apparatus can improve the temperature until 78 ^{o}C, data collected at solar collector.
3. Solar tunnel dryer apparatus is significant increases and reach the maximum at noon then the temperature decreases with increasing drying time.
4. Solar tunnel dryer apparatus is significant to reduce the drying time from three days with traditional open sun to one day to produce cocoa dried.
5. Good heat air circulation in drying chamber with tunnel shape is critical on drying cocoa, so turbine ventilator applied its function for forced heat convection air.

Acknowledgements

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Finite Element Simulation of Micromechanical Bending Behavior of Typha Fiber Reinforced Composite

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Abstract

One of the natural fiber that have the potential to replace synthetic fibers is *Typha spp* fiber. Typha is mostly found in a stock of water and also in wastelands. A few studies have been done before to investigate mechanical properties of Typha fiber reinforced composite by experimental approaches. This work focuses on the study of the micromechanical bending behavior of Typha fiber reinforced epoxy resin and investigates the interface conditions between Typha fiber and matrix by numerical simulation approach. Micromechanical of Typha reinforced composite is modeled with bonded model contact and no separation model contact conditions, then three types of mesh were adjusted and analyzed using ANSYS. The result showed that with contact model applied, epoxy resin distributed load to fiber immediately and Typha fiber capable of carrying the load out properly. Based on the simulation result of two model contact we occurred the gap between fiber and matrix on the bottom surface where the area does not directly face load. The gaps indicate debonding fiber from the matrix.

Keywords : Finite element, micromechanics, bending, Typha, composite

Introduction

The use of natural fiber as an alternative reinforcement is suggested to reinforce composites because its superior properties such as high specific strength, low weight, low cost, eco–friendly and bio–degradable (Sanjay, *et al*., 2015). One of the natural fiber that have the potential to replace synthetic fibers is *Typha spp.* fiber. Typha is mostly found throughout the world (Baldwin *et al*., 2007) especially in province Aceh. Typha can be found in a stock of water and also in waste lands. Typha is still regarded as a plant that doesn't have a lot of benefits and has no sale value, therefore the growth of Typha is not expected. These plants are often considered parasitic. Despite Typha is mostly available and renewable, but their potential compared to other natural fibers is still underutilized (Ramanaiah, *et al*., 2011). Actually, a lot of things that can be provided from this plant, one of them is Typha fiber for reinforcing composite. A few studies have been done before by experimental approaches, Typha fiber reinforced composite has a good flexural strength (Bajwa, *et al*., 2015), low weight (Wuzella, *et al*., 2011), fairly good mechanical properties, low density and renewable (Ponnukrishnan, *et al*., 2014).

Ramanaiah, *et al*. (2011) investigated mechanical properties and thermal conductivity of *Typha angustifolia* fiber reinforced polymer composites. Based on his research he concluded that tensile strength of Typha fiber reinforced composites increases with increasing amount of fiber. As well as the same result conducted by (Ponnukrishnan, *et al*., 2014) he was studied the mechanical characteristic polymer composite reinforcing by *Typha domingensis*.

One limitation in the analysis of natural fiber composites is difficult to predict the condition of the interface between fiber and matrix. Instead of analytical methods, numerical simulation was used to predict contact interface. Finite element method has been used to analyze the global behavior of composite structures and plays an important role in detecting damage of composite (Alnafie, 2009). The aim of this work is to study micromechanical bending behavior of Typha fiber reinforced epoxy resin and investigates the interface conditions between fiber and matrix by numerical simulation approach.

Methods

Material

Unidirectional and continuous Typha fiber was modeled using ANSYS Workbench. Typha fiber length and fiber diameter is 220 mm and 26,6 μm (Wiztum *et al*. 2014). The Poisson ratio of epoxy resin was 0,4. Determination of the natural fiber Poisson ratio is extremely difficult. Thus, the Poisson ratio is determined randomly in the range of 0,00– 0,35(Leandro José *et al*., 2012). Material properties Typha fiber and epoxy resin presented in Table 1.

Table 1. Properties of Typha fiber and Epoxy Resin

Property	Typha Fiber[1]	Epoxy Resin[2]
Density (g/cm^3)	1,25*	1,16
Maximum Tensile Strength (MPa)	202	73
Young's Modulus (MPa)	11.565	5.000

[1] (Wiztum *et al*. 2014), [2] (Joao Marciano 2012),* (Mortazavi *et al*. 2009)
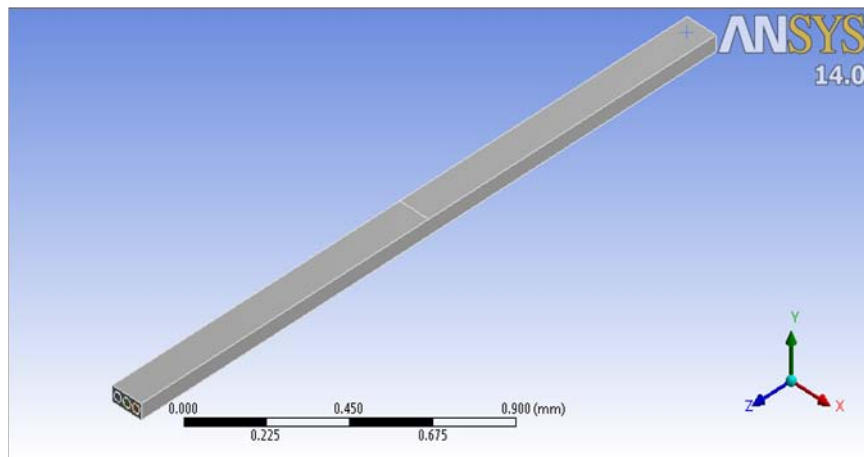
Figure 1. Model geometry

Contact Model

The micromechanical composite strength was affected by fiber, matrix and interface, all of the items are usually referred to the Unit Cell (UC) (J. Modniks, 2013). Matrix surface interacting with fiber surface causes the occurrence of contact. See Figure 2.
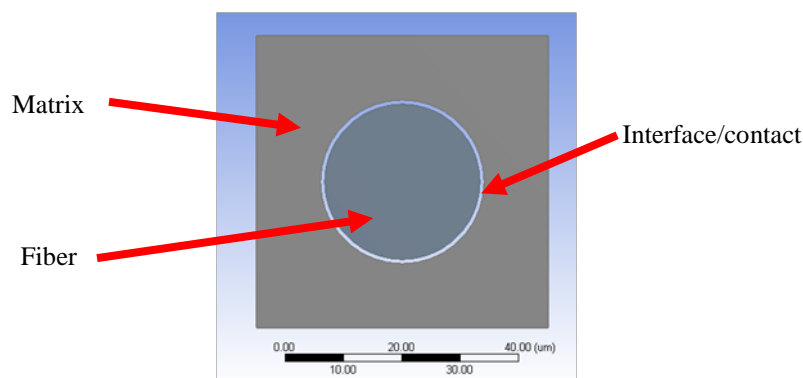

Figure 2. Schematic of the unit cell

Contact between the fiber and matrix was modeled with some contact features that exist in ANSYS Workbench. The blue highlights represent the target face and the red highlights represent the contact face. One thing that should be a concern in the modeling of contact is the target body should always be stiffer than the contact body. In this case, the matrix is stiffer compare to the Typha fiber. Therefore, matrix surface which is interacting with the fiber is highlighted in blue color and the fiber is highlighted in red color. As

seen in Figure 3. In this case, contact condition was modeled by utilizing bonded contact and no separation contact features.
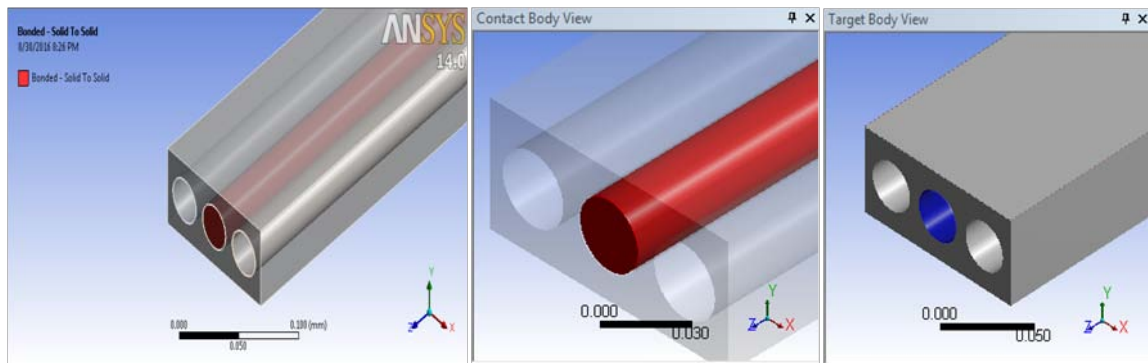

Figure 3. Unit Cell contacts model

Mesh and Boundary Conditions

There are three selected models of mesh, the first is adaptive mesh, the second is refine mesh relevance center, and the third is refine mesh center span angle. The difference type mesh after applying to the model was shown in Figure 4. The load applied to the central part of the micromechanical composite model geometry and fixed support was used to hold two edges of the model geometry shown in Figure 4d.
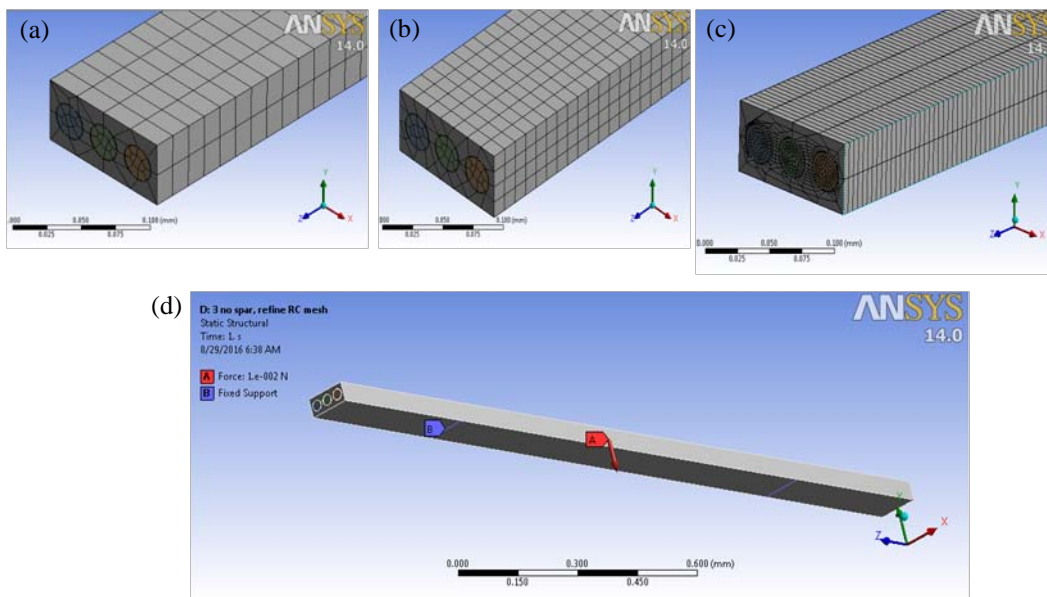
Figure 4. Mesh and Boundary Conditions (a) Adaptive mesh, (b) Refine Relevance center mesh, (c) Refine span angle centre mesh, and (d) Boundary conditions

Result and Discussion

The contact within applied on micromechanical composite showed the result that epoxy resin distributed immediately load to fiber and Typha fiber can be properly carried out the load. Adjusting contact is very important in micromechanical composite modeling to simulate the interface conditions between fiber and matrix. If model contact was not adjusted then the load received by matrix can't be distributed to fiber. As we know that fiber is the component to carry the load out. The result with contact was not applied will be shown in Figure 5a. Afterward, the result within adjusted contact will appear in Figure 5b.
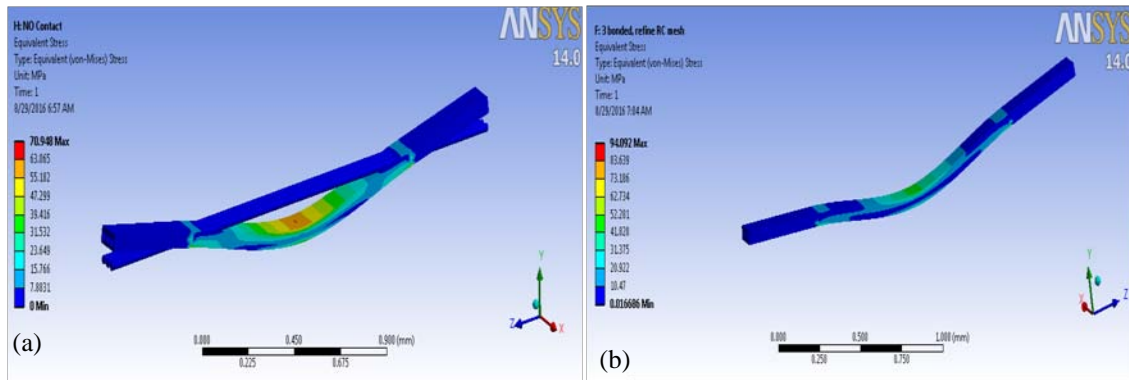
Figure 5. Result within and without contact, (a) No contact applied and (b) Contact applied

The accuracy of finite element method solutions is increasing as more as the element are used, but with more the time required for computing is also getting bigger. The value of maximum principal stress, maximum principal strain and maximum shear is affected by given mesh, as it is kwon that three types are used. In the adaptive mesh type maximum principal stress is smallest while with the refine span angle centre mesh is greater. It indicates the more detail mesh it will provide more accurate results. Bending behavior of Typha fiber reinforced epoxy resin as can be seen in Table 2.

Table 2. Bending behavior

Bending behavior	Elements	Maximum Principal Stress (MPa)	Maximum Principal Elastic Strain	Maximum Shear Stress (MPa)	Total Deformation (mm)
Bonded Contact Condition					
Adaptive Mesh	5313	36,336	0,01161	45,575	0,031374
Refine Relevance Center Mesh	8294	39,296	0,013378	53,755	0,031447
Refine Span Angle Mesh	355461	86,991	0,029563	110,5	0,031803
No Separation Contact Condition					
Adaptive Mesh	5313	36,564	0,011723	45,781	0,031396
Refine Relevance Center Mesh	8294	39,4	0,013417	53,911	0,031464
Refine Span Angle Mesh	355461	82, 672	0,028481	106,76	0,033542

Table 3. Contact status

Contact status	Maximum Frictional Stress (MPa)	Maximum Pressure (MPa)	Sliding Distance (mm)	Penetration (mm)
Bonded Contact Condition				
Adaptive Mesh	3,089	10,086	$8,9891e^{-7}$	$2,3836e^{-7}$
Refine Relevance Center Mesh	2,6666	6,5543	$7,2807e^{-7}$	$1,3867e^{-7}$
Refine Span Angle Mesh	5,2934	13,072	$2,4529e^{-6}$	$4,0766e^{-7}$
No Separation Contact Condition				
Adaptive Mesh	0	11,899	$2,0189e^{-6}$	$2,8154e^{-7}$
Refine Relevance Center Mesh	0	7,9933	$1,5242e^{-6}$	$1,6927e^{-7}$
Refine Span Angle Mesh	3,844	783,23	$5,0218e^{-5}$	$2,4427e^{-5}$

Frictional stress, pressure, sliding distance and penetration in contact status illustrate interface conditions between fiber and matrix can be seen in Table 3. On bonded contact condition, there is a gap at the bottom surface of the fiber which is surface doesn't directly deal with the applied load. The same situation occurs in no separation contact condition, the gap can be found at the fiber bottom surface. These gaps indicate that fibers are no longer attached to matrix, this condition commonly called debonding phenomena. Difference gap condition on two model contact types exists at the edges model geometry, besides fixed support area, where on the no separation contact condition larger gap was found. The gap condition of two types contact model can be viewed in Figure 6.
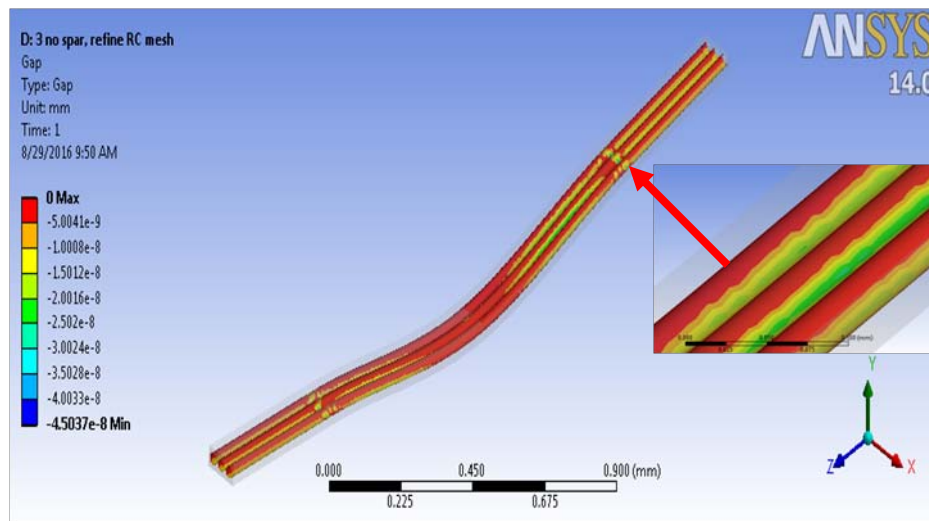
Figure 6. Gap status

Conclusions

In this paper, we suggested the micromechanical composite bending behaviour based on simulation result by adjusting contact to simulate interface conditions between fiber and matrix, the contact within applied on micromechanical composite showed the epoxy resin distributed load to fiber immediately and Typha fiber capable of carrying the load out properly. On two types of model contact, we occurred the gap between fiber and matrix on the bottom surface where the area does not directly face load. The gaps indicates debonding fiber from the matrix.

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The Power Consumption of Paddlewheel Aerator with Moveable Blades

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Abstract

The development movable blade of paddlewheel aerator is considered on fact that power is required when the blade of paddle wheel aerator entering water and contrary action of aeration effect while the blade is leaving the water. This study was carried out to design and simulate paddlewheel aerator with movable blade which will open when entering water and close when leaving water. The blade is closed at quadrant I and IV (entering water surface) and open at quadrant III and II (leaving water surface). The design of the blade was refered to commonly used as Taiwan wheel type. The component of movable blade mechanism consisted of cam, shaft, rim, rim cap, blade holder, follower, spring and bearing. The follower was able to rotate with angle of rotation of 125°, the rotational displacement of 50 mm, the maximum velocity of 0.55 m/s and the acceleration of 6.09 m/s^2. The result shows that the testing without a load at 115 rpm, the torque that occuredis 43.05 N·m and the electric power consumption is 511.72 Watt. However, the electrical consumption is still higher comparing with Taiwan aerator model due to the friction occured on the follower and cam.

Keywords:Paddlewheel aerator, movable blade, cam–follower mechanism, torque, power

Introduction

Aeration is a mechanism of adding some amount of oxygen into water to provide sufficient amount of oxygen. Aeration is carried out by increasing water and air contact using aerator device. One type of aerator device which widely used in pond farming is paddle wheel aerator (Laksitanonta, 2003). Paddle wheel aerator is considered as the most appropriate aerator device due to aeration mechanism and wide usable driven power (Romaire and Merry, 2007).

Some of parameters including water and air surface contact, differential oxygen concentration, film surface coefficient and turbulence influence aeration rate (Boyd 1998). Aeration performance was influenced by geometry, size and wheel velocity (Moulick, $etal$., 2002). Higher size tends to have higher aeration which simultaneously followed by higher driven power needs due to higher drag force. This condition creates certain problem in utilizing paddle wheel aerator as it may increase operational cost including electrical and fuel consumption.

Various models of paddle wheel aerator are offered in market. Aerator made by Taiwan is widely used by consumers due to affordable price, light in weight and corrosion–resistant but has low efficiency (Wyban, 1989). Aerator that was designed and fabricated by Taiwan has SAE (standard aeration efficiency) value of 1.063 kg O_2 kW h^{-1} (Peterson & Walker 2002). Bhuyar, $et al.$, (2009) designed aerator with SAE value 2.269 kg O_2 kWh^{-1}. The most appropriate paddle wheel aerator was designed by Moore and Boyd with SAE value 2.54 kg O_2 kWh^{-1}. Some of fabrications use aerator design with specification 2.25–7.5 kW and $SOTR$ 17.4–23.2 kg O_2 h^{-1} and average value of SAE was 2.2 kg O_2 kW h^{-1} (Moore & Boyd 1992).

Up to now, the development of paddle wheel aerator still uses non–movable blade which result in less optimum power consumption because power is linear with the increasing of aeration rate. Therefore, development of movable blade is needed due to aeration power is only required when blade entering water and in contrary the aeration effect only occurs when blade is about to leaving the water. Therefore movable blade was designed to open when leaving water and close when entering water. This study was aimed to design and simulate paddle wheel aerator with movable blade to reduce drag force acting on blade as well as power consumption.

Functional Design and Testing Methods

Functional Design
The wheel was designed to rotate clockwise with movable blade that enabled to open and close. The blade was about to close at quadrant I to IV (entering water surface) and open at quadrant III to II (leaving water surface). Blade opened to 45 from its close position which parallel to rim. Wheel dimension was designed similarly with commonly used wheel size i.e. 20 cm width, 30 cm rim diameter and 60 cm total dimension.

Testing
Torque measurement is done using a strain gauge mounted on the wheel shaft. The sensor is connected to the strain amplifier (DAS–406B Strain Amp DC) through the slip ring and the bridge box recorded with the data logger (minilab 1008) and stored on the computer just as shown in Figure 1. Data measurement results in the form of voltage (mVolt) is converted into value strain (μst) and torque measurement values (N·m) to the value of the calibration has been done previously.
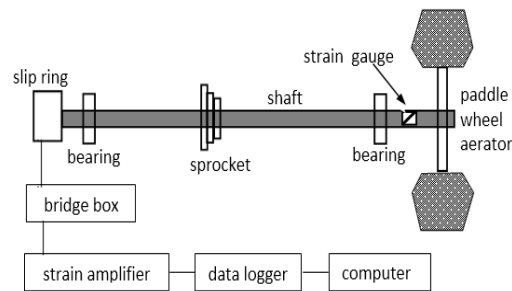

Figure1.Toque instrumen scheme

The measurement of paddlewheel power is done by measuring the power consumption of electric motors using Ammeter (DO2A) which is connected to an electrical output. To read the power measurement values (Watt) is done using a digital camera video recording on the screen Ammeter. Rated power is taken on an average value which often arises from the reading showing on video recordings.

Results and Discussion

Structural Design
The wheel structure consisted of two main components i.e.stationary and rotary component as shown in Figure 2.
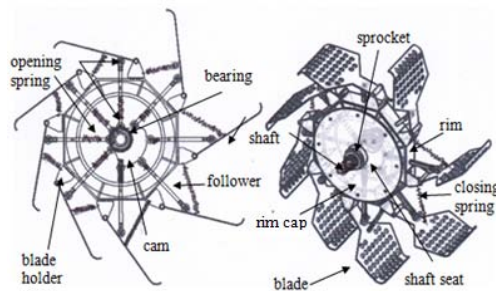

Figure2.Wheel structure with movable blade

Stationary component consisted of cam and shaft. The longest and shortest radius of cam were 680 mm and 17.5 mm, respectively. Cam was mounted to shaft with diameter of 25 mm and attached to machine frame.
Rotary component consisted of the rim, rim cap, blade holder, follower, bearing and spring. The rim was octagonal–shape encircling tube with diameter of 218 mm and height of 30 mm. One side of the tube was enclosed with metal sheet, shaft seat and bearing with diameter of 25 mm. Outside the shaft seat, sprocket that engage onto chain was attached for transmission purpose. The rim cap was a shaft seat made from metal sheet and similar bearing with rim tube which mounted to rim tube using bolt. Blade was used to directly splashing up water. Blades formed 30^0 of angle towards rim with radius of curvature was 40 cm. The

size of the blade was 15 cm of width, 20 cm of length, trapezoid–shape with 15^0 of bottom side and 30^0 of top side, had 40 holes with diameter of 1.6 cm. Blade holder was used to place blade with shaft of 8 mm and height of 25 mm and bolted at the end side of rim. The follower stem was used to push blade to open and close adjusting to cam profile. The follower stem was 150 mm of height and bearing with 19 mm of external diameter was attached on the two end–sides. Spring consisted of opening blade and closing blade. The opening spring was inserted to follower stem with diameter of the spring was 10.5 mm, length was 60 mm, wire diameter was 1 mm and spring constanta was 0.35 Nm. The closing spring of blade was attached on the front blade holder with diameter of 10 mm, length of 45 mm, wire diameter of 1 mm and spring constanta of 0.5 N·m.

Movable Components Mechanism

Movable blade were driven using cam mechanism. The cam is a simply mechanism that can provide almost all types of follower movement (Martin 1982). The movement analysis of cam mechanism is shown in Figure 3.
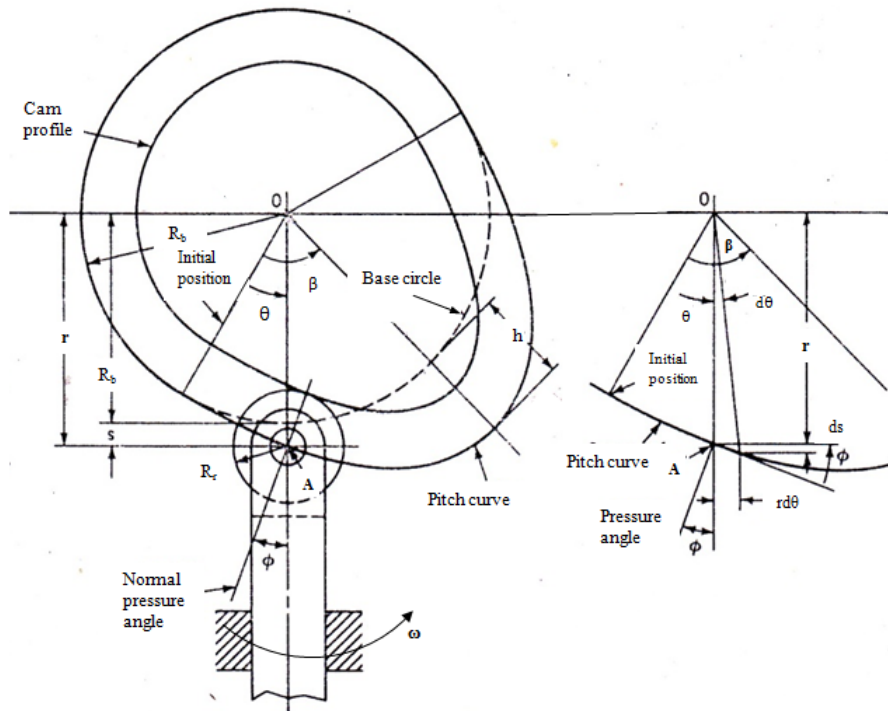

Figure. 3. Profile analysis of cam–follower

for $\quad \frac{\theta}{\beta} \leq 0.5 \qquad s = 2h\frac{\theta^2}{\beta^2}$

for $\quad \frac{\theta}{\beta} \geq 0.5 \qquad s = h\left[1{-}2\left(1{-}\frac{\theta}{\beta}\right)^2\right]$ (1)

Equation of cam velocity is written as follows:

for $\quad \frac{\theta}{\beta} \leq 0.5 \qquad \frac{ds}{dt} = \frac{4h\omega\theta}{\beta^2}$

for $\quad \frac{\theta}{\beta} \geq 0.5 \qquad \frac{ds}{dt} = \frac{4h\omega}{\beta}\left(1{-}\frac{\theta}{\beta}\right)$ (2)

Equation of cam acceleration is written as follows:

for $\quad \frac{\theta}{\beta} \leq 0.5 \qquad \frac{d^2s}{dt^2} = \frac{4h\omega^2}{\beta^2}$

for $\quad \frac{\theta}{\beta} \geq 0.5 \qquad \frac{d^2s}{dt^2} = -\frac{4h\omega^2}{\beta^2}$ (3)

The result of follower displacement, velocity and acceleration is shown in Table 1.

Table 1. Normal force of cam–follower

θ (deg)	2πθ/β (deg)	t (s)	s (mm)	ds/dt (m/s)	d²s/dt² (m²/s)
0	0	0.00	0	0.00	6.09
12.5	36	0.05	1	0.11	6.09
25	72	0.10	4	0.22	6.09
37.5	108	0.16	9	0.33	6.09
50	144	0.21	16	0.44	6.09
62.5	180	0.26	25	0.55	6.09
62.5	180	0.26	25	0.55	-6.09
75	216	0.31	34	0.44	-6.09
87.5	252	0.37	41	0.33	-6.09
100	288	0.42	46	0.22	-6.09
112.5	324	0.47	49	0.11	-6.09
125	360	0.52	50	0.00	-6.09

The maximum displacement of follower for one rotation 50 mm with angle of rotation 125̊. The maximum velocity of follower was 0.55 m/s. The constant acceleration was 6.09 m/s². Angle of pressure determines the smoothness of cam movement. The analysis of angle of pressure was illustrated in Figure 3. Angle of pressure (Ø) for every angular position was equated as follows:

$$r = R_b + s$$
$$\tan \emptyset = \frac{ds}{r \, d\theta} \tag{4}$$

The magnitude of pressure angle for every angle of rotation is shown in Table 2.

Table 2. Normal force of cam follower

θ (deg)	2πθ/β (deg)	Ø (deg)	N (N)	Nx (N)	Ny (N)
0	0	0	239.64	239.64	0
12.5	36	18.13	-380.96	-362.05	-118.54
25	72	30.60	-146.87	-126.41	-74.77
37.5	108	37.38	-120.09	-95.43	-72.91
50	144	40.46	-122.97	-93.57	-79.79
62.5	180	41.40	-144.87	-108.68	-95.80
62.5	180	41.40	-144.87	-108.68	-95.80
75	216	31.01	-324.70	-278.29	-167.29
87.5	252	22.02	-3141.54	-2912.37	-1177.88
100	288	14.10	612.74	594.28	149.26
112.5	324	6.88	328.35	325.99	39.32
125	360	0	239.64	239.64	0

The largest angle of pressure between cam and follower was 41.40°. This magnitude was too large and not necessary for cam–follower mechanism as it required high force and caused mechanism failure that led to machine damage.

Each blade had two types of spring i.e. blade–closing spring and blade–opening spring. Blade–closing spring (s_1) worked against drag force (F_d) and gravifty of the blade (w), while blade–opening spring (s_2) worked against force of blade–closing spring from cam pressure due to wheel rotation. Analysis of spring force is shown in Figure 4.
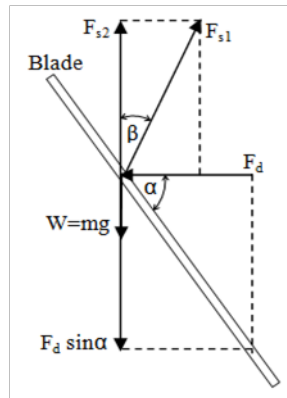
Figure 4. Spring force analysis

Based on the calculation, some of spring data were collected, including installed length, operating length, operating force, springs material, wire diameter, average diameter, inside diameter, outside diameter, free length, number of coils and allowable shear stress for blade–opening springs. The magnitude was 75 mm, 25 mm, 2.45 N, 49.05 N, chromium–vanadium A231, 2 mm, 2 mm, 10.5 mm, 14.5 mm, 80 mm, 12 coils and 922.74 MPa, respectively. The magnitude for blade–closing spring was 124 mm, 38 mm, 2.45 N, 264.50 N, chromium–vanadium A231, 2 mm, 2 mm, 8 mm, 125 mm, 130 mm, 20 coils and 815.75 MPa, respectively.

Innertia and torque analysis are shown in Figure 5. The influencing parameters consisted of force acting on follower (P), inertia force of follower (f), force of gravity on follower (W), shear stress acting on follower (F), normal force on rim towards follower (F_1, F_2), normal force of cam toward follower (N), follower overhang (a), distance between bearing surface (b), diameter of follower stem (d), pressure angle (Ø) and friction coefficient between follower (μ).
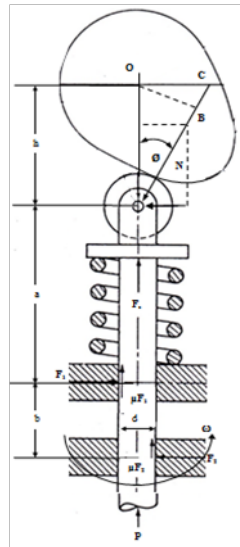

Figure 5. Analysis of angle of pressure

Total force along follower axis was:
$$F = P + f + W + F_s \tag{5}$$
Total vertical force was:
$$N \cos Ø = F + μ\,(F_1 + F_2) \tag{6}$$
Total horizontal force was:
$$F_1 = F_2 + N \sin Ø \tag{7}$$
Summing moments to a point where F_1 works, gave:
$$F_2\left(b - μd\right) = N_a \sin Ø + \frac{d}{2}\left(F - N \cos Ø\right) \tag{8}$$

By neglecting F_1 and F_2 at the last 3 equations, normal force of cam acting on follower was:

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$$N = \frac{F_b}{b \, \cos\emptyset - (2\mu a + \mu b - \mu^2 d) \sin\emptyset} \qquad (9)$$

Torque required to rotate paddle wheel was calculated as follow:

$$T = N \, (OB) \qquad (10)$$

The maximum torque required to activate blade mechanism was 80.09 N·m. Based on the required torque, using equation (6) and neglecting other mechanical loss, as much as 0.96 kW was required to rotate movable blade on paddle wheel aerator.

Torque and Power Consumption

Testing without a load at 115 rpm showed the torque that occured 43.05 N·m and the electric power used 511.72 Watt. Torque occuring reduction compared with calculation results due to modification follower. Follower rod are to be bent to minimize the contact angle that happened. That torque still high and not proportional to torque reduction of simulation result effect of using moveable blade 31.51% (Bahri *et al.* 2015). Thus, the electric power consumption was still high compared with Taiwan model paddlewheel aerator was 451 Watt. However, the resultsshowedthat the friction forcestill high occured between the cam and the follower that are caused by a cam profile which must follow the functional design of the padllewheel aerator.

Conclusion

Structure of the wheel consisted of two main components i.e. stationary and rotary component. Stationary component consisted of cam and shaft. Rotary component consisted of a rim, a rim cap, blade holders, followers, bearings and springs. The follower was able to rotate with angle of rotation was 125° rotational displacement was 50 mm, maximum velocity was 0.55 m/s and acceleration was 6.09 m/s². The follower had constant acceleration. Testing without a load at 115 rpm shows the torque that occured 43.05 N·m and the electric power used 511.72 Watt. These test results showed the friction forcestill high occured between the cam and the follower that are caused by a cam profile which must follow the functional design of the padllewheel aerator. It is suggested that to overcome the friction by increasing the dimension of mechanism contruction and reduce the angle contact between cam and follower.

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The Analysis of Relationships Among Variables Toward Medical Tourism to Malaysia by Employing Structural Equation Modelling

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Abstract

Medical tourism which is a new combination of tourism and medical treatment is now rapidly advancing. The medical tourism phenomenon gives positive impact to the destination country and at the same time negative impact to the country where the tourists come from. Medical tourism is also growing in Indonesia. For instance, Acehnese people commonly visit Malaysia for a treatment and it is called medical trip. To cope with this situation, deep analysis is necessary to identify factors which contribute to medical tourism behavior, which affects the loyalty of Aceh citizen. This study employed *Structural Equation modelling* (SEM) and there were 208 questionnaires as the samples collected through the non–probability technique. Gathered By means of AMOS software, the data revealed that the loyalty of Acehnese people were either directly or indirectly affected by perceived quality, perceived value, satisfaction, trust, image, destination competitiveness, medical tourism in Malaysia and medical tourism loyalty

Keywords : Medical tourism, structural equation modeling (SEM), perceived quality, perceived value, destination competitiveness, satisfaction, trust, image, medical tourism in Malaysia, medical tourism loyalty.

Introduction

Medical Tourism becomes the choice for having a treatment and it has recently developed tremendously. This phenomenon is a combination of medical and tourism that provides a positive impact to the economy and the health of a country's investment (Pocock and Phua, 2011). This phenomenon contributes to increasing employment, foreign exchange earnings, infrastructure, health and quality of living standard of the country of destination (Sharma, 2013). Therefore, many countries around the world have begun to promote medical tourism to obtain benefits (Sarwar, 2013), for example Jordan (Muala, *et al.*, 2011), Iran (Kazemi, 2008), India (Crooks, *et al.*, 2011), Taiwan (Chen, 2012), Thailand (Wongkit and McKercher , 2013), Korea (Oh, *et al.*, 2013), and Singapore (Pocock and Phua, 2011).

However, medical tourism gives a negative impact to the countries where medical tourists come from (Johnston, *et al.*, 2010). For instance, the United States suffered from loses, for its citizens preferred to have a treatment with cheaper medical costs and the same facilities in India (Washington Times, 2013). Specially attracting the international tourists, Medical tourism steadily develops year after year. Asian Medical Tourism Analysis 2013 pointed out that India and Thailand are currently competing to earn the nickname as the "crown" medical tourism. It is estimated that in 2013, medical travelers will experience an increase of more than 25% and it is also supported by the emergence of new treatment destination countries in Asia such as the Philippines, Malaysia, Singapore and South Korea.

The phenomenon of medical tourism is also grown in Indonesia. For example, Acehnese people often travel to Malaysia for a medical tourism. According to the management of a hospital in Malaysia, Aceh residents spend an average of 20 billion per month and more than 300 billion per year having a treatment in Malaysia (Serambi Indonesia, 2013). This statement is strongly supported by the head of the immigration office first class Banda Aceh. According to him, the Immigration Office issues the passport about 1300 books each month, more than 70% of which is intended for medical treatment abroad (Serambi Indonesia, 2013). Another factor supporting the increasing number of medical tourism abroad is that people find it easy to deal with the bureaucracy and even get the special promotion programs of medical tourism tour packages offered by several travels and airlines. Based on data from PT. Angkasa Pura II (Persero), there are 2000 Acehnese heading to Malaysia and Penang each month. Similarly, the secretary of Commercial Aeronautical also

acknowledges that Acehnese departing from Sultan Iskandar Muda to Malaysia generally have an interest to seek treatment. The high interest of the people of Aceh to conduct a medical tourism has caused some hospitals in Malaysia and Penang to establish an Johor treatment office (KPJ). KPJ is an office that provides information and free consultation for those who intend to conduct a medical tourism. The existence of several KPJ is apparently supposed to threaten the health industry in Aceh.

Aceh government has actually attempted to design some programs to increase public confidence in the medical and health facilities in Aceh. One of the strategies undertaken is to increase the medical system performance through Aceh health insurance program (JKA) in early June 2010. However, this strategy has not been effective enough so that further analysis is required to analyze the factors that influence the development of medical tourism in Aceh. The data collection for the study is conducted through questionnaires and interviews, while the data is analyzed by using structural equation modeling (SEM).

Therefore, the problem in this study is that uncomplicated bureaucracy, facilities and services offered to go to Malaysia affect Acehnese society to conduct a medical tourism in Malaysia. Furthermore, the presence of Johor treatment office (KPJ) in Aceh is also a threat to the health industry in Aceh, resulting in lack of trust of Aceh citizens and causing the services in Aceh hospitals to unable to progress. In addition, it also makes Indonesia lose its income every year and thus it is necessary to identify the variables that affect the behavior of medical tourism and the need for the development of medical tourism in Aceh to reduce public interest to have a medical treatment in Malaysia. Meanwhile, this study aims to determine the relationship among variables that affect medical tourism activities in Malaysia and is expected to result in the inputs that can be used to improve the performance and competitiveness of the hospitals in Aceh.

Literature Review

This part deals with the previous studies that serve as the underlying theories of this research. The medical tourism which has become a blooming phenomenon is thought to be able to give the benefits and potentially help the economic growth of a country. Many previous studies in the area of medical tourism have been carried out. Chen (2012) for example investigated the strategies used in medical tourism by means of DAMATEL method. The finding showed that the best strategy to increase the medical tourism is to improve information and marketing. Other strategies in enhancing medical tourism were to boost the service quality, satisfaction and loyalty. Similarly, in his case study with regression analysis in Pattaya, Thailand, Mechinda et al (2010) found that the most important factor for tourists in a hospital is trust, whereas satisfaction became the main factor for them in clinic.

Beside, several qualitative research related to medical tourism have also been done by some researchers. Crooks et al (2001) and Song et al (2010) conducted the studies by using content analysis and pointed out that the medical tourism in Barbados and Hong Kong will give a positive effect if infrastructure, human resources, government policies and cooperation with hotels and medic are managed and conducted well.

Table 1. Research Literature Review

Researchers	Years	Satisfaction	Trust	Tourist loyalty	Service quality	Destination competitiveness	Costumer service	Image	Medical tourism
Lertwannawit, *et al.*	2011	X	X	X	X				
Sarwar	2013				X	X	X		X
Yoon, *et al.*	2003	X		X		X			
Muala, *et al.*	2011	X		X				X	
Ho, *et al.*	2014	X	X	X					
Fatehi, *et al.*	2010	X			X				
Debata	2010	X	X	X					X

The researches related to the factor analysis and causal relationship were conducted by Yoon et al (2003), Lertwannawit, *et al.* (2011), Muala, *et al.* (2011) and Sarwar (2013) by employing SEM method. These studies found that there is a significant relationship between satisfaction, service quality, and image and medical tourists' destination loyalty throughout the world. These studies were carried out in Bangkok, Jordan, Mediterranean and Malaysia. The phenomenon of medical tourism above gives a positive effect for the destination countries and simultaneously results in a negative impact for the medical tourists' native countries such as the exacerbation of health care, loses for tourist' native countries (Johnston, *et al.*, 2010)

and health discrepency globally (Johnston, *et al.*, 2012). According to Synder, *et al.* (2013) medical tourism provide potential economy and job vacancy for the destination countries yet decreases the people trust of health in the native countries (Snyder, e*t al.*, 2013).

Based on the table above, it can be concluded that this research tried to analyze medical tourists in their original countries and the factors that affect the interests of Acehnese in doing medical tourism to Malaysia through some additional variables based on literature, interviews with KPJ stakeholders in Aceh and the Acehnese who have done medical tourism. Through analysis of these variables, it is expected to obtain more comprehensive, valid, reliable and objective data or research results. Hence, the variables that influence the medical tourism in Aceh trend could be figured out. The finding was expected to be right recommendations and strategies for medical industries in Aceh.

a. **Medical Image**

Image is formed based on news, media and word of mouth information (Mayo and Jarvis, 1981). Some research revealed that tourism destination can build an image, give effect to the satisfaction of travelers and shape behavior in the selection of travel destinations (Bigne, *et al.*, 2001; Chon, 1990; Hunt, 1975; Ritichainuwat, *et al.*, 2001; Ritichainuwat, *et al.*, 2003). Therefore, the hypothesis is proposed :

H_1 : Medical image influences destination competitiveness.
H_2 : Medical image influences overall satisfactionn.

b. **Destination Competitiveness**

Destination is the intended tourism places that are visited by tourists, for they have something which can influence people to come (AIEST)., multiple promotions and marketing trends of medical tourism carried out have increased the tourists' trust and encourage them to give a visit to Malaysia (Sarwar, 2013). Based on the above argument, the following is hypothesis :

H_3 : Destination competitiveness influences medical tourism in Malaysia.
H_4 : Destination competitiveness influences overall satisfaction.

c. **Perceived Quality**

Service quality is a very important part in the health industry (Wanlanai, 2011). Many tourists who come from developed countries to developing countries to get cheap medical treatment with high quality (Bookman and Bookman, 2007). A qualified service at affordable prices, expert staff, and friendliness is the core of customers' satisfaction (Sarwar, 2007). Therefore, the hypothesis is proposed :

H_5 : Perceived quality influences medical image
H_6 : Perceived quality influences overall satisfaction
H_7 : Perceived quality influences perceived value
H_8 : Perceived quality influences medical tourism in Malaysia

d. **Perceived Value**

Consumers' assessment of the usefulness of a product is based on perceptions that have been obtained and received (Zeithaml, 1988). The assessment is measured based on services, benefits received and costs budgeted to obtain such services (Hellier et al, 2003). Eggert and Ulaga (2002) states that the perceived value gives a direct influence on satisfaction. Qualified service will provide benefits to the consumer which will end on trust and vice versa (Kang, Shin & Lee, 2012). Therefore, the following is hypothesis :

H_9 : Perceived value influences overall satisfaction.
H_{10} : Perceived value influences trust.

e. **Overall Satisfaction**

Satisfaction is an evaluation of the use based on perspective, cognitive and affective point of view (Oliver, 1997). According to Baker & Crompton (2000) satisfaction tourism is influenced by tourists' perception after experiencing an event / experience and feels its benefits that led to the creation of trust. Medical tourism is a combination of medical travel and tourism, so in the healthcare industry patient's satisfaction is the main priority (Wanlanai, 2011). Therefore, the hypothesis is proposed :

H_{11} : Overall satisfaction influences trust.
H_{12} : Overall satisfaction influences medical tourism in Malaysia.
H_{13} : Overall satisfaction influences medical tourism loyalty.

f.   **Trust**

A trust will be created if there is confidence and feelings of security of a thing perceived by consumers (Morgan & Hunt, 1994). Trust is one of the things that underlies medical tourism goal in deciding to take a trip to Malaysia (Sarwar, 2013).Therefore, the hypothesis is proposed:

H_{14} : Trust influences Medical Tourism in Malaysia.

g.   **Medical Tourism in Malaysia**

Malaysia has offered various competitive programs in an attempt to make Malaysian become an attractive place in Asia for tourists. The Malaysian government also puts a high priority on improving the overall quality of health for both public and private hospitals to attract more medical tourists (Manaf, 2005). In addition, to adhere to the international standard, every hospital in Malaysia is demanded to obtain accreditation MSQH and quality certificate (ISO 9000, 9002) by the Malaysian government (Chua, 2007). Based on the above argument, the following is hypothesis :

H_{15} : Medical tourism in Malaysia influences medical tourism loyalty.

h.   **Medical Tourism Loyalty**

Loyalty is a behavior exhibited by routine purchases based on the decision–making unit (Griffin, 2005). Bei and Chiao (2001) explain that loyalty is not directly affected by the presence of comfort, satisfaction and alternative/intention to return again in the future.

i.   **Structural Equation Modeling (SEM)**

Structural Equation Modeling (SEM) is a statistical procedure employed to investigate the relationship among complex variables which is either recursive or non recursive to elicit the overall picture of the model thoroughly (Marlina, 2009). SEM uses multiple models to find out the relationships among the variables observed by employing quantitative test to prove the theories hypothesized by the researcher (Susetiyana, 2009). By testing the hypothesis through the interrelated statistical formula, the researcher can examine various theories by using SEM. SEM is the development of double equation model derived from the econometric principle and psychology and sociology principles (Hair, Anderson, Tatham, & Black, 1984). Thus, SEM is numerously used in the social, economic, managerial, and academic researches. It is also called covariance structure analysis, latent variable analysis, LISREL model dan AMOS model. It is also recognized as multivariate technique due to its procedure in combining confirmatory factor analysis and double regression analysis (Marlina, 2009)

Research Methodology

Research Methodology explain about several issues related to research methodology, particularly the data collection, questionnaires design , identification of variables (constructs) and sample size determination. The method of data collection in this study was conducted by distributing questionnaires to respondents who had medical travel to Malaysia for use in the current study. The questions in the questionnaire are based on a reviewing scientific journals and books, and using the results of interviews with KPJ stakeholders in Aceh and the Acehnese who have done medical travels.Part 1 of the questionnaires present respondents demographic information with 12 items, such as sex, age, education, occupation, travel purpose, last year travel, destination of country, accompany travel, another country to destination, kind of treatment and etc. Part 2 of the questionnaire deals with the measurement using 34 attributes is also rated using a five point likert scale. The Data was successfully collected as much as 208 questionnaire that can be processed. Data collecting is done in non probability method with the kind of purposive sampling. For the Conceptual model, this research bases it on previous research literature and interviews with stakeholders in Aceh KPJ. Conceptual model of this study can be seen in Figure 1.

Result and Discussion

The data and the result of analysis is obtained based on the result analysis factor on medical tourism. The discussion of the research will start from the descriptive analysis of the profile of respondents, the test of validity and reliability factors used in the study and analysis of factors affecting medical tourism by means of AMOS software. The results of the study discussed in this chapter is based on the explanation of hypothesis testing, both the hypothesis objected and rejected.

The profile of respondents

After the questionnaires distributed and the data obtained, the next step was to conduct a descriptive analysis of the data to see its overall picture. Based on the findings, it can be seen that generally Acehnese people who travel to Malaysia medical tourism are women aged between 26–50 years. Meanwhile, the information and recommendations given by their friends / relatives who have ever done a medical trip to Malaysia become the main reason for Acehnese people to choose a medical trip to Malaysia. Most of the respondents stated that hearing and reading success of others who have already done the treatment in Malaysia is one of the main factors for choosing Malaysia as their medical trip. Another factor for Aceh Citizen to conduct a medical treatment in Malaysia is presence of KPJ in Aceh because the presence of KPJ in Aceh makes people easier to obtain information and consult with the intermediate Malaysian hospital office in Aceh. In addition to the reasons above, the other reasons are that people lack of trust toward the doctors in Aceh and the promotion like the one carried out by Malaysian government is still inadequate.
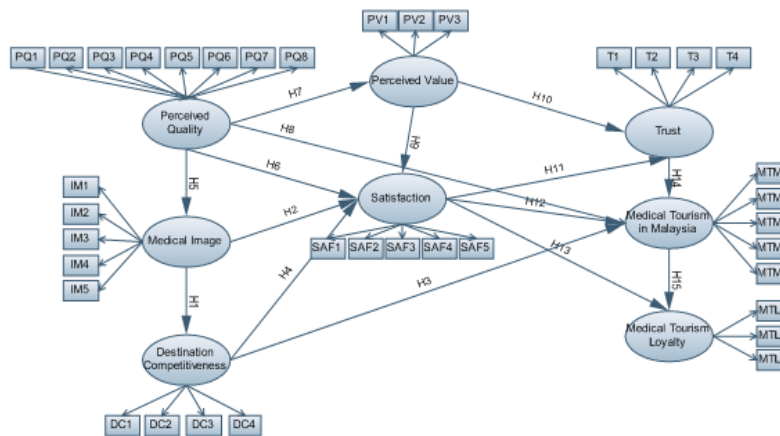

Figure 1. The structural model of medical tourisms by Acehnese people to Malaysia

The analysis of Structural Model

After conducting a test on the measurement model (measurement model) and stating that the fit model and the entire construct could explain the latent variables formulated, the researcher then further tested the structural model (structural model). Santoso (2002) suggests that the structural model is a relationship among constructs that have a cause–effect relationship (causal). Structural model consists of independent variables and the dependent variable. This is in contrast to the measurement model (measurement), which treats all variables (constructs) as independent variables. This is a major difference between the measurement model with the structural model. But in essence, the basis of the SEM is all constructs and relationships between constructs should be based on certain theoretical basis. Testing the structural model consists of two main parts, namely the overall model test (overall model fit) and analyze the relationship between the constructs of the structural model (Susetiyana, 2009). Overall structural model (full model) can be seen in Figure 2.
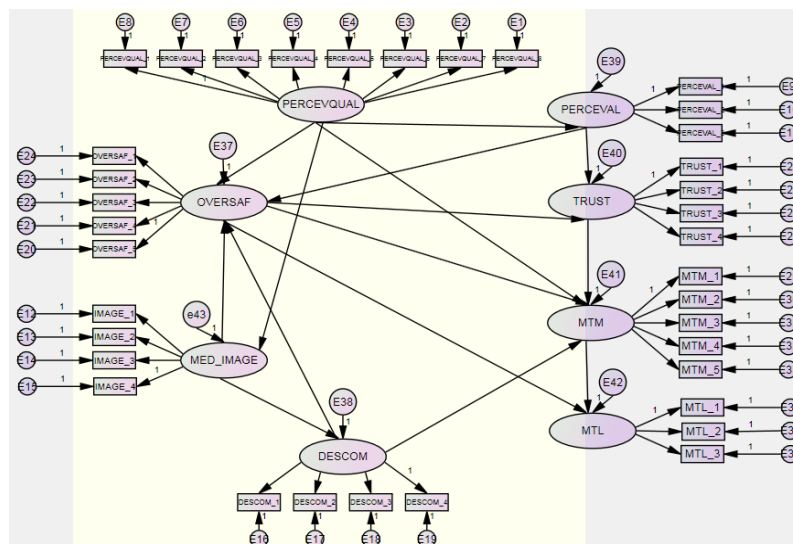

Figure 2. The model of equation structural through AMOS

To investigate the overall model, the testing can be conducted by employing software AMOS. The result of the test can be seen in Table 2. The Model is good if the result of CMIN on default model is in between CMIN Saturated Model and CMIN Independence Model (Santosos, 2002). As in Table 2, CMIN's value on default model is 2144,036 which is in between CMIN Saturated Model and CMIN Independence Model. The number of GFI indicates value of 0,650 and 0,60 for AGFI which approach to the value 1, whereas RMR's value indicates the value of 0,066 which approaches to the value 0, so with these matters support the statement that the model is fit with the existing data and the submitted model is good.

Table 2. The testing result of *Goodness of Fit Full Model SEM*

Testing Fit	The model of testing result	The Level of Acceptable Suitability
Absolute Fit Indices		
CMIN	2144,036	CMIN Independence Model < CMIN Default Model < CMIN Saturated Model
GFI	0,650	Approximate score 0–1; close to 1 better
AGFI	0,60	Approximate score 0–1; close to 1 better
RMR	0,066	Approximate score 0–1; close to 0 better
Incremental Fit Indices		
NFI	0,597	Approximate score 0–1 ; close to 1 better
RFI	0,561	Approximate score 0–1; close to 1 better
IFI	0,670	Approximate score 0–1; close to 1 better
TLI	0,637	Approximate score 0–1; close to 1 better
CFI	0,666	Approximate score 0–1; 1 better
Parsimony Fit Indices		
PNFI	0,548	Approximate score 0–1
PCFI	0,612	Approximate score 0–1

Figure 3. showed the result research of using AMOS Sotware. Based on the figure below it can be seen that there are 2 (two) hypotheses from 15 (fifteen) hypotheses that submitted in this research are rejected, the relation between perceived value construct and trust , and the relation between satisfaction construct and medical tourism in Malaysia. These cases indicate that the benefit perceived by Aceh people while taking medical treatment to Malaysia is not affected by the credibility of the Malaysia's treatment. However those cases are more affected by satisfaction level, which means when Aceh people has perceived the benefit, then it will affect the satisfaction level and inflict the trust. So it can be said that Aceh people who takes medical tourism to Malaysia is because the trust and the service quality that is given by Malaysia's hospital.
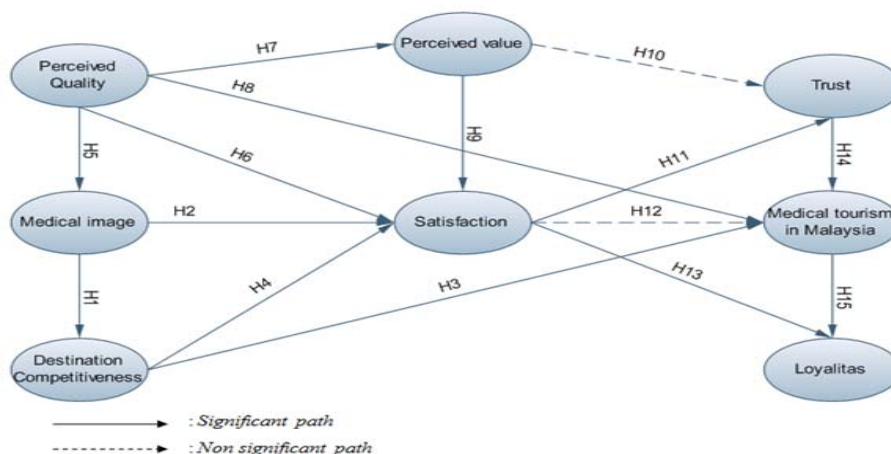

Figure 3. The result of model using AMOS

Conclusion

Based on the data collection, processing, and analysis conducted, it can be concluded as follows:
1. The effect of latent variable on structural equation modeling (SEM) can be elaborated as follow:

a. The variables of medical image, perceived quality, perceived value, and destination competitiveness significantly influenced overall satisfaction and indirectly affected trust and medical tourism loyalty, while perceived value did not influence trust significantly.
b. Perceived quality significantly influenced medical image and indirectly affected destination competitiveness.
c. Overall satisfaction and medical tourism in Malaysia significantly influenced medical tourism loyalty, while overall satisfaction did not affect medical tourism in Malaysia.
d. Destination competitiveness and perceived quality significantly influences medical tourism in Malaysia and indirectly affected medical tourism loyalty.
e. Variable destination competitiveness and significant effect on the perceived quality of medical tourism in Malaysia, and indirectly affected on medical tourism loyalty.

2. To improve the customer loyalty and performance of hospitals in Aceh, the quality of hospital servicesin Aceh need to be improved. Also, doctors and medical staff should further improve their service in terms of attitude, friendliness and attention to patients. In addition, by improving the performance and expertise of the doctor, they can provide accurate diagnosis and information to patients.

Acknowledgements

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Productivity Improvement SMEs Makers Aceh Typical Traditional Cake (Karah Cake) Mechanization Tool Makers on Cake

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Abstract

Karah cake is a kind of snack that is quite popular among the people of Aceh, which is made of rice flour, a triangular–shaped often also doubled. The people of Aceh made this cake as well as part of customs and ceremonies, particularly in Aceh Barat, the wedding ceremony and also events of death. For example, in Khanduri Peuet Ploeh. However, this cake is also known familiarly by the public in some other districts in Aceh. During the production process of making a Karah cake is manually and traditionally, the operator looks at the attitude of working postures performed in a seated position squatting in front of the container frying pan, allowing the operator to experience temperatures elevated body temperature due to excessive hot environment, and also complaints on the hands, arms, shoulders and waist, because the working attitude long enough and done continuously repeated approximately 4–5 hours per day. Influence works continuously repeated in a long period of time can increase the weight of the load and the frequency is high, this can result in fatigue, because the muscle receive pressure from workloads continuously repeatedly (repetitive), that will cause pain lead to reduced work performance. Work activities are carried out repeatedly in a long time, causing Musculoskeletal Disorder. The emergence Musculoskeletal Disorder on the operator can reduce work productivity due to operator motion relaxation to reduce the pain. So this research aims to identify the complaints Musculoskeletal Disorder on the carrier, determine the dimensions of anthropometry appropriate to do the repair design work facility, to analyze the condition of workers when using the facilities of existing work methods QEC and designing machine operator working in accordance with the work pattern making Karah cake so expect can increase the productivity of SMEs

Keywords : Karah Cake, work tool design, Musculoskeletal complaints.

Introduction

Micro, Small and Medium Enterprises (SMEs) have a strategic role in the economy of Aceh, as applicable in the national economy. Data from the Ministry of Cooperatives and Small and Medium Enterprises shows that the number of SMEs in 2011 amounted to 55,206,444 units and employment for 101 722,458 people, while in 2012 as many as 56,534,592 units provide employment for 107,657,509 people. (BPS 2013).

Based on these data from year to year an increasing number of SMEs and employment in the field of SMEs, then certainly a very big potential of SME sector in moving the national economy. SMEs can create a stable domestic economy through economic independence.

It is estimated that, currently SMEs Aceh has absorbed a workforce of about 275 thousand people (www.waspada.co.id, 23.08.2013). MSMEs are engaged mainly in the sectors of trade, services, agriculture, industrial, and marine fisheries.

The decisive role of SMEs for the economy of Aceh in line with the contribution of SMEs to the national economy. Data from the Ministry of Cooperatives and SMEs in 2008 showed a significant contribution of SMEs nationwide. First, industrial SMEs in the economic sector reaching 99.9% of total business units. Second, the ability of SMEs to absorb the employment reached 97.04% of the total labor force works. Third, SMEs accounted for 55.56% in the establishment of the Gross Domestic Product (GDP) (Amin, 2013).

Given the significant presence of SMEs, the Government of Aceh should support the economy's serious business gait. The government's policy to develop and strengthen SMEs in economic activity need to be formulated and implemented properly and carefully. The policy should lead to the creation of conducive business climate, support business development, improving the quality of human resources, and institutional strengthening of SMEs.

Although it has a prominent position in supporting the regional economy, SMEs Aceh has not developed to the optimum. Various problems twisting steps of SMEs, which are related to capital, product marketing, managerial ability, equipment and working tools are still traditional which ultimately boils down to productivity in the SME.

These problems also occur in a typical traditional pastry maker SMEs Aceh (Karah cake). The production process manually is found in the manufacture of pastry products Karah. The production process is done manually is of course affect the quality and quantity of production that will eventually lose the competitive market.

The production process of making a Karah cake manually and traditionally, the operator looks at the attitude of working postures performed in a seated position squatting in front of the container frying pan, allowing the operator to experience temperatures elevated body temperature due to excessive hot environment, and also complaints on the hands, arms, shoulders and waist, because the working attitude long enough and done continuously repeated approximately 4–5 hours per day.

Figure 1. Posture working Maker Karah Cake

So that one can work with both the necessary comfort of the workplace environment. Conditions of excessive heat resulting in fatigue, sleepiness, reducing the stability of the body, which in turn raises the stress level, (Grandjean, 1986). Heat exposure in the work environment increases blood flow, to bring the heat to the surface of the body. As a result of the blood flow, the skin dilate and open pores to remove the heat sweating. The mechanism of evaporation causes the body to cool and the body temperature decreases, (Prece, 1994).

Hundreds of millions of workers around the world working in uncomfortable conditions and can cause health problems. Each year 1.1 million deaths occurred which caused the disease or which is caused by the work. Approximately 300,000 deaths occurred from 250 million accidents and the rest are due to occupational deaths which occurred 160 million is estimated due to unsafe working relationship and uncomfortable, cause of death related to work (Buchari, 2007), as in Figure 2.
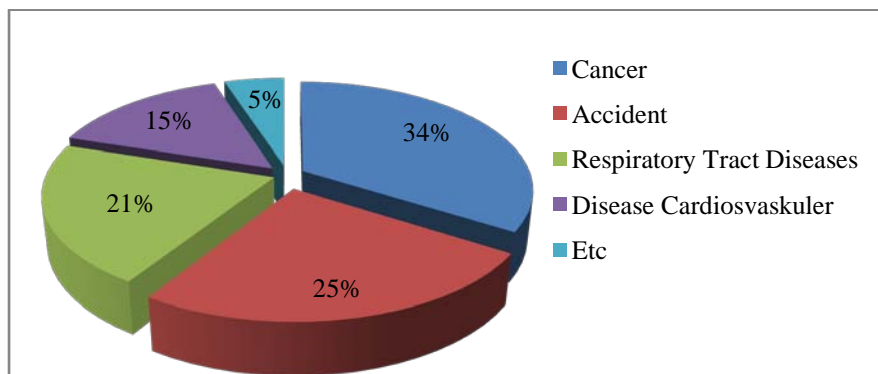

Figure 2. The comparison between death caused by disease and accident in job.

Based on data district health centers Meureubo of West Aceh district, there are seven types of disease heaviest experienced in 2015 including the flu, muscles network system diseases, respiratory tract diseases, hypotension, gastric injury, hypertension, skin disease. As in Figure 3
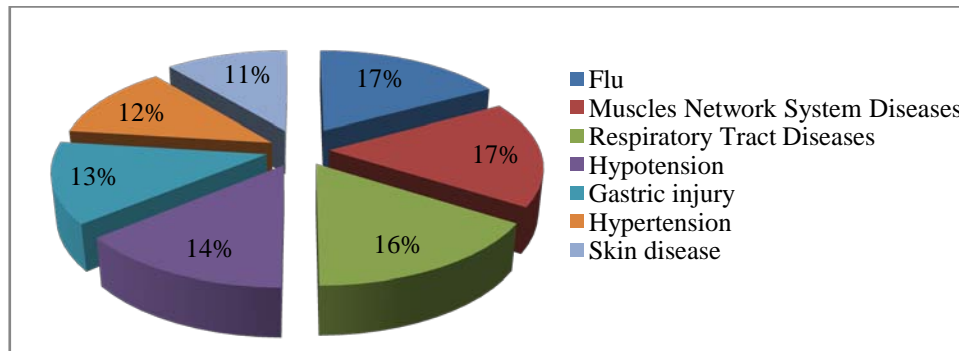

Figure 3. Type of diseases in Sub–Meureubo 2015

Based on the data above shows that six of the seven diseases at district health centers Meureubo ie Muscles Network System Diseases, Respiratory Diseases, hypotension, gastric injury, hypertension caused by muscle fatigue and exposure to heat. The conditions were very hot, humid or excessive clothing, can easily increase the body temperature to 41 ^{o}C – ^{o}42 C, at this level of temperature rise becomes destructive to tissue cells especially damaging brain cells. If this happens, start creating various symptoms include extreme weakness, fatigue, headache, dizziness, nausea, sweating, confusion, unsteady gait, collapse and unconsciousness. (Guyton & Hall, 2006). This shows that the district community as a central production Meureubo Karah cake maker indicated disease that one reason is the working tools and facilities that do not work ergonomics. Based on the results of field research data showed that operators always have complaints Musculoskeletal Disorder (complaints of pain in skeletal muscle). therefore, researchers must conduct repair work at the facility operator Acehnese cake maker (Cake Karah) that is expected to increase productivity in the SME.

Experimental Methods

Type and Design Research
This study is the descriptive method (Descriptive Research). The study was conducted identification ergonomics produces workings assessment is in conformity with the principles of ergonomics or not. The method used is Quick Exposure Checklist (QEC)

Step Research
Designing maker traditional cake (Karah Cake) then needs to be done in several stages, namely: Sampling on SMEs engaged in the business of making cakes Aceh (Karah Cake), measure the posture of the operator and the operator's body anthropometric data Acehnese traditional cake maker (Karah Cake), identify the complaints of the workers' traditional Acehnese cake maker (Karah Cake) (Ratings Form SNQ), processing SNQ, determination of the level of risk scores and actual working posture, acquisition of dimensions required to design facilities, testing uniformity, adequacy and normality of data, complaints Analysis Based on Questionnaires been SNQ and finally the design of the machine tool maker Aceh typical traditional cake (Karah Cake).

Results and Discussion
Based on the results of anthropometric measurements of body carriers Karah cake maker, then then the data can be processed using the QEC.

Posture Data Processing Work With QEC Method
Exposure value calculation (E) for the extraction of the batter into the mold storage warehouse.
X = total score obtained from the assessment of posture (back + shoulder / arm + wrist + neck + vibration + run + trouble + stress) X = 18 + 24 + 14 + 6 + 4 + 1 + 1 + 3 = 71

Body type is a static state, including sitting or standing with / without repetition (repetitive) were frequent and the use of force / load is relatively low Xmaks = 162. Exposure (E) can be calculated with the following formula:

$$E\,(\%)=\frac{71}{162}\text{ x }100\%=43,8$$

Exposure value will be used to determine the level of action QEC as shown below

Table 1. Value Level Event Actions QEC On Making Dough.

Score percentage (%)	Total score of exposure	Action level	Action
0–40	32 –70	1	Secure
41–59	71–88	2	Needed some repair some future time
51–70	89–123	3	corrective action in the near future
71–100	124–176	4	remedial action now

Based on the table above shows that the value of E = 43.8%, so the action level is at level 2, and based on the table of actions taken to mold the dough–making activities are needed some fixes some future time. The same treatment done also for other activities work station, so that the data obtained recapitulation of the whole work posture assessment activities such as in the following table.

Table 2. Summary of working posture assessment overall activity

No.	Description of activities	exposure (%)	Action Criteria
1	Making dough	43,8	Needed some repair some future time
2	Taking the mold tool	43,6	Needed some repair some future time
3	Knocking mold tools with tools	45,6	Needed some repair some future time
4	Put the mold into the shelter dough	43,8	Needed some repair some future time
5	Folded and shaped cake with tools	43,8	Needed some repair some future time
6	Lifting and draining cake	35,8	Secure
7	Draining container to drain the cake	30,2	Secure
8	Storage	25,3	Secure

The table above shows that there are five work stations require repair some future time ie work stations 1 – 5 work stations, while to the work station 6 – 8 work stations that are in a safe condition. So based on these results into five work stations Anthropometric data processing is carried out to obtain the right tool dimension data in accordance with the operator's body anthropometry.

Anthropometric Data Processing
1. Uniformity Test Data

Table. 3. Summary of Uniformity Test Data

No	Dimension	$\overline{X}$	σ	X_{max}	X_{min}	UCL	LCL	Inf
1	HR	74,1	1,58	77	71,8	77,2	70,9	Uniform
2	HES	139	4,87	144	130	149	129	Uniform
3	DHG	4,12	0,20	4,25	3,75	4,52	3,72	Uniform

The table above is the result of data processing uniformity test data for operators in the body dimensions to five workstations that require repair to the front. Measurements conducted on 30 carriers Karah cake maker. The results of measurements of body dimensions, the average shows that the three dimensional body is measured according to their activity in a state of uniform is hand reach 74.1 cm, height eye standing 139 cm and 4.12 cm diameter hand grip.

2. Test the adequacy of the data
The next step is to test the adequacy of the data, where the test was conducted to determine whether the data collected is sufficient or not. If you find that the data collected is not enough then to do additional measurements to another operator. Decision–making is done by comparing the value N '(N arithmetic) with N (N data), if N'> N, then the lack of observational data and the need for additional data. If N '<N, then the data is sufficient. Processing results can be concluded that all data collected is enough, these results as listed in the following tables.

Table 4. Summary of Test the adequacy of the data

No	Dimension	N	Xi	Xi^2	(Xi)^2	N'	Inf
1	HR	30	2221,5	164574,75	4935062,25	0,70	Enough
2	HES	30	4162	578096	1732244	1,90	Enough
3	DHG	30	123,7	511,625	15301,69	3,79	Enough

3. Test Data normalcy with the Kolmogorov–Smirnov

Table 4. Calculation Results Summary of Kolmogorov–Smirnov test on the Dimension Anthropometric Workers

No	Dimension	$\overline{X}$	Fa (X)	S	Z	Fe$_{(X)}$	D max	D table	Inf
1	HR	74,1	0,4	1,58	0,475	0,9706	0,1367	0,9706	Normal
2	HES	139	0,9	4,78	1,027	0,8106	0,3914	0,8106	Normal
3	DHG	4,12	1	0,20	0,65	0,7549	0,2451	0,7549	Normal

The table above is the result of the test data normality by Kolmogorov–Smirnov carried out on data based on measurements on the body dimensions of operators to five workstations that require repair to the front. Normality test is done to measure whether the data has a normal distribution so that the body dimension data measured can be used for designing the machine. Normality test results data by Kolmogorov–Smirnov above show that the three dimensional body of the operator are in normal condition, so that it can be concluded that the body dimension measurement data carriers can be used to design a Karah cake maker.

4. Calculation Percentile

After anthropometric data obtained from measurements of all workers, will be determined percentile value. Percentile value is sought is the percentile values 5, 50, and 95.

Table 5. Summary of Calculation of percentile 5, 50, and 95 for the whole dimension of anthropometry

No	Dimension	$\overline{X}$	S	P$_5$	P$_{50}$	P$_{95}$
1	HR	74,1	1,58	72	74,05	77
2	HES	139	4,78	131	139	147
3	DHG	4,12	0,20	3,791	4,12	5

Based on calculations percentile in the table above shows the variation of the measuring results for all three types of percentile. So that the percentile calculation results that can be used as a reference for the dimensions of the tool is the percentile P 50. This is done so that the tools are designed to have the flexibility and formability adjust to the dimensions of the operator's body in a certain range. If there is a variation in the product design to the actual size, then it should be able to design products that have the flexibility and formability adjust (adjustable) with a certain range (Wignjosoebroto, 2008).

Karah Cake Makers Equipment Design

Based on the analysis, it can be designed machine Karah cake maker on the basis of the calculation engine dimensions nerujuk percentile. The machine dimensions are.
1. High–Rod Iron Machine
    a. Dimensions Body   : Eyes High Standing (EHS)
    b. Data Size   : Average
    c. Allowance   : None.
    d. High Iron Rod Engine   : 139 cm

2. Distance Operator Panel Against
    a. Dimensions Body   : Reach Hands(RH)
    b. Data Size   : Average
    c. Allowance   : None
    d. Operator Panel Against distance : 74,05 cm
3. Against Iron Hand Grip Diameter Crank
    a. Dimensions Body   : Diameter Hand Grip (DHG)
    b. Data Size   : Average
    c. Allowance   : None
    d. Hand Grip Diameter   : 4,12 cm
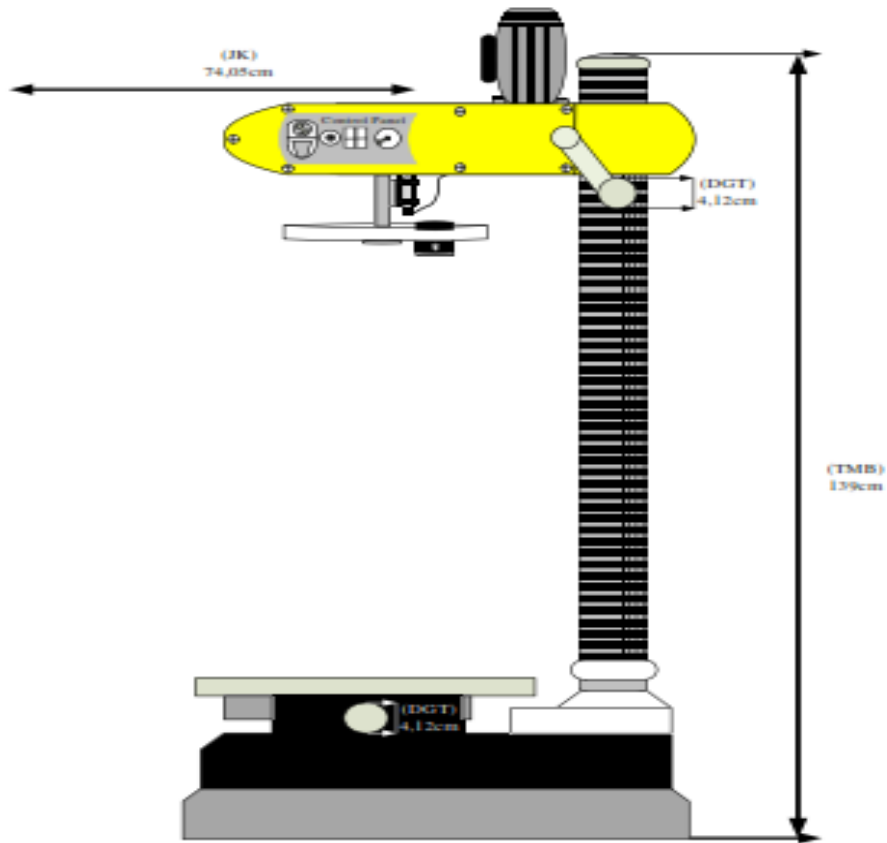Based on the results obtained following the design of tools like this.

Figure 4. The design of Karah Cake tool makers.

Conclusions

In conclusion, Productivity Improvement SMeS Makers Aceh Typical Traditional Cake (Karah Cake) Mechanization Tool Makers On Cake been getting results after observing the working conditions of the operator Karah cake maker using the QEC found complaints of musculoskeletal disorders on the carrier is found on the thighs, arms and waist, so that based on these findings can be found in only five of the eight activities which require improvement activities to come, that is making the dough, put the mold tool and folded and shaped cake. While the three other activities that are in a safe situation. Based on the results of data processing and some tests done is test the uniformity of data, the adequacy of the data, the normality and the importance of the dimension percentile calculation tool designed Karah cake maker is Eyes High Standing (EHS) 139 cm, Reach Hands (RH) 74.05 cm and Diameter Hand Grip (DHG) 4.12 cm. These findings need to be an evaluation tool designed so that it can be used by the society so as to improve productivity of SMeS Makers Aceh Typical Traditional Cake (Karah Cake).

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(www.waspada.co.id, 23.08.2013)

Controlling of the Exhaust Emissions of the Natural Gas Vehicles using Palladium Deposited on a Mixture of TiO$_2$ and ZSM–5

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Abstract

The exhausts of natural gas vehicles (NGVs) still contain unburned methane and other contaminants such as CO and NOx while methane has a CO$_2$ greenhouse gas warming potential (GWP) of 25 over a 100 year time horizon. Successful development of catalytic converters for natural gas vehicles would significantly reduce the greenhouse gas emissions. This work aims to develop a suitable catalytic converter using palladium catalyst supported on zeolite combined with titanium oxide. Prepared sample was tested in a–micro tubular stainless steel reactor under condition mimicking the exhaust gas of NGVs. The understanding on the activity and stability of the catalyst were explored by characterizing the catalyst using TPD, analysis as well as N$_2$–adsorption–desorption analysis. The results suggest that catalyst can fully oxidize methane at reaction temperature below 430 °C. Water vapor produced from reaction does not significantly inhibit the activity of this catalyst. However, co–feeding 4 % vol. water vapor into the feed reduces the methane conversion level up to 40 %.

Keywords : Natural gas vehicles, methane, total oxidation, palladium, zeolite, titanium oxide

Introduction

Natural gas is widely accepted as a prospective energy source to reduce pollution lean–burn natural–gas engines due to its higher thermal efficiencies and cleaner exhaust gases than stoichiometric engines. The exhaust emissions of the natural gas vehicles however, remain contain unburned methane and other contaminants such as CO and NOx. Compare to diesel vehicles exhaust, NOx emissions and particulates from NGV exhaust pipe are significantly low. Thus, the only major drawback of the NGVs is unburned methane. Methane is known as a gas with a CO$_2$ greenhouse gas warming potential (GWP) of 25 over a 100 year time horizon (Solomon, *et al*., 2007) and development of catalytic converters are required (Gelin and Primet 2002) in order to reduce greenhouse gas emissions associated with NGVs.

In general, the exhaust gas of the NGVs contains ~0.1% CH$_4$, 10–15 % H$_2$O, CO$_2$, SO$_x$ and NO$_x$ in a high excess of oxygen. The temperature of the engine exhaust is ranging from 500 to 550 °C (Gelin and Primet, 2002). Catalytic combustion of methane is a promising solution for methane emission abatement where methane is oxidized to carbon dioxide on a catalytically–active solid surface. This flameless combustion is applicable for highly diluted air–methane streams.

Supported Pd catalysts are considered as excellent catalysts for this reaction (Gelin and Primet, 2002). Poisoning by water and other contaminants can have long–term deleterious effects, and significantly reduce their potential for their use in catalytic converter for NGVs exhaust. Earlier studies reported that the water significantly inhibits the activity of Pd on Al$_2$O$_3$ (Burch, *et al.*, 1995, Roth, *et al.*, 2000) and Pd on zeolites (Shi, *et al*., 2007, Zhang, *et al.*, 2008) at lower temperatures which is due to competition between water and methane for adsorption on the active site (Ribeiro, *et al.*, 1994, Burch, *et al.*, 1995, Roth, *et al.*, 2000). Furthermore, an irreversible deactivation can possibly be induced by the presence of water where the active site (PdO) could transform into a less active site (palladium hydroxide) (Ribeiro, *et al.*, 1994, Burch, *et al.*, 1995, Roth, *et al.*, 2000). Ciuparu, et al. (2001) suggested that the hydroxyl groups produced by reaction are bound strongly on the surface and accumulated on the support (Schwartz, *et al.*, 2012). Therefore, when the external water is introduced the surface becomes saturated and the rate of desorption is decreased (Ciuparu, *et al.*, 2001). Attempt to improve the tolerance against water was carried out by choosing TiO$_2$–SiO$_2$ as a support to avoid or delay the reaction between Pd and H$_2$O (Carlo, *et al.*, 2010). Enhanced hydrothermal stability was reported recently by Liu *et al.* (2012) by using Ni–modified alumina as support at a reaction temperature of 600 ºC.

In this work, we prepare palladium supported on a mixture of TiO_2 in ZSM–5 catalyst for lean–methane combustion. The nature of water involved in the reaction is investigated based on catalyst characterization. Hydrothermal stability of the Pd/TiO_2–ZSM–5 catalysts is evaluated in time–on–stream experiment under dry and humid conditions.

Experimental

Catalyst preparation

Pd based catalyst (1.1% g/g) was prepared by an incipient wetness technique. As a sup–port, 5 wt. % of titanium (IV) oxide (Sigma–Aldrich) was physically mixed with NH_4–ZSM–5 (Zeolyst International) in methanol (0.1 M) and stirred overnight at room temperature. The solid was collected after evaporation of methanol in a rotary evaporator and then dried in the oven at 110 °C for 20 h. Pd (II) nitrate solution (Sigma–Aldrich) was then added drop–wise and mixed with TiO_2–ZSM–5. The dried catalyst was ground, pressed and sieved to 250–425 µm. Prior to measuring the catalyst activity, samples were pre–treated in–situ in air at 500 °C for 2 h.

Catalyst characterization

The surface area of catalysts was measured by nitrogen adsorption at 77 K using Gemini 11 2370 surface area analyzer according to the Brunauer–Emmet–Teller (BET) method. Temperature–programmed desorption (TPD) analysis was performed using a Pfeiffer prisma quadrupole mass analyzer. The palladium and TiO_2 loadings were quantified using Varian 715–ES inductively coupled plasma optical emission spectrometer (ICP–OES).

Catalytic activity measurement

Catalytic activity measurements were performed in a tubular stainless steel micro reactor. The inlet methane concentration was set at 0.5 % balanced with air at GHSVs between 15,000 and 200,000 h^{-1}. The inlet and outlet mixtures were analyzed using an online gas chromatograph equipped with a thermal conductivity detector (TCD) and concentric packed column (Alltech CTR–I). For humid feed experiments, the reactant mixture was passed through a saturator operated at 25 °C ± 3 ℃ and a humidity probe was installed at the outlet. The actual reaction temperatures were observed by placing a K–type thermocouple into the reactor close to the catalyst bed.

Results and Discussion

The loading of palladium and TiO_2 quantified by ICP–OES resulted in 1.1 wt. % for Pd and 5.7 wt. % for TiO_2, respectively. The catalytic activity test of Pd/TiO_2–ZSM–5 catalyst was performed by feeding the reactor tube with 5,000 ppm methane (balance air) at gas hourly space velocity (GHSV) of 15,000 h^{-1}. The light–off curves were recorded at temperatures from 200 to 450 °C. A preliminary blank experiment was carried our prior to catalytic activity test and confirmed that no observable methane conversion was detected until a temperature of 650°C (Setiawan, Kennedy et al. 2014). Figure 1 shows methane conversion as a function of temperature where 10 % conversion (T_{10}) is achievable at 200 ℃ which indicates an active catalyst at low temperature. The total oxidation of methane was observed at 420 ℃ which is within the range of engine exhaust temperature of NGVs.
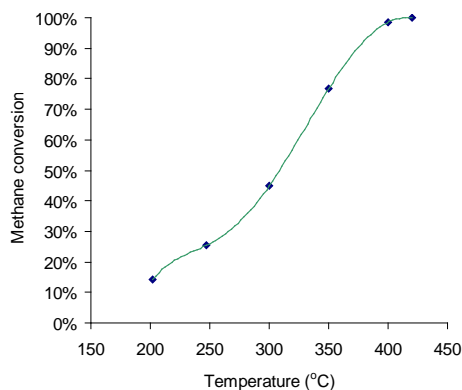

Figure1. Methane conversion as a function of reaction temperature of methane oxidation over Pd/TiO_2–ZSM–5. Feed = 0.5 vol. % CH_4 balanced air, GHSV = 15,000 h^{-1}.

Catalytic activity evaluation of Pd supported on TiO_2–ZSM–5 catalyst was performed in a time–on–stream experiment under dry feed at 400 ℃ with results plotted in Figure 2. Zhang et al. reported previously that the activity of Pd/ZSM–5 without water shown rapidly decreased from 100 % to 82 % (Zhang, *et al.*, 2008). Interestingly, no significant deactivation was observed within 20 h from our catalyst indicating the addition of TiO_2 into zeolite enhances the thermal stability.

Time–on–stream catalyst performance in dry and humid conditions is plotted in Figure 3 at 425 ℃. Under humid conditions, the methane conversion decreases slowly from ca. 90 % to 50 % and stays constant until 20 h. This saturated stream sample was then analyzed in TPD. The effect of water on palladium supported on TiO_2–containing–zeolite catalyst was also investigated using TPD analysis. Water has been selected as an adsorbate with the purpose of investigating the interactions between water, active sites and the support material. Before adsorption, sample was pre–heated for 1 h at 500 °C with a heating rate of 5 °C·min^{-1} to remove any pre–adsorbed compounds. Water was adsorbed at 110 °C to avoid any weakly bound adsorbate retained on the sample. The spectra of water desorbed from the used sample are plotted in Figure 4. Interestingly, the maximum intensity of water dissociated from this catalyst occurs at 105 ℃, far below our reaction temperature. However, a little amount of hydroxyl is strongly bonded on the catalyst which is thought to be responsible for catalyst deactivation.
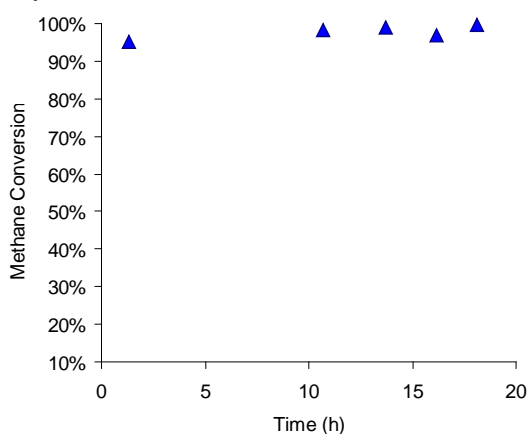
Figure 2. Evaluation of time–on–stream behavior at 400 ℃ over Pd/TiO_2–ZSM–5. Feed = 0.5 vol. % CH_4 balanced air, GHSV = 15,000 h^{-1}.
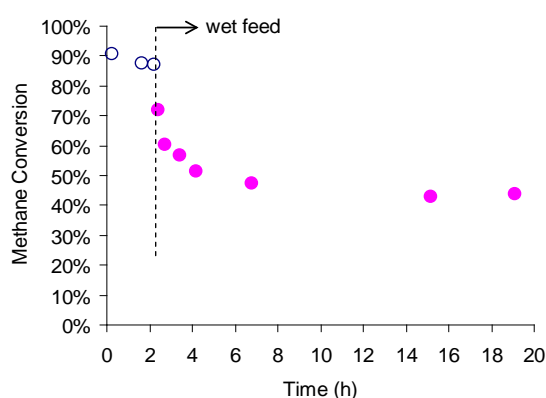

Figure 3. Time–on–stream behavior under dry and wet feed conditions over Pd/TiO_2–ZSM–5 catalyst at 425 ℃, GHSV = 100,000 h^{-1}, CH_4 inlet = 0.6 vol. %, H_2O = 4 %, balanced air.
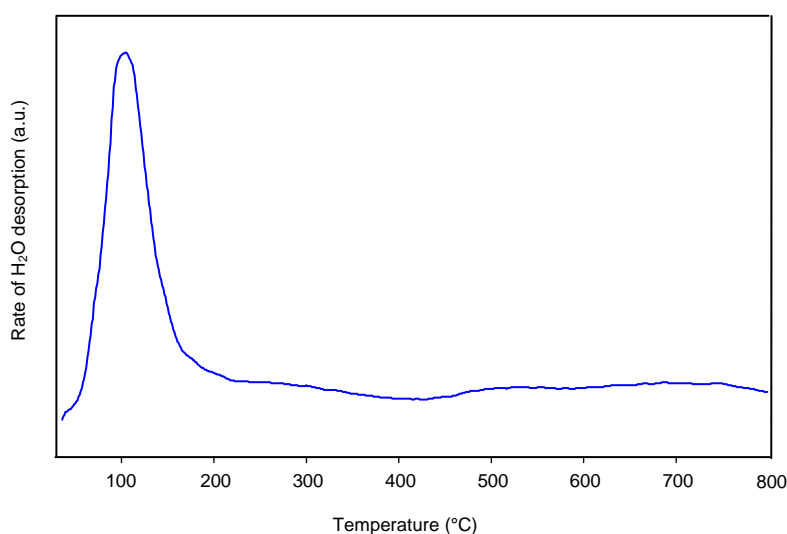
Figure 4. TPD curves of water desorption from Pd/TiO$_2$–ZSM–5 catalyst. Water was adsorbed at 110 °C at a heating ramp of 5 °C·min^{-1}.

Conclusions

Pd supported on TiO$_2$ and ZSM–5 catalyst have been prepared and studied in order to explore a new strategy for improving the stability and activity of catalyst for NGVs emission control. This Pd–based catalyst can fully oxidize methane at reaction temperature below 430 °C. It shows that water produced from reaction does not significantly inhibit the activity of this catalyst. However, adding 4 % water vapor into the feed reduces ca. 40 % of methane conversion.

Acknowledgements

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Actions and Supports Needed for University during Recovery & Reconstruction of Mega–Disaster, such as 2004 Indian Ocean Tsunami

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Abstract

This paper discusses the role of university as a higher educational institute during/after mega–disasterssuch as the 2004 Indian Ocean Tsunami and the 1995 Great Hanshin–Awaji Earthquake. Syiah KualaUniversity is located in Banda Aceh where about 10,000 people lost their lives during the 2004 Tsunami,and Kobe University is located in Kobe where about 6,000 death and 100 billion US$ direct economicaldamage have been resulted. Such scale of human losses and economical damages have a severe impact onthe society, and reconstruction of the society affected by such mega–disasters take places over a very longtime period, easily over one decade. The university can play a significant role in reconstructing the societybecause it can function as an academic & outreaching institution over such long–term process ofreconstruction where continuous and never ending monitoring, archiving and evaluations on societaldevelopments are necessary. In the case of reconstructions at Aceh from the 2004 Indian Ocean Tsunami,the international helps dominated the financial support for reconstructing the society and this situationaffected very much the way in which the university was given the support. The role of university inreconstructing the society from mega–disaster should be the same irrespective of the disasters indeveloping or developed countries, and the action of and support for the university should be recognizedand established with due considerations on the long–term reconstruction and rehabilitation process from mega–disasters.

Keywords : reconstruction, rehabilitation and mega–disasters.

Introduction

On December 26th 2004, vast coastal areas in countries, such as Indonesia, Thailand, Sri Lanka and India, surrounding the Indian Ocean were hit by a huge tsunami and the casualty in Aceh Province of Indonesiarose to over 220,000. The capital of Aceh province is Banda Aceh city, and nearly 100,000 lives in thecity have been lost. Syiah Kuala University in Banda Aceh which is the leading institution of highereducation in Aceh was heavily damaged also by loosing more than 150 staffs due to tsunami.

This year of 2014 marks the 10th commemoration from the 2004 Indian Ocean Tsunami Disaster, but inmany countries hit by this Mega–disaster the affected residents and societies have not fully built backbetter themselves to their expectations and they are still in a state of reconstructions. The reconstructionsituation in Aceh is very special because the society before the 2004 Tsunami was in the midst of internalconflict that has lasted nearly thirty years. Because of this conflict war between Aceh and centralgovernment of Indonesia, there was almost no locally governing institutions properly functioning at thetime of the 2004 Tsunami Disaster, and huge helping hands from international community and also fromcentral government of Indonesia were poured into the region to start the rescue and recovery operations.After the 2004 Tsunami Disaster, the recovery and reconstruction of Banda Aceh have been progressingthrough collaborations among

a large number of stakeholders. As noted above, the social situations atBanda Aceh have changed dramatically from before to after, and furthermore new players such asinternational funding agencies and NGOs joined into the stakeholders. It is also to be noted that thereconstruction process from a Mega–disaster takes place over a very long period, well over a decade ormore, because of extensiveness and complications created by Mega–disaster. The experience through the1995 Great Hanshin–Awaji Earthquake of Kobe, Japan has demonstrated such examples. Thus thereconstruction at Banda Aceh is taking place through collaborations of international/central/localstakeholders over a very long time period during which the roles of stakeholders and even their existenceare constantly changing.

In this paper, the writers aim to examine and identify the role of University in a society stricken by aMega–disaster, and also to discuss the roles of international & external supports for the recovering andreconstruction process from a Mega–disaster.

The Role of University During/After The Mega–disaster
Kobe University and the 1995 Kobe Earthquake

Discussion on the role of university during/after mage–disaster is firstly to be made by reviewing whatKobe University has experienced when the Great Hanshin–Awaji Earthquake, so called Kobe Earthquake,has hit Kobe City in January 17th 1995. This disaster has resulted human losses of more than 6,400 anddirect economic loss of 100 billion US$. Kobe University is centrally located in the epicenter of heavilydamaged area, and is a leading institution of higher education with nearly 17,000 students, 1,500 teachingstaff, and having more than ten comprehensive faculties and of a national public university. More than 40students were killed by the earthquake, and the physical damages of university facilities amounted to over100 million US$. Because of being a national public university, the cost for recovering those physicallosses has been fully supported by the ministry of education and also there were several academic schemesof supporting the recovery & reconstruction of university activities. Notable example of such supportswere 1) a 3year research grant about 0.7 million US$ to the university for studying the effect of thedisaster to society, and 2) an establishment of a new research center, RCUSS (Research Center for UrbanSafety and Security), that allowed hiring of additional permanent academic staff.

Immediately after the earthquake, the university campus became a temporary refugee place for neighboring residents and one of campus has been used for this nearly 6 months. Emergency response of the university was to check the safety of all students and university staff, and also to plan for restarting its function as a higher education. Additionally, academic staff have served for the society at his/her own capacity to support the disaster affected society, for example, by setting up an emergency medical treatment center at medical school, and by helping many overseas students who cannot get & comprehend available public supports, and by conducting damage survey of housing and infrastructures and reporting its results to the public. As the recovery progresses, many of academic staff were involved in consulting with the local governments to help creating the reconstruction plans through their expertise. Also a number of staffs and students are involved in volunteer works to help residents as many volunteers, nearly 1.5 million volunteers equivalent to the population of Kobe City, have gathered from all over Japan to help the disaster affected residents. This Kobe Earthquake is said to be a starting year of volunteerism in Japan.

Role of University during Long Term Reconstruction

The importance of university to support the disaster affected society for recovery & reconstruction ishowever not limited only during initial few years after the disaster, but more importantly its role to sustainthe reconstruction and to build better plans for reconstruction and future in a very long term becomes amajor and unique task of university. The university located in any region or city never moves out from theplace it was founded, and its function to serve the society where the university is located is thefundamental importance for recovery & reconstruction from a mega–disaster. Another example of majorfunctional differences between university and local government is the duration of staffs in eachorganization working for a specific task or subject in his/her work. In local government offices, the staffs are usually mandatorily rotated to other sections or departments in every 3 years or so to avoid collusions,while the university academic staffs are assigned to specific field of research and activity for his/her entirecarrier. It is utmost importance to recognize that the reconstructions from a mega–disaster does require avery long and continuous attention to the societal changes over a time span of well over 10 years, andtherefore local government staffs can only take part in a short–segment of long reconstruction managementprocess.

This recognition of a very long time span well over 10 years required for the reconstruction from megadisasters is therefore essential to define the role of university with respect to functions and outcomes that the university should provide towards a goal of building back better. University staffs serve usually 20 to

40 years for the same institution unless the individual seeks his/her promotion by being transferred to other institution. Therefore, a continuous monitoring and gathering data of mega–disaster affected society is possible over a 10 year period of reconstruction. Over such a long period, the society constantly changes politically and economically and also peoples' thinking and memories over the mega–disaster changes. The meaning of reconstruction would changes from physical & economical betterments to more psychological omforts and satisfactions over such a long reconstruction process. In Kobe, a museum to commemorate the Great Hanshin–Awaji Earthquake was built and its main function is to pass the experience of the 1995 Kobe Earthquake to the next generation. At Kobe University, a library to archive all relevant data and articles with respect the disaster recovery and reconstruction was setup. By having a good archive of all items & publications over a long period of such, academic research studies in terms of sociological and technological studies of a mega–disaster become possible. Also based on such archives, academic staffs at university can conduct trainings or seminars on the lessons learnt from the megadisaster. At Kobe University, a two–month training on urban disaster has been conducted for the overseasparticipants over 8 years from 2004 to 2011 in collaboration with JICA (Japanese InternationalCooperation Agency), and in total over 100 overseas participants have joined the training. It wasemphasized in the training that DRR (Disaster Risk Reduction) for such mega–disaster requires aconsorted effort among multi–disciplinary stakeholders and the overseas participants who are specialists intheir fields of expertise have realized the importance of holistic & proactive approach for DRR.

The collaboration between or among the mega–disaster affected regions is also very important, and the role of university is unique and vital in bridging those disaster affected societies. When Banda Aceh was hit by the 2004 Sumatra Tsunami, a reconnaissance team from Kobe University visited Banda Aceh in March 2005 and then the collaboration between Syiah Kuala and Kobe Universities has started. In 2006, Syiah Kuala University has established TDMRC (Tsunami Disaster Mitigation Research Center) by its own initiative & fund to carry out an integrated study of such mega–disaster. Kobe University has collaborated with UNSYIAH in supporting the center and in organizing an annual international conference of AIWEST–DR (Annual International Workshop & Expo on Sumatra Tsunami and Disaster Reduction).Such collaboration was possible by understanding, mutually by both universities and academic staffs, the long term effects of mega–disaster to society and also the role of university in reconstruction. Such initiatives by UNSYIAH has attracted attention from outside organizations, such as BRR (Rehabilitation and Reconstruction Agency), and UNDP as implementing agency from Multi Donor Fund (MDF), and TDMRC was given a fund to conduct studies on DRR as will be described later.

In March 2011 when the Great East Japan Earthquake and Tsunami has stricken Tohoku region of Japan, Kobe University immediately sent an emergency support to Tohoku University which is a leading national
university in that region. As Kobe University had been supported by the Ministry of Science and Education after the 1995 Kobe Earthquake, the Ministry has granted Tohoku University to establish a large scale research centre, IRIDeS (International Research Institute of Disaster Science). The total number of research staff at this institution is more than one hundred including those holding concurrent position with their own faculties. The role that has been taken by university during and after the megadisaster and in the society affected is very similar when we compare the cases in Japan and Indonesia.

However, there are large differences among the supports given to those universities because the socioeconomic situations have been different during the time of and in the society where the disasters have stricken, as discussed below.

Outline of Recovery & Reconstruction Budgets
We first compares the impacts of the 1995 Kobe Earthquake and the 2004 Sumatra Tsunami to the national economies of Japan and Indonesia, and then examine next on how the overall supports for reconstruction were made in each country. The direct economical loss due to the Kobe Earthquake is estimated to be about 100 billion US$ while the actual loss due to the 2004 Tsunami in Indonesia is estimated to be about 4.5 billion US$. Based on these figures, the percentages of disaster loss against the GDP at each country are 2.3% and 1.9% for Japan and Indonesia respectively, and the economical impacts of two mega–disasters to each country were nearly the same. Figure 1 illustrates the historical changes of the GDPs at two countries, and in terms of economical damages in comparison with the GDPs are nearly the same. However, the GDP per capita is quite different for two countries and they are US$ 32,400 and 1,200 for Japan and Indonesia respectively. Furthermore, the casualties in Kobe and Banda Aceh were vastly different.

Because the 2004 Indian Ocean Tsunami was a huge global mega–tsunami disaster in developing countriesand also Aceh suffered a very large number of casualties, many developed countries including Japan have responded to support the recovery and reconstruction in Aceh, Indonesia. In Figure 2, the total costofrecovery & reconstruction including that of Nias disaster, that occurred few months after the Indian

OceanTsunami, is shown in comparison with the allocated or committed funding supports from IndonesianGovernment, International Institutions & Countries, and NGOs. The total cost of recovery &reconstruction is well over 7 billion US$, and more than 5 billion US$ was allocated/committed byinternational donors and NGOs. Therefore, the supports from international organizations comprise morethan 70% of reconstruction cost. The huge financial supports from foreign organizations in Aceh haveaffected the reconstruction process in a very complex manner, especially for supporting the university'sreconstruction activities as will be described later.
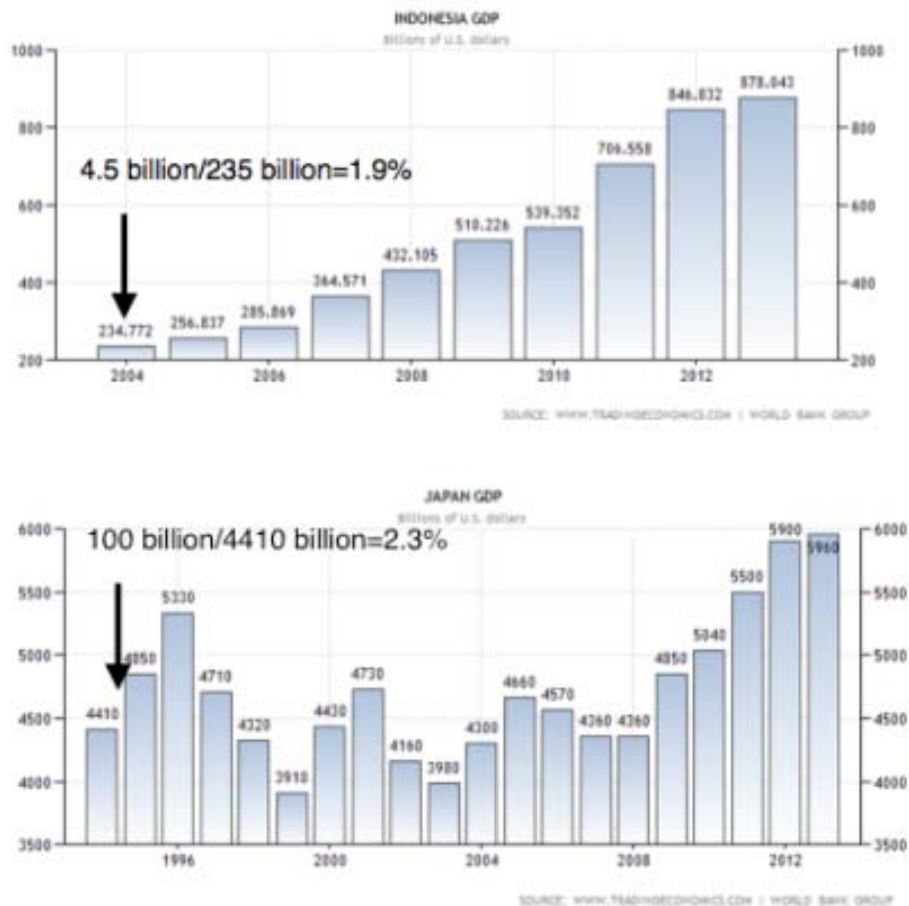
Figure 1 Comparison of Economical Damages to GDPs of Indonesia and Japan.

Figure 2. Reconstruction Budget and Supporting Organizations (Masyrafah, H. and McKeon, J. 2008)

It may be also noted here that the financial contributions of not only central government but also of local governments played a huge role for the reconstruction from the Kobe Earthquake disaster. In this case, the contributions from central and local governments are about 50% and 40% respectively, out of total expenditure of 163 billion US$. In contrast to this, in Aceh there were no properly functioning local governments due to the prolonged conflict war, and therefore no financial contribution from local

governments on reconstruction budget could be mobilized. To act as an interim local government and also to implement the financial aids from Indonesian Government and International Institutions, BRR (Rehabilitation and Reconstruction Agency) was established in Aceh for the recovery and reconstruction of Aceh and Nias earthquake disasters. Thus the post disaster management of Aceh was performed by involving a complex chain of stakeholders, such as local residents who are represented by leaders of various backgrounds, representatives of international NGOs and institutions, and BRR staffs who are mostly sent from the various offices of central government in Jakarta. Recovery and reconstruction plans have to be built and implemented through such a mixture of different stakeholders, and it would be easily understood that how difficult to utilize the available funds for effective reconstructions by satisfying the local needs.

Table 1 List of MDF Donors (based on MDF Final Report 2012)

MDF Donors	Contribution (million, US$)
European Union	271.30
Government of the Netherlands	146.20
Government of United Kingdom	68.50
World Bank	25.00
Government of Sweden	20.72
Government of Canada	20.22
Government of Norway	19.57
Government of Denmark	18.03
Government of Germany	13.39
Government of Belgium	11.05
Government of Finland	10.13
Asian Development Bank	10.00
Government of United State	10.00
Government of New Zealand	8.80
Government of Ireland	1.20
Total Contribution	654.66

Multi Donor Fund (MDF) Support for Recovery & Reconstruction

Among the many international supports provided to Indonesia, the MDF played the most significant role to support the university's role in reconstructing Aceh by allocating TDMRC a large sum of money. The function of MDF was unique as compared with other international supports because 1) the total sum of fund, more than 650 billion US$ committed, was the largest, nearly 10% of entire reconstruction cost for Indonesia, and 2) the duration of support, ending its financing in 2011, was very long, enough to cover various stages of reconstruction. MDF, which consisted of 15 countries & organizations mostly of Europeans, has cerebrated its completion of its task in 31 December 2012. Table 1 shows the amounts of contributions by the countries and organizations that formed MDF. It may be noted that the countries participated or not participated in MDF have also made significant contributions. For example, USA and Germany as a member of MDF have also contributed separately large sums to Indonesia through their international agencies, while UK, Japan, and Australia have contributed similarly large sums without participating to MDF. The exact amounts of funds given by international countries and organizations are not listed here because the tracking of these is said to be very difficult & inaccurate according to the World Bank report, which states that "In Aceh and Nias, the DAD (Development Assistance Database) system has run into a multitude of problems and has rarely been able to deliver credible data and analysis".

According to MDF report, the fund implemented reconstruction activities by carrying out twenty–three projects under the following six different categories of programs;

Table 2. Reconstruction Projects Completed Under MDF (based on MDF Final Report 2012)

Category	Number ofProjects	Amount used(US$ million)
1. Recovery of Communities	5	208.2
2. Recovery of Large Infrastructure and Transport	7	207.5
3. Sustaining the Environment	2	56.9
4. Strengthening Governance and Capacity Building	3	45.5
5. Enhancing the Recovery Process	4	56.2
6. Economic Development and Livelihoods	2	58.2
Total	23	632.5

It may be noted that the most of implementing project are of physical recoveries and reconstructions, such as roads and housings, and the fund used for non–physical items are those two programs, 5&6, listed in the last. The support for university was included in the 5 th program "Enhancing the Recovery Process" and the project name was "Making Aceh Safer Through Disaster Risk Reduction in Development (DRR–A)" as shown in the second of the list below with its details.

As can be seen from the list above, the three out of four projects with budgets nearly 80% of the program are of an indirect assistance for DRR. The direct support for building DRR in Aceh was nearly 10 million US$ (about 1.6% of MDF 632 million US$) to be spent over 3.5 years. The planning of how to use this DRR support fund was made public in 2008 (Report "Project Appraisal Document" by Provincial Government of NAD, BRR, and UNDP) by listing five expected outputs for the organizations including TDMRC, Aceh provincial government, and communities. A budget of 4.5 million US$ for TDRMC was allocated, but there were specifications on the use of fund, such as hiring outside consultants and contractual service companies, besides the fund that can be used to enhance the DRR activities of TDMRC. The breakdown of 4.5 million US$ budget is shown in the following list according the announced specifications.

Table 3. Budget Details of MDF Program No.5 (Enhancing the Recovery Process)

Enhancing the Recovery Process (Total US$ 56.2 million)		
Technical Assistance (TA) to BRR and Bappenas		
1	Grant Amount	US$24.78 million
2	Implementation	Period July 2005–December 2012
3	Partner Agency	United Nations Development Programme
4	Implementing Agency	BRR (to April 2009), Bappenas (since April 2009)
Making Aceh Safer Through Disaster Risk Reduction in Development (DRR-A)		
1	Grant Amount	US$9.87 million
2	Implementation Period	November 2008–May 2012
3	Partner Agency	United Nations Development Programme
4	Implementing Agency	Ministry of Home Affairs and Provincial Government of Aceh
Aceh Government Transformation Programme (AGTP)		
1	Grant Amount	US$16.98 million
2	Implementation Period	July 2008-June 2012
3	Partner Agency	United Nations Development Programme
4	Implementing Agency	Ministry of Home Affairs and Provincial Government of Aceh
Nias Island Transformation Programme (NITP)		
1	Grant Amount	US$4.59 million
2	Implementation Period	April 2009-June 2012
3	Partner Agency	United Nations Development Programme
4	Implementing Agency	Ministry of Home Affairs, Provincial Government of North Sumatra and District Governments in Nias

It is clear that the indirect cost for managing the DRR fund (i.e., consultants and contractual service) amounted nearly 67% of total budget and the direct support for TDMRC to achieve DRR output was about only 1.5 million US$ (about 0.2% of MDF 632 million US$) over 3.5 years. TDMRC was conducting its DRR activities by employing 20 to 30 researchers over this period of 3.5 year. By examining the detail plans for the DRR–A budget, about 10 million US$, the total indirect cost such as consultants and contractual service was 55% of the DRR–A project. Such high proportion of indirect cost was necessary probably due to extremely severe international demands for the accountability and the transparency on the use of fund in Indonesia.

As discussed earlier about the role of university in recovery & reconstruction from mega–disaster, its roleas a higher education to sustain the reconstruction and to build better plans for reconstruction and future isvital. This role becomes more important after say 10 years when the mega–disaster affected area starts to build a culture of DRR. Presently, the financial support for TDMRC and UNSYIAH for conducting DRR activities is very limited after the MDF completed, and even to maintain its DRR related facilities is severely

restrained. The support given from MDF to TDMRC of UNSYIAH was limited to 3.5 years, and other experiences in Japan at universities in areas of mega–disasters indicate that long–term supports had great values for such situations.

Table 4 Budget Details of MDF Support for TDMRC Activities

	Local Consultants	Travel	Contractual Services- Companies	Grants	Communications and audio visual equipments	ALD Employment cost	Miscellaneous Expenses	Total
3.1	110,000	65,000	75,000	675,275			15,000	940,275
3.2	75,000	45,000	835,000	150,000	30,000		15,000	1,150,000
3.3	65,000	50,000	1,670,000				15,000	1,800,000
3.4	55,000	30,000	30,000				12,000	127,000
3.5	35,000	25,000	80,700	75,000		284,420	15,564	515,684
Sum	340,000	215,000	2,690,700	900,275	30,000	284,420	72,564	4,532,959
	7.50%	4.74%	59.36%	19.86%	0.66%	6.27%	1.60%	

A study conducted by ADB (Asia Development Bank) after the completion of Indian Ocean Tsunami supports concludes, among a number of findings, that "much greater priority needs to be given to predisaster programs in developing countries in Asia". Such pre–disaster programs are only possible by creating and sustaining local cultures of DRR at the disaster affected areas over a long–term plan. Again the role of university in this aspect should be carefully considered.

Concluding Remarks

In this paper, the role of university in a mega–disaster affected area was analyzed by evaluating the casehistories in Banda Aceh of the 2004 Indian Ocean Tsunami and Kobe of the 1995 Kobe Earthquake. It is clear that the situations in which the universities are placed during/after the mega–disaster are vastly different between developed country and developing country. However, the function that the university has to provide to the local society should be the same, and therefore the action of and support for the university needs to have a common framework.

Examining of the case in Aceh, Indonesia shows that the international aids & supports dominated the recovery and reconstruction activities in this region. The fund management of such international supports was conducted by applying a very severe rule on accountability and transparency that has reduced the amount of fund to be directly used for DRR activities.

Building the DRR capacity of the society and community in disaster prone area is vital for fast and better recovery & reconstruction from a mega–disaster, and the role of university in developing such capacity in the society and community should be carefully considered. Since the reconstruction process from megadisaster is a very long–term task, the action of and support for the university should be recognized andestablished with due considerations on the same long–term activities.

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The Effect of Length Variation of Pegs on the Flexural Strength of Laminated Bamboo Beam (*Dendrocalamus Asper)*

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Abstract

This research studies the effect of distances variation of bamboo pegs on the flexural strength of laminatedbamboo petung beam.The beam's height and width ratio is 2:1 and longitudinal beam length 180 cm. The beam bending strength wasmeasured with lateral loading method for flextural capacity with three variations of bamboo pegs of distances 10 cm, 15 cm, 20 cm,respectively. The outer skinof the beam was glued bywhitewash adhesive glue 60#Multi Layer Double Glue Line (MDGL). The results show that pegs variations have difference strength and stifness. The 15 cm pegs has maximum strength 11.18 kN and flexural strengh 35.041 Mpa.

Keywords : Bamboo petung, laminated beam, flexural strength, variation distance pegs.

Introduction

Forest condition is apprehensive about and this has direct impact on availability of wood material. Wood is rare and to be luxurious things. Forest area in Indonesia is decreasing. Because of difficulty to get wood, people need material to substitute the wood. Bamboo is one of alternative material because of its abundant in nature. Bamboo has economic value and ease to be cultivated. It can grow on dry to wet climate, from the plain land to plateau, and open land on which it is free flooded area. The plant is known fast growing and the best quality is 3,5–5 years age. In the contrary, wood needs 30 years to be ready for felling (Morisco, 2006). In Banten Province, people usually use bamboo for making house, furniture, and another handicraft. Banten Creative Community is a non–government organization which concern on bamboo's cultivation and use for Banten community. Unfortunately, laminating method is not known yet. Nowadays, the make use of bamboo is laminating method. The advantage is any quality of bamboo can be used. It has economic benefit and also bamboo conservation (Syahrir, 2014).There is no significant difference between shear stress and stiffness of the laminated bamboo if the bamboo is laminated by glue (Zulmahdi, 2009). The uses of pegs on the laminated bamboo blades reduce the glue and making time. This research concerns on making the laminated bamboo on which the blades are united by pegs. The pegs distances have varied in order to get optimum strength and economic.

Research that will be proposed is the manufacture of laminated bamboo beams with planks together by using a variation of distance pegs, in order to get the use of distance pegs that have the power optimum and economical in manufacture. Comparison of the size or dimensions of the beam between the beam height and width is 2: 1 size (12 cm x 6 cm) with 3 pieces of distance variation peg 10 cm, 15 cm, 20 cm. Afterward, tested the strength of the beam against bending strength, which has the properties lamina beam flexural strength of the weak against flexural failure type.

Experimental/Methods

The tools used in this study can be divided into two groups, namely equipment manufacture test specimens, testing equipment and mechanical physical properties of bamboo and laminated beams. The preliminary test to determine the size of the physical properties of the specimen for testing the physical properties of bamboo follow the ISO (International Standard Organization) 22157–1– 2004. The test object laminated beams made as many as 9 beam size 6 cm x 12 cm with 3 variations within pegs 10 cm, 15 cm, 20

cm, each with 3 replications using adhesives labur resulting from previous studies and use the outer skin of bamboo. Laminated beams Tests conducted at the Laboratory Research and Development Center of Settlement MPW PUSKIM Cileunyi – Bandung on simple supported (joint–roller) with two loading points at a distance of one third of the free span. Lateral restraint is provided to prevent lateral torsional buckling contributions influence. From this setting is expected to occur under flexural failure

Material

Petung obtained Pasir Kalapa area – Kab. Pandeglang. Thermo set adhesive types of cold setting type or can be hardened at room temperature, namely Polyvinyl Acetate (PVAC) is obtained from Adhesive Specialty PT. Ligno Tangerang–Banten.

ResultsandDiscussion

A.   The Nature of Physics

Checking the level of water and density is done by using the oven in the laboratory of Civil Engineering, Faculty of Engineering, University of Sultan Ageng Tirtayasa. The sample used in this trial is the end of the bamboo, middle of bamboo, and the stem bamboo (Table 1 and 2).

Table 1. Average bamboo water level

No	The Bamboo PETUNG	Average The level of water %
1.	End of	17,37%
2.	Among	19,39%
3.	The stem	17.30–percent

Table 2. Average density of bamboo

No	The Bamboo PETUNG	Average Density (g/cm³)
1.	End of	0.66
2.	Among	0.60
3.	The stem	0.50

B.   The strength of the beam Laminated

Based on the results of the test of elastic beam laminated obtained the results of the strength recapitulation of the beam laminated burden and maximum graphics can be seen in the Table 4 and picture 5,6,7, from the table and pictures drawn the conclusion to beam laminated with the influence of the use of the pivot obtained the highest maximum load is on the beam 15cm with maximum load the average 11180 N. The average maximum load on the low beam 10cm of 8340 N.
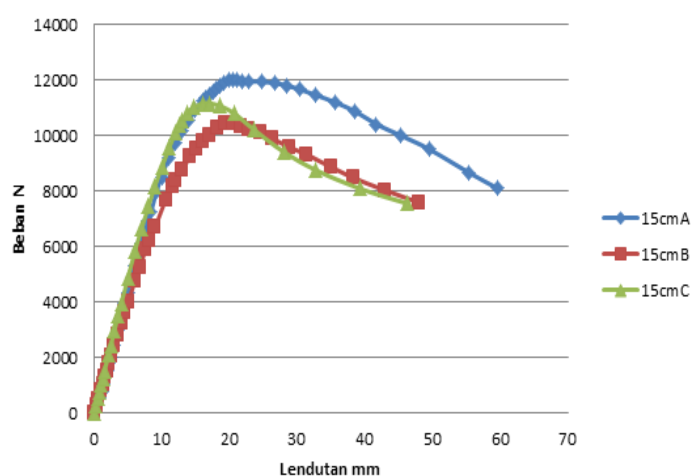
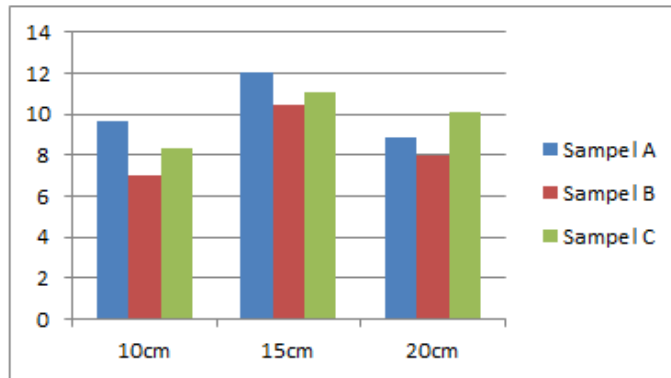Figure 1. Graph load relations – remote Flextural Pegs 15 cm

Figure 2. The beam strength column diagram

Table 3. The recapitulation of the burden and maximum moments

Name of the Test Objects	Maximum load (KN)	Average Maximum Load (KN)	Flextural mm
10cmA	9.66		17.10
10cmB	7.03	$ 8.34	28.44
10cmC	$ 8.34		25.40
15cmA	12.02		20.52
15cmB	10.44	11.18	20.48
15cmC	11.08		17.06
20cmA	8.9		13.46
20cmB	8	8.99	23.32
20cmC	10.06		22.32

C.   Laminated Beams Stiffness

The value of the stiffness is a comparison between the burden with Flextural. Comparison of stiffness beam laminated with the variation of the distance Pegs on the beam laminated blades which reviewed the collapse of elastic. Thegreatness of the value of the stiffness shows the level of daktilitas from a beam. The more rigid a beam then more daktail beam. Based on the table 5 can be seen that the variation of the distance Pegs affect stiffness beam, this can be seen from the average value of the stiffness of each distance is relatively the same and not much different. The values from the table also shows that the beam with the distance of the pivot 10cm has a value of average stiffness the least 0.40 KN/mm.

The values from the table also shows that the beam 10cm more daktail compared the beam 15cm and 20cm, this is indicated by the average value of rata stiffness which is smaller than the beam 15cm and 20cm.
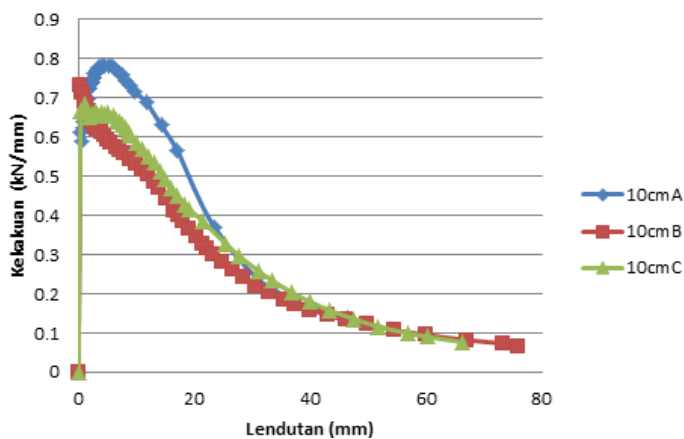
Picture 3. Graph load relations – intimacy – Remote Flextural Pegs 10 cm

The value of the capacity of the flexible beam wood or commonly called *modulus of rupture* (MOR) *and modulus of elastic* (MOE) (Gere and Timoshenko, 1985).Flexible voltage (MOR) maximum at the beam a distance of 15 cm with an average of 35,041 Mpa, compared with the distance 10 cm and 20 cm in a row elector value of average 25,739 Mpa, and 28,027 Mpa. To the value of the elasticity modulus (MOE) maximum are also available on the beam a distance of 15 cm with an average of 11761,03 Mpa, compared with the distance 10 cm and 20 cm in a row elector value of average 8537,87 Mpa, and 9421,37 Mpa from

these results it can be concluded that the influence of the variation of the distance Pegs value that acquired an average of different.

Table 4. The recapitulation of the stiffness beam bamboo strong elastic

The name of the Test Objects	Maximum load (KN)	Average Maximum Load (KN)	Maximum moment (KN–mm)	Average Maximum Moment (KN–mm)	Stiffness (KN/m²)	The average Stiffness
10cmA	9.66		3864.00		0.56	
10cmB	7.03	$ 8.34	2812.00	3337.33	0.32	0.40
10cmC	$ 8.34		3336.00		0.33	
15cmA	12.02		4808.00		0.59	
15cmB	10.44	11.18	4176.00	4485.33	0.51	0.58
15cmC	11.08		4472.00		0.66	
20cmA	8.9		3560.00		0.66	
20cmB	8	8.99	3200.00	3594.67	0.34	0.48
20cmC	10.06		4024.00		0.45	

Table 5. The recapitulation of the value of MOR and MOE Beam Bamboo Laminated

No	The name of the Test Objects	Pprop (N)	Flextural (mm)	MOR (MPA)	Average	MOE (MPA)	Average
1	10cmA	5830	7.7	30.1875	25.739	10647.32	8537.87
	10cmB	5670	11.02	21.968		7235.424	
	10cmC	6630	12.06	25.06		7730.876	
2	15cmA	7980	9.26	37.56	35.041	12118.65	11761.03
	15cmB	6210	8.12	32.63		10754.695	
	15cmC	8860	10.04	34.94		12409.736	
3	20cmA	5530	7.12	27.81	28.027	10922.14	9421.37
	20cmB	6050	12.08	25.00		7042.89	
	20cmC	6650	9.08	31.27		10299.07	

Conclusions

Based on the discussion and purpose of the research that has been done can be drawn some conclusions among others as follows:Testing the beam flexible with distance latch 10 cm, 15 cm, and 20 cm produce flexible strength by an average of USD 25,739 berututan Mpa, 35,041 Mpa, and 28,027 Mpa. The results of the test is there is a significant difference is the existence of the influence of the use of remote variations latch toward the strong elastic beam laminated bamboo.The average for damages the beam laminated there on the continued latch beam laminated where some latch apart from the beam bar bar laminated bamboo.The beam with the distance of the pivot 15 cm have the value of the average stiffness is greater compared with the beam distance latch 10 cm, and 20 cm that has a value of average sequentially 0.40 kN/mm, 0.58 kN/mm, and 0.48 kN/mm. The value shows that the beam 10cm more daktail compared the beam 15cm and 20cm, this is indicated by the value of the average stiffness which is smaller than the beam 15cm and 20cm.

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Surface Roughness Analysis in Machining of TiC Reinforced Aluminum LM6

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Abstract

With increasing quantities of applications of Metal Matrix Composites (MMCs), the machinability of these materials has become important for investigation. This paper presents an investigation of surface roughness dry machining of aluminum LM6–TiC composite using uncoated carbide tool. The experiments carried out consisted of different cutting models based on combination of cutting speed, feed rate and depth of cut as the parameters of cutting process. The cutting models designed based on the Design of Experiment Response Surface Methodology. The objective of this research is finding the optimum cutting parameters based on workpiece surface roughness, the minimum values of Ra are the good machinability of MMCs. The results indicated that the minimum value of surface roughness was found at the cutting parameters ($v = 250$ m min^{-1}, $f = 0.05$ mm rev^{-1}, $ap = 1$ mm).

Keywords : Aluminum composites, cutting parameter, surface roughness.

Introduction

Now a day's metal matrix composites (MMCs) are the new class of materials and rapidly replacing conventional materials in various engineering applications, especially in the automobile and aerospace industries. Aluminum alloy is light metal commonly used in the MMCs as matrix phase reinforced with particles reinforcement such as SiC, TiC, SiO_2 and Al_2O_3. Aluminum MMCs have low density, excellent wear resistance, high specific strength and high specific modulus over conventional materials. The machining process of these materials is more difficult than the conventional materials, due to the addition of reinforcing materials which are harder and stiffer than the matrix (Bhushan, *et al.,* 2010; Seeman, *et al.,* 2010; Muthukrishnan, *et al.,* 2011; Yusuf, *et al.,* 2014).

In machining operations, the surface finish requirement restricts the range of cutting parameters and tool geometries which can be used, especially finishing operations. Surface finish is a factor of great importance in the evaluation of machining accuracy. A lot of factors affect the surface condition of machined part. However, machining parameters such as cutting speed, feed and depth of cut have a significant influence on surface quality.

The machinabilty of aluminum matrix composites reinforced particulate has investigated by several researchers. Bahera was investigated manchinability of LM6 reinforced with 5 and 10 wt.% SiC particles (Bahera, *et al*., 2011). The effect of SiCp reinforcement on the machinability and the effects of machining parameters such as cutting speed and depth of cut at constant feed rate on surface roughness and the cutting forces has been investigated. The experiment was conducted on a conventional lathe machine using HSS cutting tool without use of coolant. The results show that higher weight percentage of SiC reinforcement produced a higher surface roughness. At constant feed rate and different cutting speed, the cutting forces are increases on increasing the depth of cut, it is indicated that the power consumption increases on increasing the depth of cut. The surface roughness increases on increasing the depth of cut and decreases on increasing the cutting speed at constant feed rate.

Surface roughness and wear of the cutting tool during the turning of LM6 aluminum with 2 wt.% TiC composite using uncoated carbide tool in dry cutting condition was investigated (Yusuf *et al.,* 2014). The results indicated that the minimum values of surface roughness was found at high cutting speed of 250 m min^{-1} with various feed rate within range of 0.05 to 0.2 mm rev^{-1}, and depth of cut within range of 0.5 to 1.5 mm. Turning operation at high cutting speed of 250 m min^{-1} produced faster tool wear as compared to low cutting speed of 175 m min–1 and 100 m min^{-1}.

This study is concerned with the effect of cutting parameters (cutting speed, feed and depth of cut) on the surface roughness in turning process aluminum LM6 reinforced with 10 wt% of TiC (Titanium Carbide)

particles composite. The objective of this research is to obtaining the optimum cutting parameters to get a better surface quality

Experimental Setup

Material

Metal matrix composite of LM6 aluminum alloy (BS 1490–1988 LM6) type was used as the matrix material with 10 % wt TiC (Titanium Carbide) particles as reinforcement was prepared by liquid metal stir casting technique. The chemical compositions of LM6 aluminum in percentage of mass have been included in Table 1. The small ingot of LM6 is melted in crucible using an electrical resistance furnace. The TiC particles were preheated at the temperature of 600°C before mixed with the LM6 liquid to make their surface oxidized. The melt was mechanically stirred by using a hard steel impeller and then the preheated titanium carbide particles added with the stirred LM6 liquid. The processing of the composite was carried out at the temperature of 720°C with the stirring speed of 200–250 rpm for 20 minutes (Figure 1). The melt composite was poured into the round bar sand mould with the dimension of diameter of 50 mm and length of 300 mm. The vibration technique was used during solidification process by putting sand mould on the vibration table as shown in Figure 2. This technique has a remarkable effect on the castings properties. Figure 3 shows the round bar casting products of LM6 aluminum reinforced with 10 wt.% TiC particles.

Machine and cutting insert

The machining were carried out under dry cutting condition on CNC lathe machine (Mazak SQT 200MY). The round bar casting product of aluminum LM6 with 10 % wt TiC composite used as the workpiece material in machining trials. The cutting tool insert uncoated carbide VCGT 160402 FL K10 with tool holder SVJCR was used in the experiment. The cutting parameters which are cutting speed (v), feed (f) and depth of cut (a_p) were selected as the control parameters of the machining. The cutting parameters and levels each parameter were set as shown in Table 2. The combination of cutting parameters as the cutting condition models designed based on the Design of Experiments (DOE) Response Surface Methodology represent Box–Behnken design (Myers and Montgomery, 2002). The surface roughness was measured using portable MarSurf PS1 to measure of average surface roughness (Ra).

Table 1. Chemical composition (wt. %) of LM6 aluminum

Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Ti	Other	Al
10–13	0.6	0.1	0.5	0.1	0.1	0.1	0.05	0.2	0.15	Rest

Table 2. The cutting parameters process and their levels

Factor	Unit	Levels		
		Low	Medium	High
Cutting speed (v)	m min^{-1}	100	175	250
Feed (f)	mm rev^{-1}	0.05	0.125	0.2
Depth of cut (a_p)	mm	0.5	1.0	1.5

Figure 1. Stirring process of liquid LM6 with TiC particles

Figure 2. Vibration technique for solidification process

Figure 3. The round bar casting products of LM6 aluminum reinforced with 10 wt.% TiC particles.

Results and Discussion

Surface roughness is a factor of great importance in the evaluation of the machinability of metal matrix composites. Surface roughness is the final surface quality formed after the machining on a workpiece. Many factors affect the surface roughness of a machined part such as properties and constituents of workpiece material, tool geometry, and machine condition. However, cutting parameters such as cutting speed, feed rate and depth of cut have a significant influence on surface roughness.

In the present study, the value of surface roughness of cast TiC reinforced aluminium LM6 has been investigated at selected cutting speed, feed and depth of cut as the cutting parameters. Based on DOE response surface methodology, with use of Minitab software was found fifteen the cutting condition models represent Box–Behnken design to run the experiment. The cutting condition models and the experimental results as given in Table 3.

The effect of different cutting parameters on machining of LM6 composites can be studied by using response graph and response table. The effect of cutting parameters on surfaces roughness is shown in Figure 3. It is clearly observed that in figures, cutting parameters has significant effect on surface roughness. Figure 3 shows that surface roughness is low at high cutting speed. This was due to the velocity of chips flow that is faster at high cutting speed than low cutting speed. This causes a shorter time for the contact of chips with the newly formed surface of the workpiece (Boothroyd, 2006). The surface roughness increase with increased feed parameter. Actually this case is commonly expected, due to agreeable with a popular model to estimate the surface roughness with a tool having nonzero nose radius (Boothroyd, 2006), is:

$$\text{Ra} = \frac{f^2}{32 \cdot r} \quad (1)$$

where *Ra* is the average surface roughness, *f* is the feed parameter, and *r* is the cutting tool nose radius. The surface roughness increased with increased dept of cut.

The minimum values of surface roughness are the good quality of workpiece surface. From Tabel 3, machining of LM6 aluminum reinforced with 10 wt.% TiC composite was found at the cutting parameters (*v* = 250 m min⁻¹, *f* = 0.05 mm rev⁻¹, *ap* = 1 mm).

Table 3. The cutting condition models and the experimental results

Cutting models	Cutting parameters			Ra (μm)
	v (m min^{-1})	f (mm rev^{-1})	a_p (mm)	
1	100	0.05	1	7.014
2	250	0.05	1	3.022
3	100	0.2	1	7.379
4	250	0.2	1	6.208
5	100	0.125	0.5	6.344
6	250	0.125	0.5	3.381
7	100	0.125	1.5	9.405
8	250	0.125	1.5	4.156
9	175	0.05	0.5	3.390
10	175	0.2	0.5	7.614
11	175	0.05	1.5	4.137
12	175	0.2	1.5	7.851
13	175	0.125	1	5.099
14	175	0.125	1	4.937
15	175	0.125	1	5.018
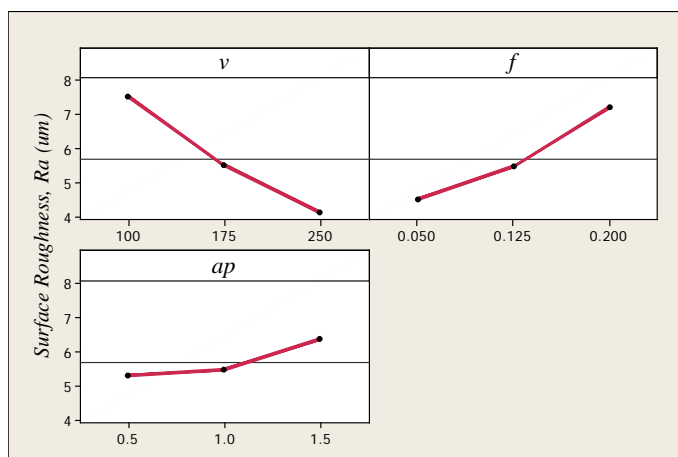
Figure 3. Effect plot for surface roughness

Conclusions

In this study, effect of parameters cutting speed, feed, and depth of cut on surface roughness during machining of LM6 aluminum with 10 wt.% TiC composite using uncoated carbide tool have been analyzed. Based on the results, it was found that cutting parameters has significant effect on surface roughness. The minimum value of Ra in the workpiece was found at the cutting parameters (v = 250 m min^{-1}, f = 0.05 mm rev^{-1}, ap = 1 mm).

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Effect of Cutting Conditions to the Thrust Force in Drilling of Coconut Composite Panel

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Abstract

In drilling of composite material, the thrust force is one of the main problems which affect the quality of the drilled hole. This paper reports the thrust force in drilling process of natural composite panel. The composite panel was made of coconut fiber and synthetic adhesive by using manual lying process. Epoxy and resin were used as adhesive with the ratio of 30% coconut fiber and 70% adhesive. The drilling processes were conducted on vertical machining center by using High Speed Steel drill tool. Three drilling parameters were selected as independent variables with three levels of values respectively (spindle speed: 1,000; 3,000 and 5,000 rpm, feed rate: 75, 150 and 225 mm/min and tool diameter: 8, 10 and 12 mm). The thrust force as the response of the experiments were measured and analyzed. The result shows that the spindle speed, feed rate and tool diameter give significant effect to the thrust force in drilling process of coconut composite panel. Recommendations could be given for the best cutting condition to minimize the thrust force.

Keywords: Coconut composite panel, drilling, thrust force

Introduction

The coconut fiber is a natural fiber (vegetable) made from coconut shell. It is considered as short fiber with the average length of 10 mm and diameter of 0.5 mm. It is a side product of coconut farm (the main product of coconut farm is coconut fruit for food consumption, food industry, cosmetic industry and medicine industry). Traditionally, coconut fiber has been used as long as human ages to make rope, broom, mantras and food sack. Coconut fiber has been used to make composite metal. As the side product of coconut farm, coconut fiber has an economical benefit compares to other natural fiber. The coconut composite panel is used in many technical applications (Ikpambese, *et al.*, 2014 and Sarki, *et al.*, 2011) mostly because of their high tensile properties (Salleh, *et al.*, 2013; Sapuan, *et al.*, 2003, and Vijayakumar, *et al.*, 2014).

Composite panel requires machining processes to achieve final shape and dimension. Drilling and milling processes are mostly used in manufacturing of composite panel product. Milling is used to make side profiles. Drilling is used to make holes for assembly and fitting processes. The quality of machining product is determined by the surface characteristic and the precise of its dimension. Both of those quality characteristics depend on the thrust force developed during the machining process. Previous related research shows that the thrust force and surface quality were influenced by the cutting parameters (Iqbal, *et al.*, 2014 and 2015).

This paper reports the result of a research to investigate the effect of cutting parameter to the thrust force in drilling process of coconut composite panel. Three cutting parameters were selected as independent variable: spindle speed, feed rate and tool diameter. The drilling processes were conducted at different cutting condition (3 levels of each machining parameters) by using High Speed Steel (HSS) drill tool. The thrust force of each drilling process was measured and the results were analyzed to study the effect of each drilling parameter to the thrust force as well as to predict the drilling condition that minimize the thrust force.

Material and Methods

The composite panel was made from 70 % of coconut fiber and 30% of epoxy resin by manual hand laying process. The dimensions of the panel are 300 mm length, 260 mm width and 14 mm thickness. Drilling process was conducted on vertical CNC machining center Agma A–8 by using HSS drill tool.

Spindle speed, feed rate and tool diameter were selected as independent variables and 3 levels of value were determined for each of the parameters as shown in Table 1 (Valarmathi, *et al.,* 2013). The design of experiment was developed by using Box–Behnken of Response Surface Methodology (Myers and Montgomery 2002, Srinivasan, *et al.*, 2012). Seven teen experiments were proposed by the said method as shown in Figure 3. The drilling process was repeated 2 times for each of cutting condition and the average measure was taken as the result. The thrust force of each drilling process was measured by using Kistler 9272 vertical dynamometer.

Table 1. The drilling parameters

Parameters	Level		
	1	2	3
Spindle speed (N, rpm)	1000	3000	5000
Feed (f, mm/min)	75	150	225
Diameter (D, mm)	8	10	12

The dynamometer was placed on CNC machine's working table. The composite panel was clamped on the top surface of the dynamometer. Only one drill hole can be made at one position. Consequently, the new repositioning of the composite panel is required whenever new drill hole need to be made. The dynamometer was connected to a multi–channel amplifier and continues to a computer with the software. The experimental equipment and process are shown in Figure 1.

The result of the measurement was presented by the dynamometer in value and graph as shown in Figure 2. As the tool rotate and heading to the hole position, the reading shows some small value of the force. As the drill point touches the composite panel, the thrust force increase sharply and become stable during the drilling process. The thrust force reduces rapidly as the drilling process come to the end. It was found that all of the drilling process has the same trend of the signal plot as described above.

Drilling process with dynamometer arrangement

Multi–channel amplifier

Computer

reading
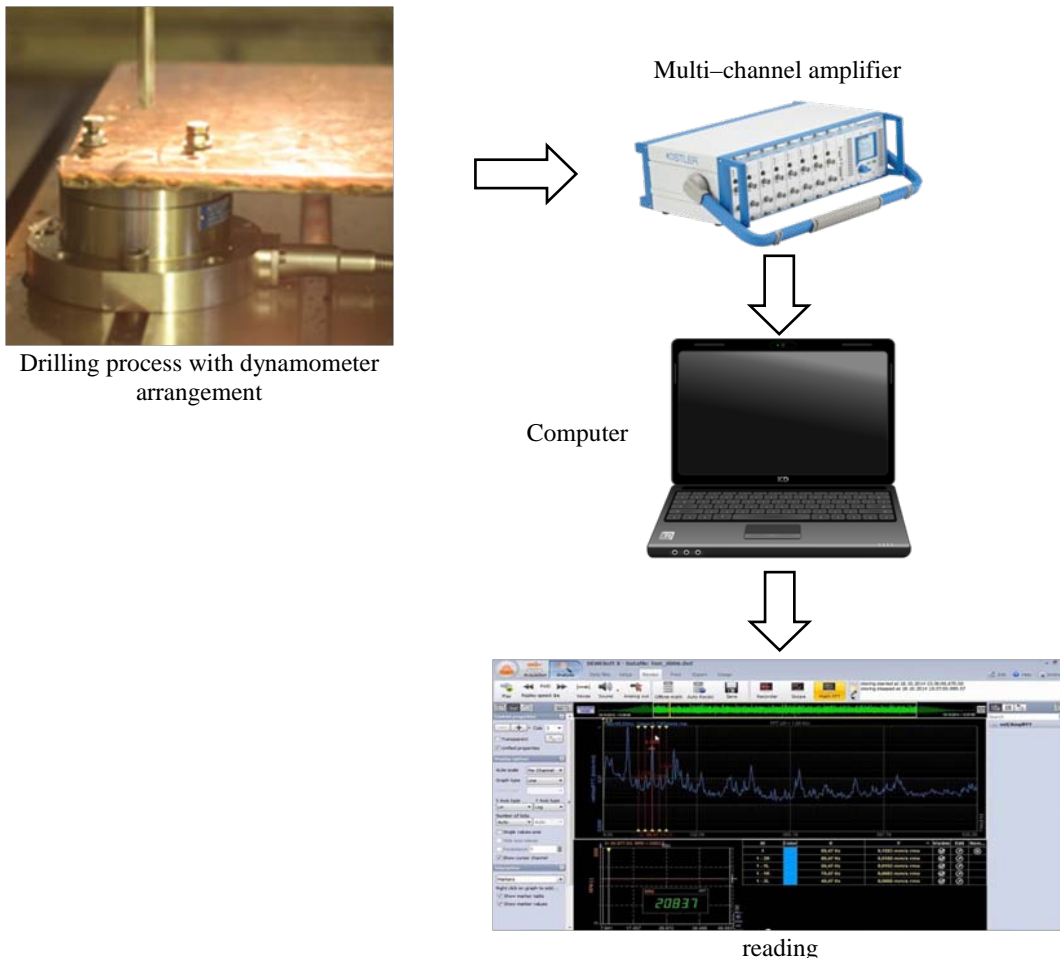
Figure 1. Experimental setup
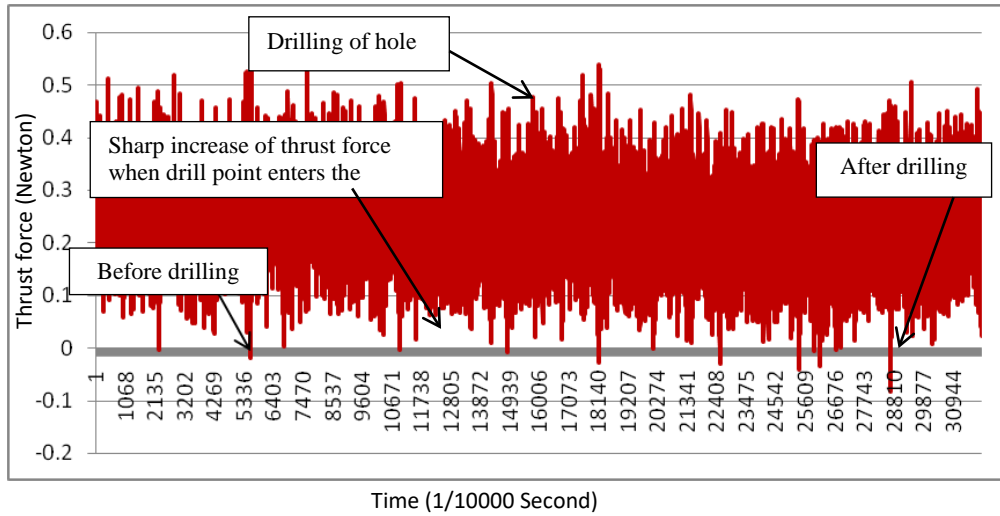
Figure 2. Thrust force signal plot

Results and Discussion

The result of the experiment was statistically analyzed by using Design Expert Software ver. 6.0.8, as shown in Figure 3. The analysis of variance (ANOVA) was carried out to identify the factors which are having more influence on the thrust force in the drilling of coconut composite panel. The result of ANOVA (Figure 4) shows that the model is significant with F–value of 12.53 and the probability of 0.0015. Values of Probe F less than 0.05 indicate that the model terms are significant. In this case spindle speed (N) and feed rate (f) are the significant model terms which influence the thrust force (with the value of Probe F are 0.0002 and 0.0048 respectively).

	Std	Run	Block	Factor 1 A:Spindel speed N,rpm	Factor 2 B:Feed rate f,mm/min	Factor 3 C:Diameter D,mm	Response 1 thrust force Fz,N
	15	1	Block 1	3000.00	150.00	10.00	18.8
	9	2	Block 1	3000.00	75.00	8.00	5.49
	11	3	Block 1	3000.00	75.00	12.00	3.49
	2	4	Block 1	5000.00	75.00	10.00	6.92
	14	5	Block 1	3000.00	150.00	10.00	19.5
	12	6	Block 1	3000.00	225.00	12.00	8.23
	17	7	Block 1	3000.00	150.00	10.00	21.6
	1	8	Block 1	1000.00	75.00	10.00	20.3
	10	9	Block 1	3000.00	225.00	8.00	16.7
	6	10	Block 1	5000.00	150.00	8.00	8.6
	8	11	Block 1	5000.00	150.00	12.00	6.99
	7	12	Block 1	1000.00	150.00	12.00	19
	3	13	Block 1	1000.00	225.00	10.00	25.5
	4	14	Block 1	5000.00	225.00	10.00	13.6
	16	15	Block 1	3000.00	150.00	10.00	14.2
	5	16	Block 1	1000.00	150.00	8.00	19.4
13		17	Block 1	3000.00	150.00	10.00	18.2

Figure 3. Result of the experiment as recorded in Design Expert software

Transform	Fit Summary	Model	ANOVA	Diagnostics	Model Graphs			

Use your mouse to right click on individual cells for definitions.

Response: thrust force

ANOVA for **Response Surface Quadratic Model**

Analysis of variance table [Partial sum of squares]

Source		Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model		661.56	9	73.51	12.53	0.0015	significant
	A	289.08	1	289.08	49.29	0.0002	
	B	96.81	1	96.81	16.51	0.0048	
	C	19.47	1	19.47	3.32	0.1112	
	A²	10.38	1	10.38	1.77	0.2251	
	B²	50.12	1	50.12	8.55	0.0222	
	C²	179.68	1	179.68	30.64	0.0009	
	AB	0.55	1	0.55	0.093	0.7688	
	AC	0.37	1	0.37	0.062	0.8099	
	BC	10.47	1	10.47	1.78	0.2234	

Figure 4. Result of analysis of variance by using Design Expert software

The effects plots for cutting parameters are presented in Figure 5. From Figure 5 (a), it is evident that the thrust force developed decreases with increase in spindle speed. Figure5 (b) shows that the increase of feed rate increases the thrust force. The increase of feed rate increases the contact area and load on the tool, which in turn increases the thrust force in drilling. Figure5 (c) indicates that 10 mm tool diameter produces higher thrust force than 8 mm tool diameter. However, 12 mm tool diameter produces lower thrust force than 10 mm and 8 mm tool diameter. Figure 5 (c) shows a non–linier effect of tool diameter to the thrust force. It has been indicated in the analysis of variance as no significant model terms. From the results (Figure5), it is revealed that the thrust force developed in the drilling of coconut composite panel can be minimized with higher spindle speed and lower feed rate by 12 mm tool diameter combination.
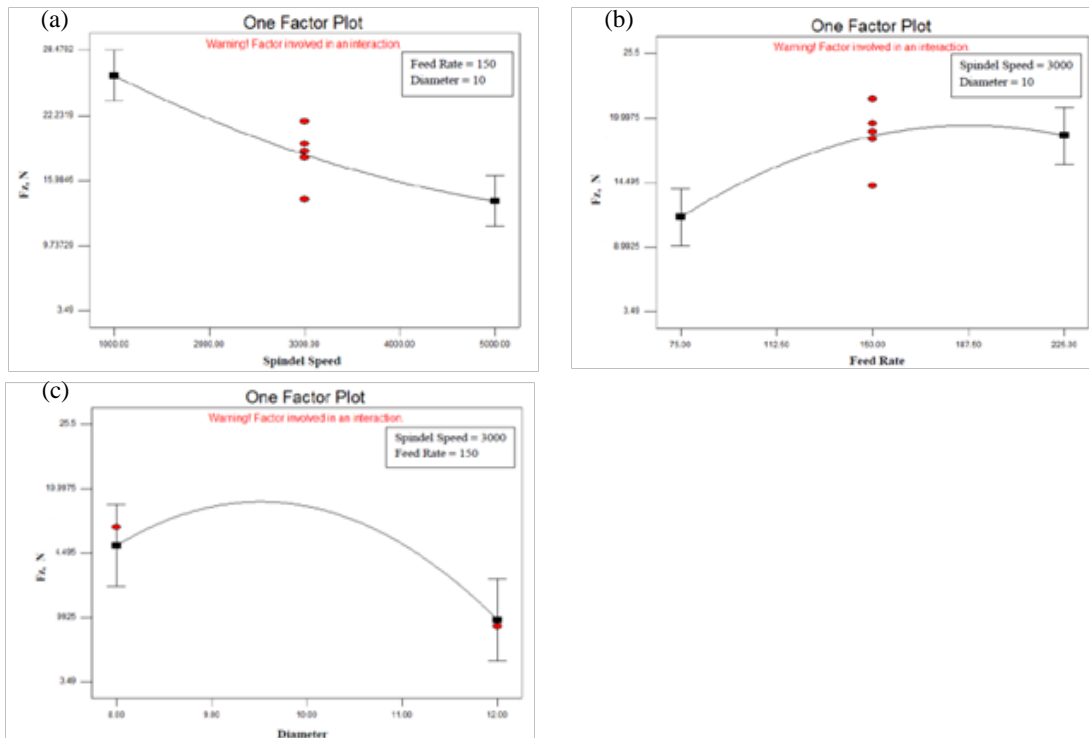
Figure 5. Effect of cutting parameters on thrust force. (a) Effect of spindle speed, (b) Effect of feed rate, and (c) Effect of tool diameter.
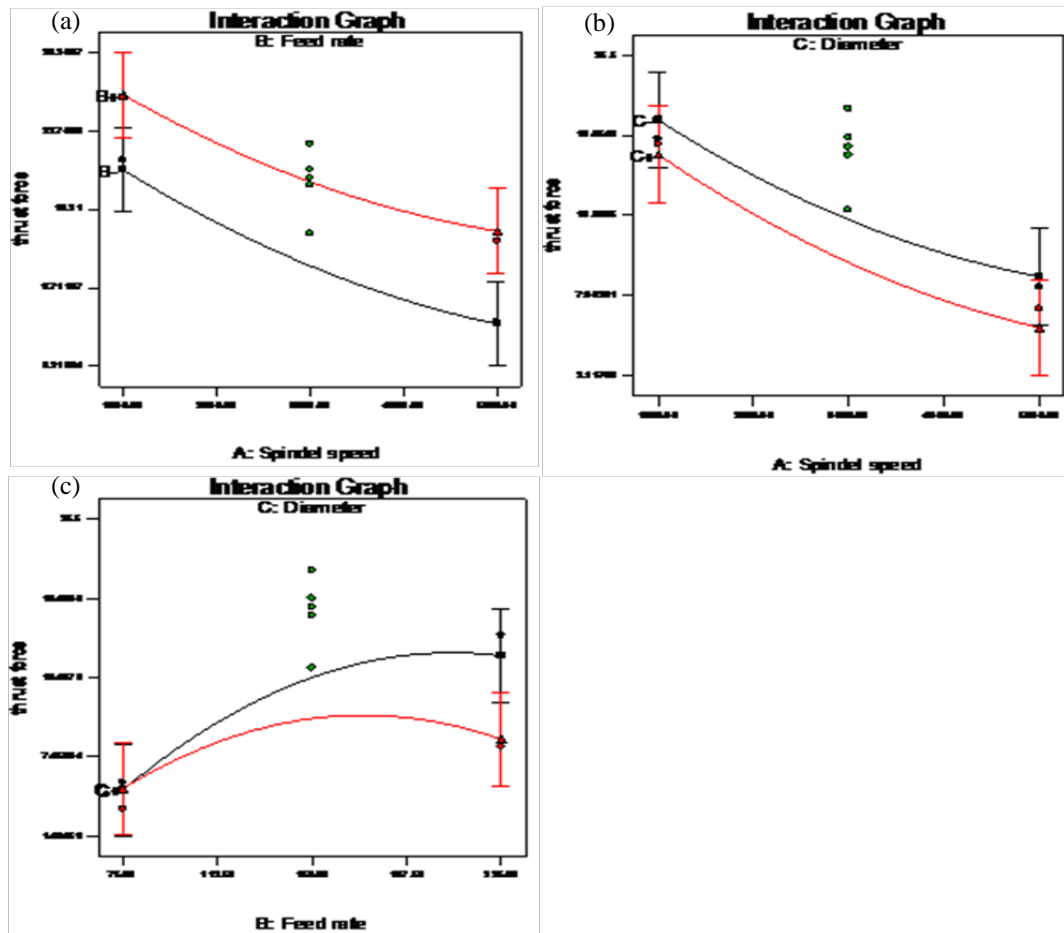
Figure 6. The interaction effects between the cutting parameters and thrust force. (a) Between spindle speed and feed rate, (b) Between spindle speed and tool diameter, and (c) Between feed rate and tool diameter

The interaction between the parameters was investigated based on the result of the experiment. The interaction plots for the thrust force are presented in Fig. 6. From Fig. 6 (a), it is observed that the thrust force decreases with the increasing of spindle speed at both low and high level of feed rate. Figure 6 (b) shows that the thrust force decreases with the increasing of spindle speed at both low and high level of tool diameter. Figure 6 (c) indicates that increasing the feed rate will start with the increasing of the thrust force at the beginning and slowly decrease at the end for both low and high level of tool diameter. Figure 6 shows the similar trend produces by each of the first parameter at any level of the second parameter. Un–significant interaction is found between spindle speed and feed rate, between spindle speed and tool diameter, and between feed rate and tool diameter in which the lines are almost parallel to each other. The similar result has been found in the result of analysis of variance where the probability of F is greater than 0.05.

Figure 7 shows the three–dimensional surface plots for thrust force developed in the drilling of coconut composite panel with different cutting conditions. The surface plot can help to visualize the response surface. These are used to establish the desirable response values and operating conditions. The surface plots show how a thrust force relates to two factors based on the model equation. The surface plots show only two variables, the third variable is kept as constant. For analyzing the thrust force, the third variable is kept at constant middle level. Figure 7 (a) shows the relation between spindle speed and feed rate on thrust force. This plot shows how spindle speed and feed rate are related to thrust force. This plot reveals that for minimizing the thrust force, high spindle speed and low feed rate are preferred.

Figure 7 (b) shows how spindle speed and tool diameter are related to thrust force in the drilling of coconut composite panel. This graph indicates that maximum spindle speed and maximum tool diameter are preferred for drilling of coconut composite panel. Figure 7 (c) shows how feed rate and tool diameter have influenced the thrust force. The result indicated that for obtaining minimum thrust force, 75 mm/min feed rate and 12 mm tool diameter are preferred. From Figure 7, it is asserted that maximum spindle speed, minimum feed rate and maximum tool diameter are preferred for drilling of coconut composite panel.
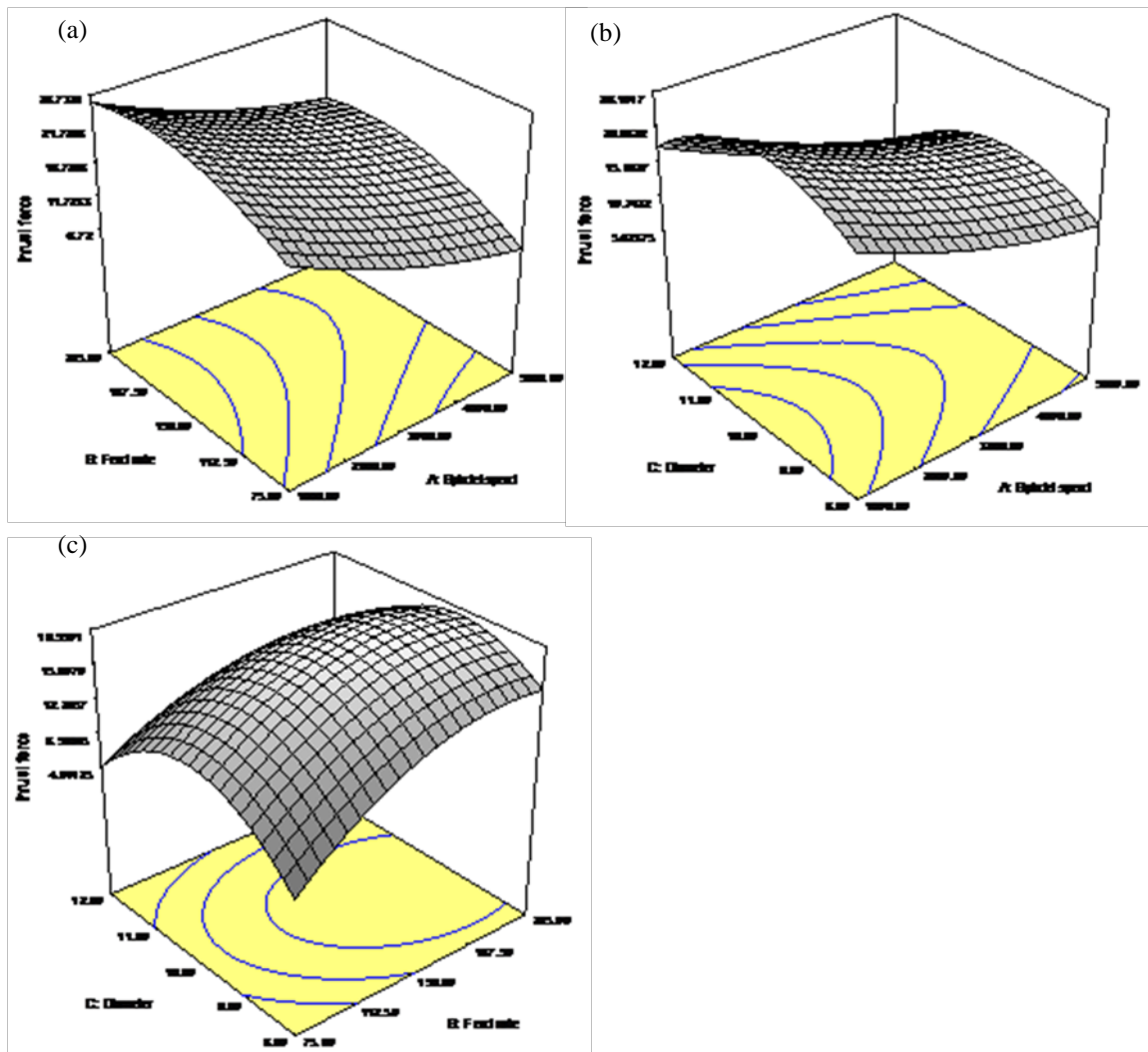
Figure 7. Three–dimensional surface plots for thrust force. (a) Spindle speed versus feed rate. (b) Spindle speed versus tool diameter. (c) Feed rate versus tool diameter.

Conclusions

The experiments are planned and conducted by using Box–Behnken of Response Surface Methodology design to predict the influence of cutting parameters on thrust force at various cutting conditions in the drilling of coconut composite panel by using HSS drill tool. Based on the result of the experiment, the following conclusions can be obtained:

- The result indicates that all the drilling parameters influence the thrust force. However, no interaction between the drilling parameters was found with significant influence on the thrust force during the drilling process.
- The decrease of spindle speed, the increase of feed rate and the decrease of tool diameter increases the thrust force.
- From surface plots, it is confirmed that the thrust force developed is more at low spindle speed and high feed rate combinations and less at high spindle speed and low feed rate combinations.
- The combination of high spindle speed with low feed rate and big tool diameter minimizes thrust force developed in the drilling of coconut composite panel with HSS drill tool.

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Refuse Derived Fuels in the Cement Industry–Potentials in Indonesia to Curb Greenhouse Gas Emissions

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Abstract

Refused derived fuels RDF are increasingly utilized in energy intensive industries and are thereby substituting conventional fossil fuels to a large extent. This applies also for cement works. In many European countries already more than 70% of the overall energy consumption of cement manufactures is covered by RDFs. Besides cost savings for fuels, the utilization of RDF usually goes along with lower CO_2 emissions, as these fuels contain biogenic matter whose combustion is considered climate neutral. In the present study the potential substitution rate for fossil fuels (coal) by the utilization of RDF in Indonesian cement works has been assessed. Based on the quantity and composition of Municipal Solid Waste a maximum production rate of RDF has been derived, which was estimated to 6.3 Million tons/a with an average calorific value of almost 17 MJ/kg. This amount of RDF theoretically derivable from MSW generated in Indonesia could substitute 58% of the coal currently used in cement works. Thereby annual CO_2 emissions of cement plants could be reduced by 3.6 Million tons. Considering in addition also avoided methane emissions by diverting waste from landfills due to RDF utilization, the total savings of greenhouse gases would reach almost 10 Million tons of CO_2 equivalents, which amounts to about 1.3% of Indonesia's overall greenhouse gas emissions.

Keywords: refuse derived fuels, cement industry, Indonesia, Austria, CO_2–emissions, greenhouse gases.

Introduction and Objective

In recent years energy recovery from mixed wastes and refused derived fuels (RDF) has become of increasing importance for energy–intensive industry branches such as cement manufacture or steel production. Especially the cement industry in Europe already substitutes high ratios of conventional fuels (such as coal)by mixed wastes and refuse derived fuels (RDFs) in their kilns to provide the necessary thermal energy. Within the European Union, in 2012 34 % of primary energy carriers in cement kilns are substituted by mixed wastes and RDF(VÖZ 2015b).In some kilns a substitution rate of up to 100 % is reported (Cemex 2011; Schöneberger 2014).

Factors that promote the use of fuels derived from waste in the cement industry are: high temperatures in the kiln, long residence time, oxidising atmosphere, alkaline environment, ash retention in clinker, regional availability of the fuel (Cembureau 1997). Besides these technological factors, there are certain economic and environmental benefits: reduction of costs for primary energy carriers (energy costs account for 30–40 % of the production costs of cement, VÖZ, 2015a), the exploitation of natural resources, and the reduction of fossil CO_2–emissions.

The latter is based on the fact that municipal solid waste (MSW), commercial and industrial waste (and thereof produced RDF) constitutes of a mixture of fossil materials (plastics) and biogenic materials (e.g. paper, cardboard, food residues). The CO_2–emissions of the latter are regarded as not relevant for the climate when they are thermally utilized, whereas plastics are usually produced out of crude oil and thus contribute to the CO_2 footprint when incinerated. Especially emission trading (Directive 2003/87 EC) and national targets for greenhouse gas (GHG) reductions have opened a new scope for the usage of RDF which are partially of biogenic origin (European Parliament, 2003). When using RDF with high a biogenic content, emission

certificates can be saved in comparison to using conventional fossil fuels (Lorber et al. 2012; Pieber et al. 2012).

Whereas in developing countries "classic" waste incineration (thermal utilization of mixed waste) as practiced in many European countries, is due to economic (high costs in comparison to alternative waste disposal routes such as landfilling) but also technical constrains (e.g. wet waste with rather low calorific content) not feasible, the production and thermal utilization of RDF represents a mean to increase the overall recovery rate of waste and helps to divert waste from landfills. Furthermore valuable resources such as primary energy carriers can be saved.

In all developing countries, also in Indonesia, the main part of MSW is still deposited on landfills, which are mostly operated as controlled dump sites rather than as sanitary landfills (Damanhuri et al. 2010). Besides landfill leachates that pollute surface and ground waters, uncontrolled emissions of methane and air pollutants (e.g. dioxins) associated with the open burning of waste represent the major environmental hazards emanating from those sites. In order to reduce these negative impacts on the environment attempts are made to better manage existing dumping sites (including the construction of new sanitary landfills) and to better valorize wastes generated, either by composting, recycling or thermal recovery.

In Indonesia waste management is currently in this transition stage from controlled dumping dominated practice to higher valorization practices. The waste management regulation from 2008 stipulates that informal landfills are being closed and negative environmental effects and GHGs from waste management activities are curtailed. In the course of the national action plan for the reduction of GHG emissions a reduction target of 26 % of GHGs until 2020 was established (below the "Business–as–Usual level) (RAN–GRK 2011), whereby the waste sector should significantly contribute to reach this reduction target. The main means to reduce waste related GHG emissions are:

- collection and utilization of landfill gas (in particular methane);
- aerobic treatment (composting) of biogenic waste;
- recycling of paper and cardboard, metals and plastics;
- thermal utilization of the waste fraction (e.g. plastics, paper and cardboard, textiles) characterized by a high energy content (RDF production and utilization).

The main objective of the present paper is to estimate the overall reduction potential for GHG emissions by the production and utilization of RDF in Indonesian cement production.

Thereto in a first step the overall amount and energy content of RDFs theoretically producible out of Indonesian MSW is determined. This data is subsequently used to evaluate the maximum substitution rate of fossil fuels (coal) currently used in cement plants. This substitution rate together with the CO_2–emission factors (emissions of fossil CO_2 per GJ of energy content) of RDF and fossil fuels are then used to assess the potential reduction of GHG emissions in comparison to the status quo. For the latter also avoided landfill gas (methane) emissions by diverting organic matter present in RDF (such as paper) from landfills is considered. Energy required for the collection and transportation of the waste as well as its processing to RDF are however not considered in the present analysis, simply due to the fact that its contributions to the overall GHG emissions are negligible.

Beside the evaluation of RDF utilization in Indonesian cement works with respect to the reduction of GHG emissions, the paper presents data on substitution rates for fossil fuels in cement production in different countries and also provides also valuable information about quality criteria for RDF utilization. It is important to notice that the potential substitution rate for fossil fuel do not only depend on the quantity and energy content of the RDFs generated but also on their composition with respect to the contents of hazardous or unwanted substances such as chlorine or heavy metals. This subject however has not been included in the assessment of RDF utilization conducted for Indonesian cement production.

Qualitative and quantitative aspects of RDF utilization

RDF characterization and quality criteria (in Europe)

Refuse derived fuels (RDF) can be produced from different types of wastes, such as MSW, industrial or commercial waste but can also include liquid and gaseous waste materials. In order to be applied as fuel in co–incineration plants the waste materials usually undergo processing steps such as shredding, separation of ferrous metals, non–ferrous metals and inert materials, drying, sorting or blending. This is done so that the RDF meet certain mechanical (e.g. particle size distribution, bulk properties), chemical (e.g. separation between combustible/non–combustible substances, volatile matter, trace analysis, etc.), calorific (e.g. heating value, air requirement, etc.) and combustion (e.g. combustion behavior, ignition temperature, corrosion potential, etc.) criteria (Beckmann et al. 2012).Apart from legal requirements (e.g. according to national limit

values given in Austrian Waste Incineration Directive, Table 1), fuel specifications are usually agreed upon between RDF supplier and plant operator.

Ensuring the necessary quality given in the supply contract and providing legal compliance requires proper monitoring of the RDF before its utilization. This is a challenging task as the waste materials are highly heterogenic and the composition is liable to strong temporal variations. Hence, proper sampling, sampling preparation and analyses are indispensable for reliable analysis results, which represent a perquisite to the utilization of quality–ensured of RDFs in cement works. This is of major importance as the quality of the final product (cement) obviously depends on the quality of the raw materials (including fuels) utilized.

Table 1. Limiting values for heavy metal concentrations in fuels from waste in cement kilns and other co–incineration plants according to the Waste Incineration Directive in Austria (BMLFUW 2010)

Parameter	Unit	Cement kiln	Other co–incineration plants
		Median	Median
As	mg/MJ_{DM}	2	1.5
Pb	mg/MJ_{DM}	20	27
Cd	mg/MJ_{DM}	0.23	0.34
Cr	mg/MJ_{DM}	25	28
Co	mg/MJ_{DM}	1.5	1.6
Ni	mg/MJ_{DM}	10	12
Hg	mg/MJ_{DM}	0.075	0.15
Sb	mg/MJ_{DM}	7	10

MJ_{DM}: Mega joule dry matter

In Europe different standards for the sampling of RDF (e.g. EN 15442:2011–Solid Recovered Fuels–Methods for sampling), for the sample preparation (e.g. EN 15413:2011–Solid Recovered Fuels–Methods for the preparation of the test sample from the laboratory sample) as well as the final analysis have been released and are applied by RDF produces. Such standards provide crucial information for a quality–controlled production and utilization of RDF and are definitely necessary to be also implemented in developing countries

Utilization of refuse derived fuels in the cement industry
Different quality criteria of RDFs

The production of clinker in cement works requires an even combustion of fuels and to maintain certain technical criteria. Thus, besides pollutants certain requirements and quality criteria are typically set by the cement producers (Beckmann et al. 2012; Rahman et al. 2015). These are for example: even particle size distribution, uniform calorific value, low moisture content, lower calorific value >14.0 MJ/kg, chlorine content< 0.2%, sulphur <2.5%, low heavy metal contents. Further the cement quality and its compatibility with the environment must not be impaired, the fuels must be available and economically acquirable (Rahman et al. 2015). In the context of environmental impacts a further quality criteria is the biomass content (i.e. the ratio of biogenic materials such as paper, cardboard). A higher content of biogenic carbon in the fuel goes along with lower fossil CO_2–emissions.With respect to the determination of biomass content in RDFs, three methods are described in the standard EN 15440:2011, namely the manual sorting method, the selective dissolution method (SDM), and the radiocarbon method (^{14}C–Method). In recent works a comparably simply method has been developed and adapted which relies on the analysis of the elementary composition of the RDF (C, H, N, S, O). This method may overcome some limitations of standardized methods, such as high chemical demands, high costs, high uncertainties, high analysis duration (Fellner et al. 2011; Schwarzböck et al. 2016a; Schwarzböck et al. 2016b) and seems thus to be promising for its application also in developing countries.

CO_2–emissions and other environmental aspects of RDF utilization

As the cement industry is accountable for 5–6 % of all CO_2 released by human activities (Rodrigues & Joekes 2011), reduction efforts in this branch can have significant effects on global GHG emissions. The substitution of fossil fuels by alternative fuels, which are (partly) composed out of biogenic materials (such as paper, cardboard, wood) is one way to curb GHG emissions.

In 2014 in Austria the production of cement (550 kg cement/cap/a) contributed around 2.7 % to the national GHG emissions (considering values given in Umweltbundesamt (2015) and VÖZ (2015a)).This equals almost the share of approximately 2.6% assessed for 1990. Thus, all in all reductions in GHG emissions observed for the Austrian cement industry are in line with the overall reduction of national GHGs. Nevertheless specific GHG emissions (CO_2 per ton cement produced) have been significantly decreased also due to an enhanced utilization rate of RDF. Whereas in 1990 around 10 % of the thermal energy in cement

works were provided by alternative fuels (based on data given in Hackl & Mauschitz (1995) and Umweltbundesamt (2002)), in 2014 this share has reached more than 75%.

CO$_2$–emissions from cement production in Indonesia (about 200 kg cement/cap/a)contribute to about 1.8% of overall GHG emissions. The CO$_2$–emissions from the cement works have soared 4–fold from 1990 to a 2013 (6,8 Mio t CO$_2$ in 1990, 27,9 Mio t CO$_2$ in 2013), see Figure 1 (Boden et al. 2016). The per capita CO$_2$–emissions have more than doubled since 1990 due to the increased cement production. In comparison, in Austria around 10% less CO$_2$ was emitted from cement industry in 2013 compared to 1990, which corresponds to a decrease of almost 20% per capita CO$_2$–emissions from cement industry (Figure 1) (Boden et al. 2016). From these CO$_2$–emissions around 60% originate from calcinations of carbonates, the remaining 40% are attributed to the combustion of fuels for thermal energy supply (Tokheim 1999).
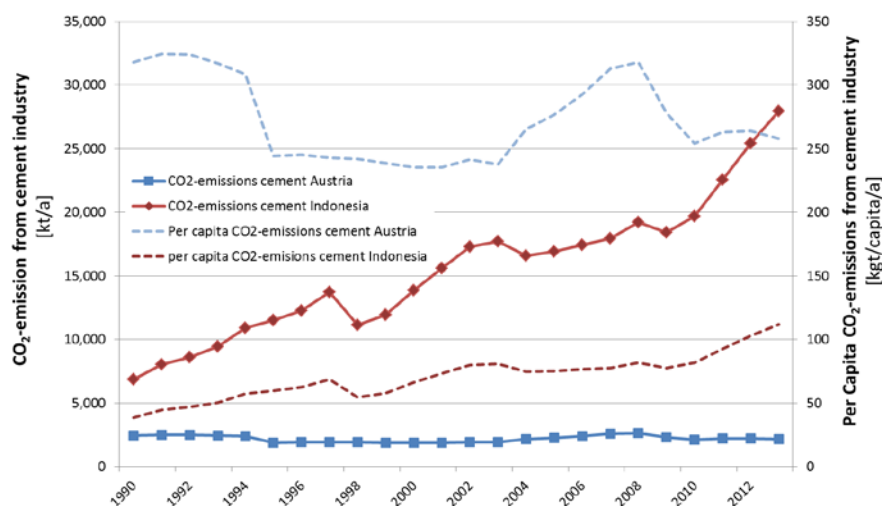
Figure 1. CO$_2$–emissions from cement industry in Austria (blue line) and Indonesia (red line) based on figures given in Boden et al. (2016)

From an environmental point of view, not only the CO$_2$–emissions but also other emissions, such as SO$_x$, NO$_x$, dioxin, furan or heavy metals need to be considered when alternative fuels are utilized in the cement works. It is reported that a higher sulphur and chlorine content in MSW can lead to increased SO$_x$ emissions and the formation of highly toxic dioxin and furan emissions(Choy et al. 2004; Genon & Brizio 2008; Garg et al. 2009). Further an increase in mercury emissions has been reported(Genon & Brizio 2008). However, some emissions can to a large extent be controlled by adapting and optimising the incineration and process conditions (e.g. lowering flame temperatures) (Rahman et al. 2015).Thus a continuous self–monitoring is crucial.

Substitution rates of fossil fuels in cement industry by RDF utilization

Within the European Union many cement kilns have been adapted to the utilization of alternative fuels and in 2012 already 34% of primary energy carriers were substituted by mixed wastes and RDFs(VÖZ 2015b). Some substitution rates in different countries are summarized in Table 2. In Austria already 75.5% of the thermal energy for the production of cement were provided by RDFs. 100% substitution rates appears feasible (and are already implemented in single plants) if some more efforts are put into the production process of RDFs and cement (e.g. chlorine reduction, optimization of waste mix, drying, grain size reduction, oxygen feed into the kiln) (Pomberger & Sarc 2014). Cement producers in Indonesia report that currently 3 to 9% of the thermal energy in the cement works is provided by fuels derived from waste (Holcim 2014; Semen 2014). A 10% substitution rate in the next few years is put into perspective by the major market player in Indonesia (Semen 2014).

The reported materials thermally utilized are rubber waste, tires, solvents, oils, rice and coffee husk, sawdust, waste shoes and others (Semen 2015; LaFarge NA).

Table 2. Substitution rates of conventional fuels with alternative fuelsin cement plants in selected countries/regions

Country/region	% Substitution	Source	Country/region	% Substitution	Source
Austria (2014)	75.5	a)	China (2012)	1	a)
Germany (2012)	61.1	b)	India (2012)	1	a)
Poland (2010)	62	a)	Philippines (2012)	13	a)
Switzerland(2014)	53.7	c)	Brasil (2012)	18	a)
UK (2012)	44	a)	Thailand (2012)	12	a)
France (2012)	30	a)	Indonesia (2014)	3–9	e), f)
			Australia (2013)	7.8	d)
EU (2012)	34	a)	Global (2012)	14	a)

a) VÖZ (2015b); b) VDZ (2013); c) cemsuisse (2016); d) Rahman et al. (2015); e) Semen (2014); f) Holcim (2014)

Evaluating the potential for CO_2 savings in Indonesian cement industry by RDF utilization

Currently there are 16 major cement plants in operation in Indonesia with a production capacity of almost 67 Mio t cement per year (Cemnet 2004; GlobalCement 2012; Holcim 2015; Semen 2015; GlobalCement 2016; Heidelberg Cement 2016). As seen from Figure 1, the CO_2–emissions from cement industry have tremendously increased over the last 25 years (4–fold increase since 1990). Around 40% of these emissions are estimated to stem from the oxidation of carbon in the utilized fuels (for thermal energy supply) (Tokheim 1999) and can potentially be substituted by alternative fuels with a lower climate relevance than fossil fuels.

In order to assess the potential savings of climate–relevant CO_2–emssions due to the utilization of RDFs from municipal solid waste in Indonesian cement plants, information about the generation rate and the composition of MSW as well as assumptions regarding the transfer of high calorific waste fractions (e.g. plastics, paper) to RDF are combined (see Table 3 and Table 4).

For simplification reasons, it was assumed that RDF for cement works contains only plastics and paper/cardboard present in MSW. Based on compositional data report for Indonesia (MoE 2008) an average content of plastics and paper/cardboard in MSW of 14% and9%, respectively, is used for the analysis performed. Furthermore it is assumed that about 70% of paper and plastics present in MSW can be transferred by mechanical splitting to RDF. This reveals a total available amount of (wet) RDF of around 6.3 Mio t/year. The lower heating value of this RDF is estimated to be in the range of 17 MJ/kg wet matter. It needs to be noticed thatthe heating value is highly influenced by the actual water and ash content of the fuel, which in the present study had to be estimated as no data was available for Indonesia. Combining the potential quantity of RDF with its heating value allows roughly estimating the overall energy supplied by RDF (~ 106.000 TJ/year).

The current energy demand of the Indonesian cement industry is estimated to 180.000 TJ/year assuming a specific energy demand of 2.74 GJ/t cement (VÖZ 2015a) and the overall production capacity of Indonesian cement plants (thus, production on full capacity is assumed). Comparing the energy content of RDF with the energy demand of cement works allows determining a "theoretically" maximum substitution rate for conventional fossil fuels of 58%. This rather low value can be explained by the relatively high water content of Indonesian waste and thus a rather low calorific value (compared to e.g. RDF in Austria with reported heating values of above 20 MJ/kg; Sarc et al. (2014); Sarc et al. (2015); Aldrian et al. (2016)).

By considering specific fossil CO_2–emission from plastic (74.7 kg CO_2/GJ) and paper (0 kg CO_2/GJ) present in RDF (resulting in an average fossil CO_2 emission factor for the RDF considered of about 61 kg CO_2/GJ) and from coal (96 kg CO_2/GJ) potential CO_2–emission savings for different substitution rates can be calculated. The results are show in Figure 2.

Table 3. Characteristics of municipal solid waste in Indonesia and figures considered for cement production (as used for calculations)

Parameter		Source
Total amount of MSW in Indonesia (2008)	38,5 Mio t	MoE (2008)
Content of waste plastics in MSW	14 %	MoE (2008)
Content of waste paper in MSW	9 %	MoE (2008)
RDF production ratio (% of input in RDF plant)	70 %	
Specific energy demand for the production of 1 t cement	2.74 GJ/t	VÖZ (2015a)
Capacity of cement works in Indonesia	66.7 Mio t	Cemnet (2004), Holcim (2015), Semen (2015), GlobalCement (2012); 2016); HeidelbergCement (2016)

Table 4. Assumptions on waste paper and waste plastic present in MSW in Indonesia (used for calculations)

Parameter		Source
Water content of waste plastics	30 %	own estimation based on Kost (2001)
Ash content of waste plastics	15 %	own estimation based on Kost (2001)
Water content of waste paper	40 %	own estimation based on Kost (2001)
Ash content of waste paper	15 %	own estimation based on Kost (2001)
Lower calorific value of waste plastics	8.4MJ/kg	based on Kost (2001) and assumptions on water and ash content
Lower calorific value of waste paper	22.5MJ/kg	based onKost (2001) and assumptions on water and ash content
Lower calorific value of RDF made mainly out of waste plastic (~ 60 %) and waste paper (~ 40 %)	16.8 MJ/kg	calculated
Specific fossil CO_2–emissions of waste plastic	74.7 kgCO_2/GJ	based on organic carbon content in packaging waste plastic given in Kost (2001)
Specific fossil CO_2–emissions of RDF	61 kgCO_2/GJ	calculated based of emission factor of plastics

Assuming a theoretically possible substitution rate of 58%, fuel based CO_2–emissions of Indonesian cement works could be reduced by almost 3.6 Million tons per year or 21% of the overall energy related emissions, which amount to 17.5 Million tons CO_2/year in case that only coal would be used as energy source. At current RDF utilization rates in Indonesian cement works (fuel substitution rate of 7%) CO_2 savings (in comparison to coal based energy supply) are limited to 0.4 Million tons/a.

Assuming the Austrian fuel substitution rate in the cement industry of 75.5% would theoretically reduce CO_2–emissions by 4.8 Million tons/a or 27%.
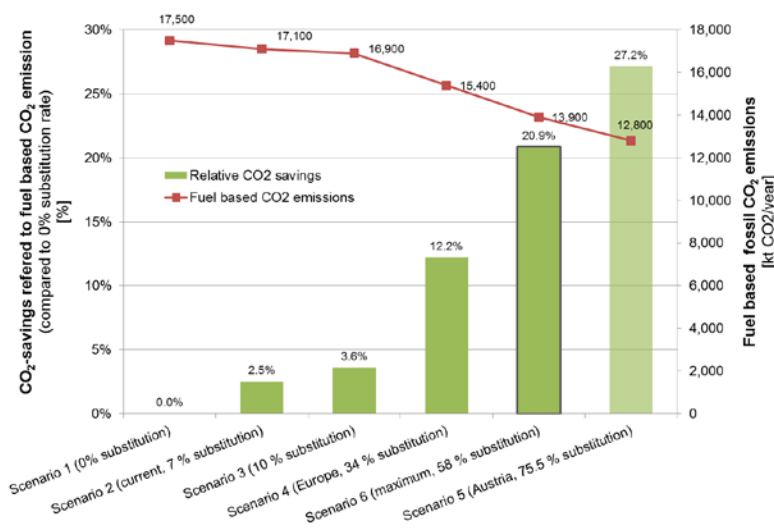
Figure 2. Estimation of possible reductions of fossil CO_2–emissions from Indonesian cement plants by substituting fossil fuels (coal) with refuse derived fuels (from municipal solid waste).

In addition to the direct reduction of CO_2–emissions by the substitution of coal, another saving of GHGs needs to be considered. The generating and utilizing of RDF diverts plastics and paper/cardboard away from landfills. The latter would biochemically decompose at landfills and thereby generate landfill gas, including climate gas methane. At the maximum substitution rate of 58% 2.5 Million tons of paper/cardboard are diverted from landfills. The thereby avoided methane emissions (assuming that 65% of the organic carbon present in paper/cardboard is converted to landfill gas and that 80% of the methane generated at Indonesian landfills is neither collected nor oxidized and thus emitted into the atmosphere) are in the range of 320 Million m³/a. Considering the GHG potential of methane 28 (IPCC, 2013), this equals to savings of CO_2–equivalents of 6.3Million tons/a.

This result indicates that savings of GHG emissions induced by diverting biodegradable waste from landfills clearly outpaces the savings caused by the substitution of conventional fossil fuels. All in all the potential savings of GHG emissions by the production and utilization of RDF in Indonesian cement works would reach almost 10 Million tons/a, and could thus substantially contribute to a reduction of the overall national GHG emissions.

Conclusions

Refused derived fuels are increasingly used as a low–cost and regionally available energy source for cement works all over the world. In many countries the utilization of conventional fossil fuels (usually coal) in cement plants was thereby significantly reduced. In Austria for instance, RDFs provide more than 75% of the overall energy consumed for cement production. Thereby not only the production costs have been decreased but also the climate impact of cement production, as RDFs usually contain also biogenic matter and thus cause lower fossil CO_2–emission in comparison to most fossil fuels. In the frame of the present study the potential substitution rate for conventional fuels used in Indonesian cement works by the production of RDF has been estimated. It was shown that at maximum 58% of the conventional fuels could be substituted, which goes a long with a reduction of fossil CO_2–emission at cement plants of about 3.6 Million tons/a. In addition RDF production and utilization diverts biodegradable waste (in the present study it was assumed that biogenic matter in RDF includes only paper and cardboard) from landfills, and thereby prevents the generation and emissions of methane from Indonesian landfills. Considering this effect as well, the overall potential savings of GHG emissions increase to about 10 Million tons per years, which equals to about 5% of the total reduction target for GHGs planned by the Indonesian government.

Despite the various benefits (reduction of GHG emissions, saving of primary resources, lower costs for energy, reduction of landfill volume) of RDF production and utilization several challenges need to be kept in mind and are currently preventing many developing countries (including Indonesia) to significantly increase the generation and utilization of refuse derived fuels.

First of all quality aspects, including the calorific value required, the water content, the ash content, the content of chlorine (PVC) or heavy metals are of major importance for a save utilization in cement works. As long as quality standards for RDF cannot be ensured and controlled, its application in production processes is too risky for industries. Another problem arising in Indonesia is the fact that most cement works are located on Java, meaning that RDF from other islands needs to be transported over long distances prior utilization. Hence, besides the construction and operation of RDF production plants (mechanical splitting plants) elaborated transport logistics would be required.

Nonetheless the benefits of RDF utilization prevails over the challenges, meaning that in any case an increased application of RDF in developing countries, including Indonesia, will be observable in the near future.

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Characterization and utilization study of byproduct water from oil and gas of Jabung block using Principle Component Analysis

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Abstract

Produced water as byproduct of Oil and Gas Industry has diverse components with high concentrations and has therefore potential negative impact on environment if not properly managed. The purposes of this research are to characterize chemical and physical components of the byproduct water and to study of possible utilization the byproduct water after treatment using waste water treatment facilities (WWTF) on the site of Jabung Block. The data collected were analyzed using Principle Component Analysis (PCA) and efficiency of WWTF was assessed by calculation of removal of major components and contamination index before and after treatment. High concentration of TDS (2495 mg/L) was found in byproduct water from Geragai area and it was strongly associated with COD, ammonia, temperature and pH. From PCA it shows that TDS could be explained by two components that are internal factor (COD and ammonia) and external factor (temperature and pH). Pearson correlation indicated TDS has positive and significant relation with COD, $r(48) = 0.422$; $p < 0.01$. and ammonia, $r(52) = 0.437$; $p < 0.01$. Spearman's rho correlation indicated TDS has positive and significant relation with pH, $r(59) = 0.465$; $p < 0.01$. and temperature, $r(32) = 0.374$; $p < 0.05$. WWTF removal efficiencies are 93.81% (COD), 76.92% (ammonia), 47.66% (oil content), 94.85% (phenol), 8.89% (sulphide) and 64.77% (TDS), respectively. From contamination index it shows that TDS and COD values are reduced from "light pollution" to "good" while phenol is from "mediate pollution" to "good" category. Based on the pollution index reduction it is possible to utilize processed byproduct water as clean water source and livestock water but its direct use for irrigation is not recommended as TDS, organic material and chloride values are still high. However, the processed byproduct water is potential to be used for internal Oil and Gas Industry such for Fire water reserved.

Keywords: characterization, byproduct water, TDS, contamination index, removal efficiency

Introduction

Produced water has quite complex composition, with inorganic and organic compounds content. Organic compounds which are oil soluble and dispersible including BTEX (benzene, toluene, ethylbenzene, and xylene), PAHs (polyaromatic hydrocarbons) and compounds fenols. Inorganic compound included dissolved minerals in the form of cations and anions such as Na^+, K^+, Ca^{2+}, Ba^{2+}, Mg^{2+}, Fe^{2+}, Sr^{2+}, Cl^-, NH^{4+}, SO_4^{2-}, CO_3^{2-}, and HCO^{3-} affecting the conductivity and the potential for the formation of scaling. Produced water also contains heavy metals in different concentrations depending on the age of the geological formations and the oil well itself (Igunnu and Chen, 2012: 2).

In the oil and gas industry in Indonesia, produced water can be reinjected into the formation/reservoir below the surface (produced water injection) for the purpose of maintaining the pressure (pressure maintenance) as well as in efforts to increase oil production (enhanced oil recovery), and or produced water can be discharged to the surface (surface treatment). In legislation on the Protection and Management of the Environment, the Law Decree No. 32 of 2009, in Article 20 (3) states that everyone is allowed to dispose of waste into the environment with the requirements; a. Meet environmental quality standards, b. Getting permission from the Minister, governor or regent/mayor in accordance with their authority.

Before injected into the formation or discharged into the environment, produced water need to be treated (water treatment) to meet waste water quality requirements or to meet the technical requirements prior to be injected into the reservoir. However, the disposal of the two options could be expected to have an impact on water quality in the environment. Besides reinjected into the formation or discharged into the surface, produced water potentially to be utilized for other purposes to meet the requirements of both the utilization and technical requirements according to standards imposed. Efforts produced water utilization for other uses is expected to reduce conflict with local communities for oil and gas operators, due to often accused of causing environmental pollution for dispose produced water to the environment.

Experimental Method

Research conducted in the field Geragai/Makmur–Desa Lagan, samples are taken at Inlet and Outlet WWTF where located in the Central Processing Station (CPS) in 3 times samplings during February to November 2015, Location field Geragai/Makmur shown in Figure1.
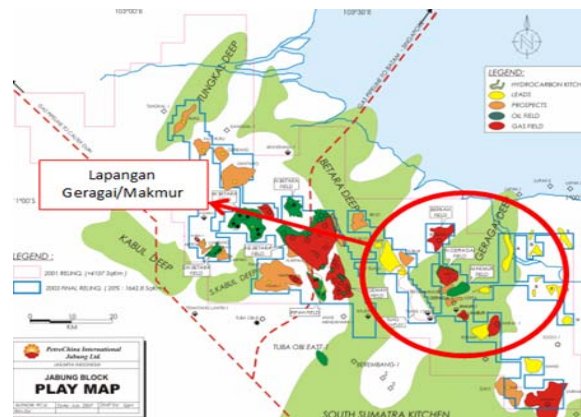
Figure 1. Geragai/Makmur Field

The characteristic of produced water were analyzed by descriptive statistical techniques using measured produced water data from2008 to 2014.Principle Component Analysis (PCA) methode used in relation with factor analysis for measured parameter, strengtened by Pearson Correlation test for parametric analysis and Spearman's rho Correlation test for non–parametric analysis. Total dissolved solid (TDS) value used as dependent variables, for salt concentration/produced water salinity can be depicted from measured TDS value.

To evaluate the quality of treated produced water before and after processing in waste water treatment Facility (WWTF), performed by calculating Percent Removal of the required parameters. Differences Significantt Test before and after the treatment process is also carried out using the Twice Difference Test measurements with Paired Samples T–Test. Rate level of contamination calculated to determine how much contamination is contained in the category of water quality parameters before and after processing in wastewater treatment facility (WWTF). The analysis conducted by calculating using Pollution Index (PI) method according to the decision of MENLH No. 115 of 2003.

$$Pij = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R}{2}}$$ (1)

Note:

L_{ij} : Concentration of water quality parameters specified in the designation of water quality standard (J)
C_i : Concentration of water quality parameters in the field
Pij   : Pollution index for designation (J)
(C_i/L_{ij}) M : Value, C_i/maximum Lij
(C_i/L_{ij}) R : value, C_i/L_{ij} average

To analyze potential utilization of produced water treatment result for other uses is done by comparing the results of samples analysis result at the end point of treatment facility compare with water quality standards contained in Regulation of the Minister of Health No. 416 in 1990 for use as raw material to clean water, and for utilization as livestock water and irrigation water categorized using TDS value content category.

Results and Discussion

Characteristic of produced water

Produced water has high salinity, dissolved solids and high mineral ions. The chemical composition of produced water is quite complex, such as the formation of the mineral content of dissolved and dispersed (dissolved and dispersed formation minerals), both inorganic and organic materials dissolved or dispersed. Descriptive statistics produced water quality data from the field Geragai/Makmur from 2008 to 2014 are given in Table 1 and Table 2.

Table 1. Physics characteristics of produced water from Geragai/Makmur field of Jabung Block.

Value	TDS (mg/L)	Temperature (^{o}C)	pH
Mean ± SD	2494,83± 1646,73	36,85	7,03
Median	2210	38	7,2
Minimum	381	20,8	5,5
Maximum	6600	45	8,1
Range	6219	24,2	2,6

Table 2. Chemical characteristics of produced water from Geragai/Makmur field of Jabung Block.

Value	COD (mg/L)	Oil Content (mg/L)	Ammonia (mg/L)	Phenol (mg/L)	Sulfide (mg/L)
Mean	927,13	21,09	8,23	9,33	0,375
Median	872	15	7,9	5	0,168
Deviation Standard	386,81	20,89	4,88	11,01	0,537
Minimum	83	0	0,005	0,056	0,004
Maximum	1906	98	35,4	51,6	2,64
Range	1823	98	35,395	51,544	2,636

From Table 1 and 2 shows that the quality of produced water from Geragai/Makmur field in period of 2008 to 2014 have an average value of 2494.83 TDS mg/L with standard deviation 1646.73 mg/L. This indicated that the produced water in the region has a high TDS content varied. The average value of sulfide was 0.375 mg/L indicated the content of dissolved sulfide anion was relatively small in compare to other mineral ion content if it refers to the average value of the measured TDS. The average value of pH was 7.03 indicated the produced water in this region categorised as neutral water. For COD measured at 927.13 mg/L indicated the organic material in the produced water was high enough. It's indicated also from average value of the ammonia content 8.23 mg/L which naturally formed from organic nitrogen de aeration, and phenol content of 9.33 mg/L which categorized as organic dissolved compounds.

InPCA analysis of 8(eight) measurable parameters, TDS assumed as dependent variable and 7 other parameters as independent variables. To explain the relationship structure between these variables analyzed with Principle Component Analysis (PCA). First feasibility by measuring the adequacy of the data using the Kaiser Meyer Olkin (KMO), if the value is above 0.5 KMO and Bartlett's test with a significance level less than significant value (α), it is considered to fulfill the prerequisites for doing analysis. KMO–MSA obtained values > 0.5 and significance level of $P < 0.05$, this shows the existing data can be further analyzed. Furthermore, anti–image correlation matrix was made to eliminate variables that have anti–image correlation matrix values smaller than 0,5.

Table 3. Value anti–image correlation matrix

Anti Image	COD	Oil Content	NH$_3$–N	Phenol	Temp	pH	Sulfide
Correlation	0,522	0,426	0,529	0,472	0,572	0,551	0,439

From the anti–image correlation matrix values, the variable that deserves to be analyzed further is COD, Ammonia (NH$_3$–N), temperature and pH, whereas the content of oil, phenol and sulfide improperly for further analysis. Determining the number of factors that are not correlated conducted using eigenvalue, eigenvalue greater than 1 (one) maintained.

Table 4. Eigenvalue

Component	Initial Eigenvalue		
	Total	% of Variance	Cumulative %
1	1,704	42,609	42.609
2	1,116	27,901	70,510
3	0,720	18.008	88,518
4	0,459	11.482	100

Based on calculated Eigenvalue indicated that the four components deserves to be analyzed with 2 PCA, there are component factor–1 (PCA–1) and component factor–2 (PCA–2). The rotation process factors conducted to optimize the correlation between the observed indicators. As shown in the graph Principle Component Analysis (PCA) below.
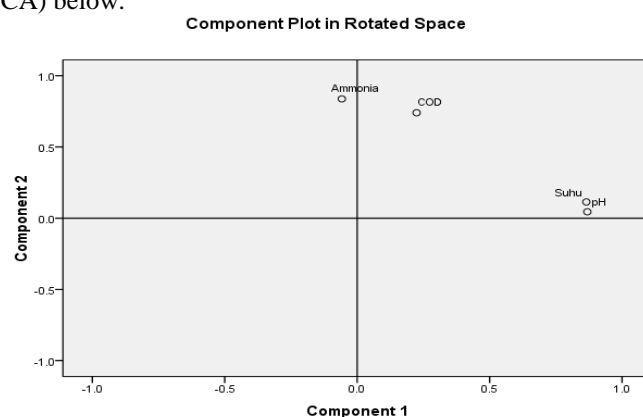
Figure 2. PCA Graph

From this analysis shows that for PCA–1 included temperature and pH, while for PCA–2 are COD and Ammonia. Furthermore, it can be said that PCA–1 is referred to as an external factor which defected environmental factors conditions that affect the value of TDS, and PCA–2 can be considered as internal factors which value of COD and Ammonia will affect the measured TDS value.

In multivariate correlation testing with Pearson Correlation of existing characteristics data, analyzes the relationship TDS value parameter with COD and Ammonia also showed a significant relationship to the parameters COD, $r(48) = 0.422$; $p<0.01$. Ammonia, $r(52) = 0.437$; $p<0.01$. Then, using multivariate Spearman's rho correlation for non–parametric analysis, correlation analysis TDS value with pH and temperature parameters showed a significant relationship to pH $r(59) = 0.465$; $p<0.01$, and temperature $r(32) = 0.374$; $p<0.05$.

From analysis factor using Principle Component Analysis (PCA), and the correlation between dependent variable and independent variables. It depicted that TDS value influenced by the value of COD and Ammonia positively, the greater the value of COD and Ammonia greater the TDS value as shown in the following graph.
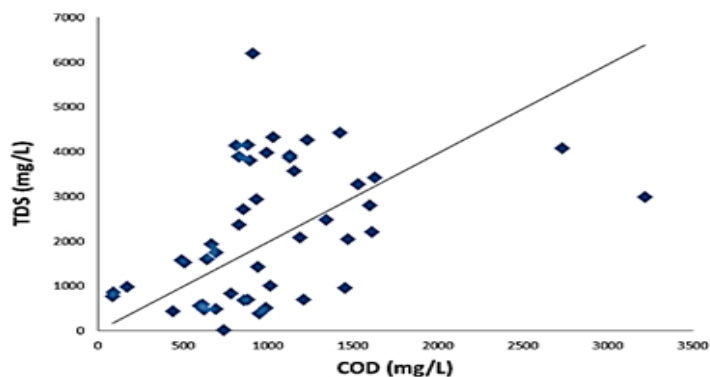
Figure 3. COD effect on TDS
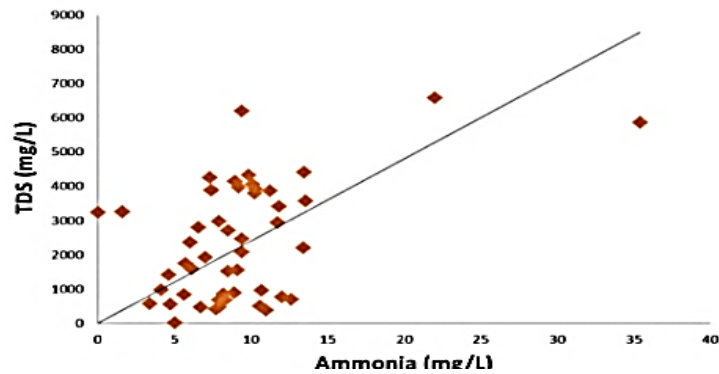
Figure 4. Ammonia effect on TDS

This condition can be explained from produced water characteristics with dissolved solids content consists of fairly high content of dissolved organic material and inorganic material. This influenced by the interaction of physical and chemical reactions with the rocky formations produced water before it lifted into the surface. COD may represent organic matter content whereas ammonia represents inorganic substances dissolved. This influence can be regarded as internal factors that affect the characteristics of produced water. From PCA analysis performed, external factors were also seen affecting the characteristics of the produced water is the influence of temperature and pH. As shown in the following graph.
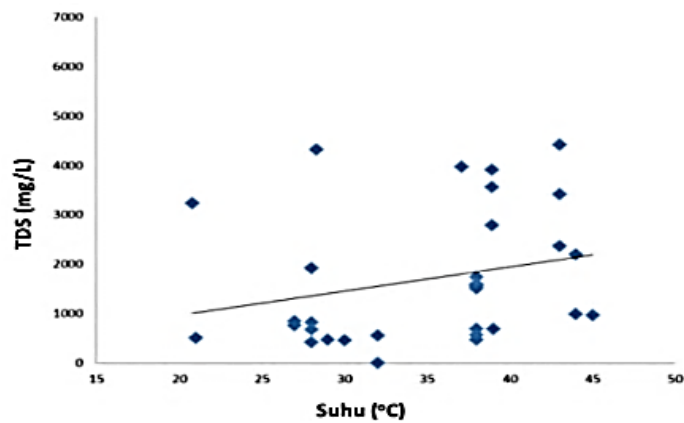
Figure 5. Temperature effect on TDS
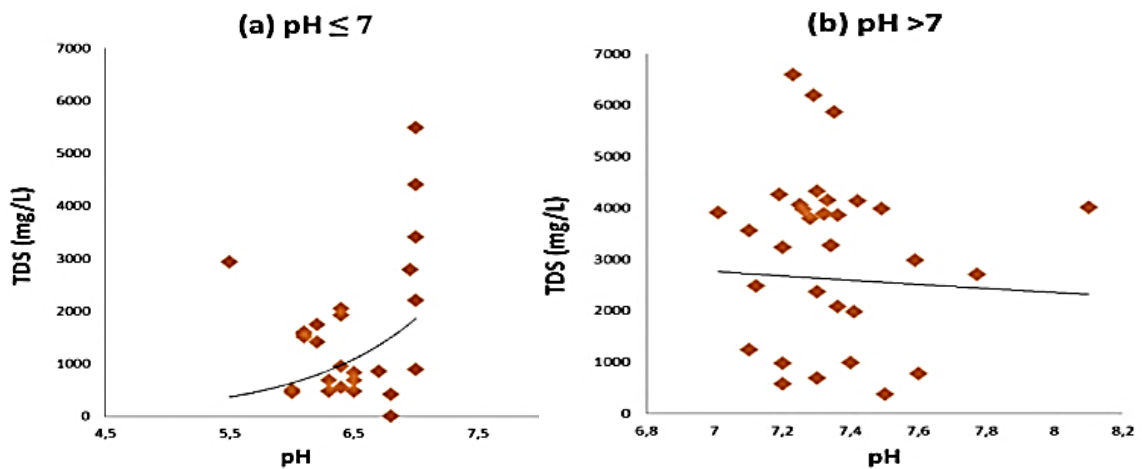
Figure 6 (a) pH effect on TDS in pH ≤ 7; (b) pH effect on TDS in pH> 7

This condition can be explained by the solubility of inorganic and organic content of which is affected by changes in temperature and pH conditions of the solution. As is known mostly solubility of inorganic minerals will increase if there is an increase in temperature. This is due to largely inorganic salt solubility is endothermic. This influence can be regarded as external factors affecting environmental conditions such as

temperature affected specific characteristics of the produced water, in this case can be seen from the tendency of most of the solubility of mineral salts that increases with increasing temperature of the produced water.

For pH conditions influenced by the nature of mineral salts to the acidic or alkaline nature of the solution. From the graph of pH effect on TDS seen that for pH close to 7, the value of TDS look bigger, but TDS value will be decreased again when the environmental conditions of produced water tends to be acidic and more alkaline with pH value away from 7. It's indicated that the presence of ions contained in the produced water tends to be neutralized and precipitation also occured, strengtened with the content of dissolved organic material that is non–polar, causing the solubility of dissolved solids greater with environmental conditions pH close to 7 which is neutral.

Waste water treatment facility (WWTF)

WWTF installation is designed to collect waste in the form of produced water from the entire field of production, which is designed with an operating life more than 15 years. Processing results are expected to meet the standard criteria for wastewater that can be discharged into surface water in the environment. In treating produced water in waste water treatment facility (WWTF), produced water generated will be treated in physics, chemistry and biology process. The series of the process is expected to lower the pollution index value of produced water quality. Effectiveness of waste water treatment systems in WWTF measured by comparing the value of 6 (six) parameters in accordance with the quality standards permitted in the Regulation of Environment Ministry No. 19 of 2010 on Wastewater Quality Standard for Business and/or activity of Oil and Gas and Geothermal. The analysis carried out on the driveway/ inlet produced water before it is processed at the WWTF and the exit/outlet WWTF after the produced water through the treatment process. Effectiveness WWTF processing of value % Removal seen below.

Table 5. Treatment affectivity of WWTF processing based on % removal

Parameter	Inlet	Outlet	*% Removal*
COD	511,67	31,67	93,81
Ammonia (NH$_3$–N)	1,58	0,36	76,92
Oil and grease	8,53	4,47	47,66
Phenol Total	14,80	0,76	94,85
Sulfide (H$_2$S)	0,15	0,02	88,89
TDS	4930	1737	64,77

From calculation of percentage value reduction (% Removal) shows that the produced water treatment process at the WWTF quite effectively reduced contaminants parameter contained value, it depicted that WWTF effective to reduce COD and phenols content parameter values to 93.81% and 94.85%. For oil and grease parameters can be lowered by 47.66%, which is the lowest percentage rate of effectiveness declines when compared with the value of other parameters content such as ammonia, sulfide and TDS which amounting to 76.92%, 88.89% and 64.77%. Through two measurements difference test with Paired Samples T–Test, seen the most significance difference occurred in impairment phenol content of the inlet and outlet WWTF with $t(3) = 3,635$; $p<0.05$ was obtained data inlet phenol (M=14.8; SD=0.82) and data outlet phenol (M=0.76; SD=0.48).

Table 6. Pollution Index value (IP) Inlet and Outlet WWTF

Parameter	Inlet WWTF		Outlet WWTF	
	Index value Pij	Pollution Criteria	Index value Pij	Pollution Criteria
COD	3,41	lightly polluted	0,22	good
Ammonia (NH$_3$–N)	0,40	good	0,09	good
Oil and grease	0,62	good	0,28	good
Phenol Total	7,18	mediate polluted	0,37	good
Sulphide (H$_2$S)	0,44	good	0,03	good
TDS	1,25	Lightly polluted	0,36	good

Source: Minister of Environment Decree No. 115 of 2003 annex II

To determine the level of contamination of the produced water quality parameters that are allowed before being discharged into surface water, the Pollution Index (PI) calculated, which refers to the Minister of Environment Decree No. 115 of 2003 annex II. Treated produced water quality on the basis Pollution Index (PI) can give description on the quality of produced water before processing and taking action to improve its quality due to the presence of polluting compounds. Pollution Index (PI) covers a wide range of

independent quality parameters based on the value of the quality standards that have been set. Produced water Pollution Index calculation before and after processing at the WWTF are shown in Table 6.

Pollution Index value (PI) in the inlet produced water before entering WWTF for phenol parameters categorized in mediate polluted criteria, for COD and TDS in lightly polluted criteria. This shows that the produced water potentially to cause environmental pollution if discharged directly into the environment without treatment efforts. However, after produced water treated in WWTF depicted Pollution Index values (PI) for all parameters are in good criteria. This shows that the produced water treatment facility (WWTF) has effectively treat produced water so all the parameters that must below the quality standard already met the requirement standard before discharged into the environment.

Utilization of Produced Water

The utilization of the processing results produced water for other uses must meet certain requirements, both to meet wastewater quality standards set by the Government, or to meet the technical requirements according to standards imposed before being used for the benefit of other uses. The average yield analysis of Jambi provincial health laboratories in produced water from outlet WWTF are shown in Table 7.

Table 7. Produced water analysis result from Outlet WWTF

Parameter	Unit	TLV Permenkes 416 th 1990	Value			
			Mean	Min	Max	SD
Physics						
TDS	mg/L	1500	3123	148	6708	3322,2
Turbidity	S. NTU	25	5,86	2,44	10,10	3,896
Color	S.PtCo	50	50	50	50	–
Inorganic chemistry						
Iron (Fe)	mg/L	1,0	0,648	0,08	1,216	0,803
Fluoride (F)	mg/L	1,5	ttd	ttd	ttd	–
Chloride (Cl)	mg/L	600	1018,2	354,6	1937,6	821,9
Manganese (Mn)	mg/L	0,5	0,03	0,03	0,03	–
Nitrate (NO_3)	mg/L	10	0,274	0	0,8154	0,4687
Nitrite (NO_2)	mg/L	1,0	0,0097	0,006	0,0172	0,0064
pH	–	6,5–9	7,50	6,00	8,87	1,439
Sulfate (SO_4)	mg/L	400	2,23	0,00	4,87	2,458
Hardness	mg/L	500	66,67	52	82	15,011
Organic chemistry						
Organic material ($KMnO_4$)	mg/L	10	18,66	0,00	31,24	16,487

Table 8. Utilization category for livestock water based on TDS value

TDS (mg/L)	Explanation
< 3000	Good for livestock water
3000 – 5000	Good, but indicated temporary little disruption diseases
5000 – 7000	Can be used, but only for laying birds
7000 – 10000	Not good for pregnant animals
>10000	Can cause brain damage and death

Source : Lardy, *et.al*, 2008:6

Based on analysis of WWTF outlet when compared with water quality standards based on the Minister of Health No. 416 of 1990, it appears there are still some parameters that do not meet the quality standards required. From 13 parameters that can be analyzed in Jambi provincial health laboratories, parameter TDS, chloride and organic material as $KMnO_4$ still above the standard quality, the average value of TDS 3123 mg/L, chloride amounted to 1018.2 mg/L and organic material as $KMnO_4$ amounted to 18.66 mg/L. This shows that the end result produced water processed by the produced water treatment plant (WWTF) cannot be used directly but still possible to use as raw material for clean water. Use of water for use as a water supply of livestock water can be categorized based on the TDS of the water (Lardy, et.al, 2008: 6) as shown in Table 8.

When referring to the 13 parameters measured include parameters TDS, based on the value of TDS average measured at 3123 mg/L compared to the value of TDS in the table above for the range 3000–5000 mg/L, then treated produced water from outlet the waste water treatment facility (WWTF) can be used for

livestock water supplies, although it will cause little disruption diseasesfor animals. Utilization of treated produced water for irrigation water can also be categorized based on the TDS value of the water (Guerra et al, 2011: 64) as shown in Table 9.

Table 9. Irrigation category water use based on the value of TDS

TDS (mg/L)	Explanation
< 160	Excellent
160 – 480	Good
486 – 1280	Permissible
1286 – 1920	Doubtful
>1920	Unsuitable

Source: Guerra, *et.al.*, 2011:64

Based on the value of TDS average measured at 3123 mg /L compared to the TDS value in the table above, the processed water from waste water treatment facility (WWTF) is not suitable when used for irrigation water, need further efforts to reduce the content of dissolved solids so that the processed water from WWTF can be utilized for irrigation water. Another utilization of the processing results produced water is to use oil and gas industry itself which are for the use of water outages, water process/support (process and utility water) and for Enhanced Oil Recovery (EOR). In the process water use/support will require further analysis regarding the tendency of water to the effects of scaling on the pipe.

In Enhanced Oil Recovery (EOR), produced water used to cleanse, push and replace the oil in the reservoir. A number of EOR techniques can be performed as a secondary recovery mechanism, one using reinjected produced water. Reinjected produced water may replace oil and push the produced oil. EOR is done by using the produced water in depleted oil field push oil up to 10% of the oil remaining in the reservoir (Guerra et al, 2011: 37). For this utilization of treated produced water will require some further testing, such as testing solids content distribution and trends of corrosion issues, trends crust problems (scale), water quality tests (membrane filter test) and compatibility test between water injection with formation water. With the current water quality conditions based on results of laboratory analysis of the provincial health of Jambi for final result waste water treatment facility (WWTF). Processed utilization of produced water is most effective for fire fighting water, quality of water used for fire water outage does not require stringent water quality, and quantity to use this water outages are relatively rare because it is only used in the event of emergency situations such as fire.

Currently, one of the protection systems in fire prevention of Geragai/Makmur field is a water storage pond containing water outages with capacity of 5000 m^3 ± that can meet the needs of the water outage for ± 8 hours. This water will be delivered via a pump system discharge to the fire hydrant and fire monitors located in and around the plant CPS and NGF. To meet the water needs in the water fire pond, this time filled with 2 (two) boreholes located around an outage. Produced water treated at the WWTF has a capacity of between ± 1000 – 3000 barrels/day or around ± 159–477 m^3/day. If WWTF process ± 200 m^3 /day produced water, then to fill the water in the pond outage will take about 25 days. With a pump capacity of 1000 GPM (3.78 m^3/min), if the average use of water for flushing and test the performance of the pump along with the fire hydrant and fire monitor takes approximately ± 30 minutes will require water of ± 113 m^3, this will applicable to fill with treatedproduced water from WWTF for only in 1 day processed.

Conclusions
1. Geragai/Makmur field in Jabung block has the characteristics of produced water with TDS average value 2495 mg/L.
2. The waste water treatment facility (WWTF) operating in CPS plant has been effectively in reducing contaminant content of COD by 93.81%, Ammonia amounting to 76.92%, oil content by 47.66%, Ammonia amounting to 94.85%, Sulphide & TDS amounting to 88.89% and 64.77%. Pollution Index (PI) Value COD and TDS can be derived from the lightly polluted category to be good and Phenol from being mediate polluted category to be good category.
3. The Utilization of produced water processed from waste water treatment facility (WWTF) in CPS plant for use as raw material for clean water still possible to use but not directly, for livestock water still possible to use and irrigation not suitable to be used based on TDS value category, organic material and measured chloride. However, it's potential for its own use in the oil and gas industry for fire water usage in fire water reserve pond.

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Characterization of Activated Carbon Prepared from Oil Palm Empty Fruit Bunch by Chemical Activation using Sulphuric Acid (H₂SO₄)

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Abstract

Activated carbon has been known as an excellent adsorbent and has widely used due to its unique characteristics and large adsorption capacity. In this study, activated carbon produced from oil palm empty fruit bunch by chemical activation with various concentration of sulphuric acid was used. The activated carbon were analyzed using nitrogen adsorption isotherm as BET for specific surface area and Fourier Transform Infra Red (FT–IR) Spectroscopy. The experimental results indicated that improvement on carbon physicochemical characteristics was obtained by a activation process using sulphuric acid material (H₂SO₄). Analysis data showed that the specific surface area of activated carbon using sulphuric acid concentration at 2 M, 2.5 M, dan 3.5 M were 4.341 m²/g, 2.190 m²/g, 1.914 m²/g respectively.

Keywords : *activated carbon, oil palm empty fruit bunch*

Introduction

Activated carbon is one type of adsorbent which most effective for the adsorption of heavy metals in water and gas pollution due to its unique characteristics and large adsorption capacity such as large surface area, high porosity and functional groups such as hydroxyl (OH), carboxyl (–COOH) and carbonyl (–CO) on its surface (Sumathi et al, 2009; Alkatib et al, 2011; Devi et al., 2012).

Recently, the development of activated carbon from agricultural wastes was widely used and more advanced in future. Agricultural wastes containing lignincellulose materials which rich carbon have been used as precursors of activated carbon is oil palm empty fruit bunches (EFB). EFB was containing lignocellulose by 55–65% dry weight. Through the production of palm oil per hectare of 20–24 tons of fresh fruit bunches per year that means its would produced 2.5 to 3.3 ton of lignocellulose materials. According to Mohamed et al. (2010) and Silvestre–Albero et al. (2012), materials containing lignocellulose can be used as the precursor material of activated carbon. Some advantages of activated carbon as precursor material of EFB is cheaper and easier to obtained.

The quality of activated carbon prepared from oil palm empty friut bunch (EFB) has been affected by the used method of carbonization and activation process. In general, activated carbon can be activated by two ways, namely chemical activation with alkali metal hydroxide, salts of carbonates, chlorides, sulfates, phosphates of alkaline metals and especially ZnCl₂, CaCl₂, inorganic acids such as H₂SO₄ and H₃PO₄ (Auta et al., 2012; Kurniawan et al, 2014) and physical activation which is the process of breaking the carbon chains of organic compounds with heating materials at a temperature of 800 °C to 900 °C and steam (Alam et al., 2008; Hidayu et al ., 2013). The types of activation methods have been used affected the physicochemical characteristics of activated carbon prepared oil palm empty fruit bunch.

According to Hsu and Teng (2000) the production of activated carbon by chemical activation using organic acid activator such H₂SO₄ is better applied to materials containing high ligninsellulose. It is because ligninsellulose materials containing high functional group of oxygen could be react with proton (H⁺) from activator.In this work, characterization of activated carbon prepared from oil palm empty bunch (EFB) by chemical activation was studied. As reported previous research, some activation methods affect the physicochemical characteristics of activated carbon. In this study, the effect of sulphuric acid concentration on the physicochemical characteristics of activated carbon is focused. Characterizations using BET and FTIR were respectively used to determine specific surface area and surface functional groups. Proximate analysis was performed according to ASTM D7582–10 and the results showed the moisture, volatile content, fixed carbon, and ash content of activated carbon.

Experimental/Methods

Material

The oil palm empty fruit bunch (EFB) was supplied by the Oil Palm Mill PKS Aramiah, Bireum Bayeun, East Aceh residence, Langsa. The materials were cleaned with distilled water several times to remove dust and impurities. Then, EFB samples were dried in oven at 110°C for 24h to remove any surface moisture. The dried EFB samples were crushed with grinder and sieved to a small particle sizes.

Activated carbon preparation

The activated carbon from oil palm EFB was prepared by chemical activation with various concentration of sulfuric acid; 2 M, 2.5 M, and 3.5 M. Then, the mixture was separated from slurry by filtration and neutralization. The process was proceeded by countinous rinsing of the suspension with water until the filtrate absenced from H^+ (tested by universal indicator). Finally, the activated carbon obtained from this step was dried and calcined at 600°C.

Characterizations of activated carbon

In this experiment, the physicochemical characteristics of the activated carbon from EFB prepared under the optimum conditions were determined. Proximate analysis was performed according to ASTM D7582–10 and the results showed the moisture, volatile content, fixed carbon, and ash content of activated carbon.

Nitrogen gas sorption analysis for BET isotherm was performed by Quantachrom Autosorb–1. The spesific surface areas of samples was calculated by the BET (Brunauer, Emmett, and Teller) method while volume of micropore was estimated using Dubinin Radushkevich (DR) equation.

The surface functional groups of raw EFB and activated carbon EFB were analyzed using Fourier Transform Infrared (FT–IR) spectroscopy. Firstly, the samples were mixed with potassium bromide (KBr) and the mixture was pressed as pellet prior to analysis. The IR spectrum was obtained at a resolution of 4 cm^{-1} over range of 500–4000 cm^{-1}.

Results and Discussions

Proximate analysis of raw sample and activated carbon

The results of the proximate analysis of raw EFB and activated carbon EFB are represented in Table 1. As described in Table 1, the proximate analysis of the raw EFB showed fixed carbon and ash content that lower than activated carbon EFB. This is due to phsyical activation at the high temperature that caused volatile matter content was released. Table 1 showed that volatile content was decreased due to the activation process from 71.95 %w/t become 15.23 %w/t. According to De et al (2013) fixed carbon and volatile contents of EFB make this material become a good precursor for production of activated carbon.

Table 1. Proximate analysis of raw EFB and activated carbon EFB

Sample	Proximate analysis (wt%)			
	Moisture	Volatile	Fixed carbon	Ash
Raw EFB	7.32	71.95	16.93	3.80
Activated carbon EFB	2.44	15.23	67.66	9.58

N_2 adsorption isotherm in activated carbon

The types of N_2 adsorption desorption isotherms activated carbon is given in Fig. 1. Based on Fig. 1, activated carbon shows isotherms type I. This type indicates that the activated carbon is microporous materials (diameter of < 20 Å in size), according to International Union of Pure and Applied Chemistry (IUPAC) classification. This means that microporous materials most adsorb nitrogen molecules. Usually, isotherms type I display a convex curve and the platform of this type come out horizontal or virtually horizontal. The adsorption isotherms directly intersects with the line P/Po = 1 (Tang et al., 2012).
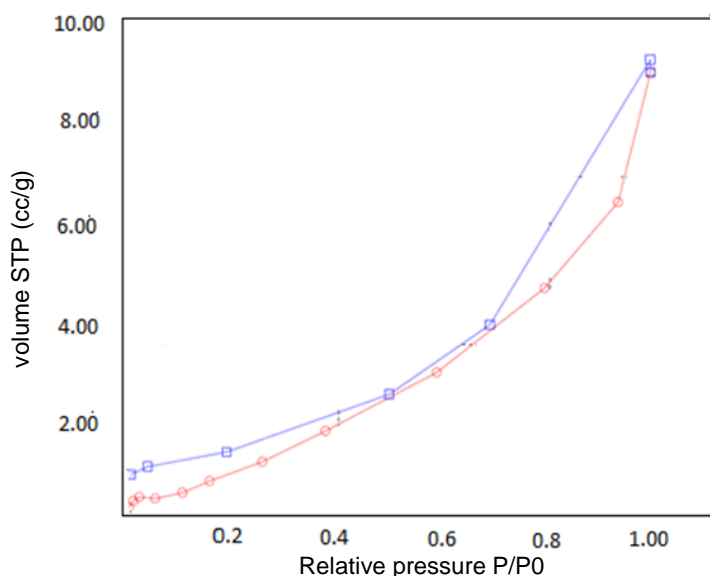
Figure. 1 The types of isotherm adsorption activated carbon from EFB

The BET specific surface areas of raw EFB and activated carbon EFB are presented in Table 2. It showed that the specific surface areas were increase after activation under optimum conditions. It occured because of activation process will enlarge the pore structure of EFB samples with breaking of hidrocarbon or oxidizing of surface molecules, so the carbon will change physically dan chemically, such the increasing of surface areas and absorption abilities.

Table 2. BET surface area of raw EFB and activated carbon EFB

Samples	S_{BET} (m^2/g)
Raw EFB	0,00
Activated carbon EFB	4,341

Fourier Transform Infrared (FT–IR) Spectrocopy

The FT–IR spectra of the raw material EFB and activated carbon EFB were given in Fig. 2a and 2b respectively. The EFB sample shows a broad adsorption peak at 3302 cm^{-1} which attributed to O–H stretching functional group. This indicates the presence of bonded hydroxide in the raw EFB. The adsorption band at 1743,65 cm^{-1} was corresponding to C=O functional group and peak at 1265,3 cm^{-1} and 1045 cm^{-1} refer to C–O stretching functional group. The result of identification functional groups based on Figure 2(a) showed that raw material of EFB has any functional groups, such as hydroxl (–OH), metoxy (−CH$_3$O), and carbonil (C=O) on its surface.

Figure 2. The FT–IR spectra of the raw material EFB (a).

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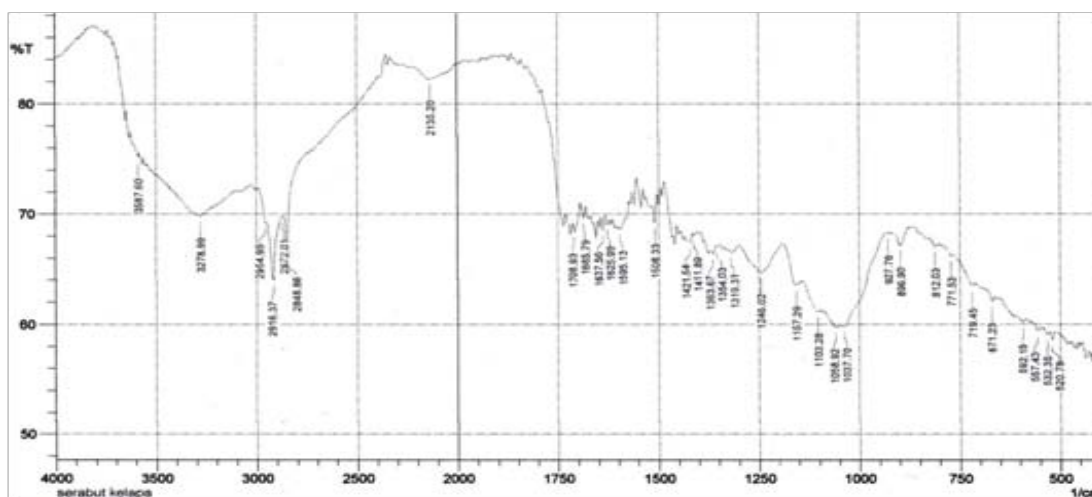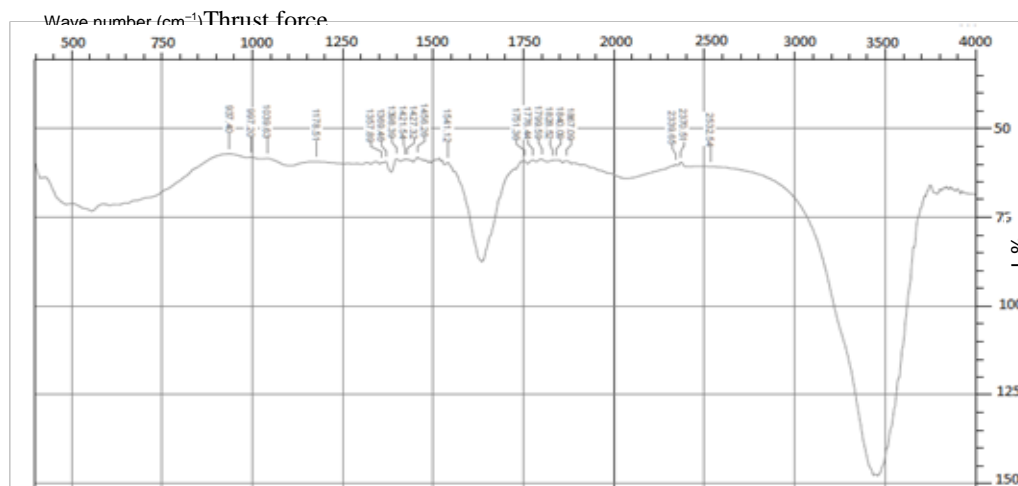
Figure 2. The FT–IR spectra of the activated carbon EFB (b)

The FT–IR spectra of activated carbon EFB was represented in Figure 2(b). The adsorption peak in Fig. 2 indicate that carbonization and activation process caused some of the adsorption peak of functional groups in activated carbon were dissapeared. This is occured because the heating at high temperature cause some of functional groups in raw material EFB were vaporized as volatile materials. This proved that the activation process was successfully converted raw material EFB into carbon. FTIR spectra show similiarties of some peaks; adsorption peak at 1751,36 cm^{-1} which attributed to C=O functional group and adsorption peak at 1043,49 cm^{-1} which attributed to C–O stretching functional group but adsorption peak at 1265,3 cm^{-1} was vaporized while activation process. It can be noticed that the adsorption peak of activated carbon EFB shift to the smaller wavenumber compare with raw material EFB.

Therefore, FTIR spectra of activated carbon EFB showed that the activated carbon has some functional groups such as hydroxyl (OH), carboxyl (–COOH), carbonyl (–CO) and aromatic structure which come from lignin and seluluce on its surface. The lignin of activated carbon EFB consists monomers of koniferil alcohol, p–kumaril alcohol, and sinapil alcohol as shown in Figure 3, respectively.
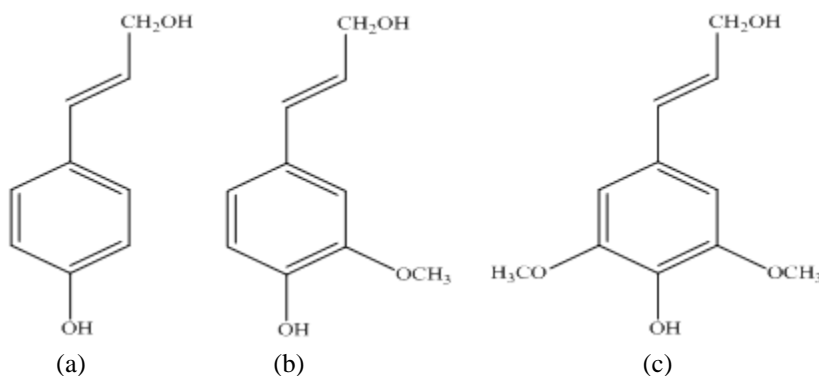
Figure 3. The structure of lignin activated carbon EFB samples (a) koniferil alcohol (b) kumaril alcohol (c) sinapil alcohol.

Effect of the sulphuric acid concentration to specific surface area of activated carbon
The effect of sulphuric acid concentration on the spesific surface areas of activated carbon shows in Figure 4. Based on Figure 4, the specific surface areas of activated carbon EFB was decreased with increasing the concentration of sulfuric acid used in the activation process. It showed that the increasing concentration of sulfuric acid in the activation process of activated carbon from the EFB would damaged the pore structure, so it cause the decreasing of specific surface area.

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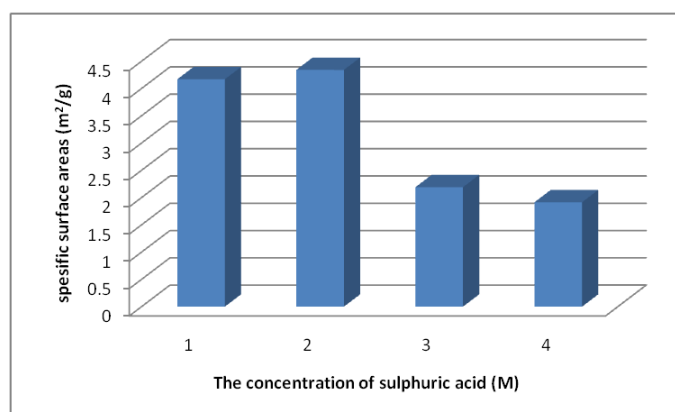
Figure 4. The effect of sulphuric acid concentration to spesific surface areas

Conclusions

The result of this research showed that the improvement on physicochemical characteristics of the raw EFB samples was obtained by a activation process. The activated carbon has specific surface area more higher than raw EFB samples yaitu 4,341 m^2/g. The result of FTIR analysis showed that the activated carbon has some functional groups such as hydroxyl (OH), carboxyl (–COOH), carbonyl (–CO) and aromatic structure which come from lignin and seluluce on its surface. The concentration of the sulphuric acid has effect on the pyhsicochemical characteristics of activated carbon. Analysis data showed that the specific surface area of activated carbon using sulphuric acid concentration at 2 M, 2.5 M, dan 3.5 M were 4.341 m^2/g, 2.190 m^2/g, 1.914 m^2/g respectively. It is concluded that the specific surface areas of activated carbon EFB was decreased with increasing the concentration of sulfuric acid used in the activation process.

Acknowledgements

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Purification of Waste Cooking Oil as Biodiesel Feedstock Using Ceramic Filter

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Abstract

The obstacle of biodiesel preparation from waste cooking oil (WCO) is mainly caused by the high content of free fatty acids (FFAs) in the sample. The high concentration of FFAs in biodiesel feedstock often leads to soap formation and difficulty of product separation. In this experiment, WCO was filtrated using a ceramic filter to reduce FFAs before being converted to biodiesel. Ceramic filters were made using natural clay, diatomite, and an iron powder mixture in various compositions. The effect of contact time and ceramic filter composition on flux was investigated. Temperature and flow rate of WCO were set at 40°C and 1.5 L/min, respectively. The results showed that FFAs concentration was decreased from 12% to 0.003% using ceramic filter with the composition of 69% natural clay, 30% diatomite, 1% iron powder, and contact time of 90 minutes. The results also showed that palmitic acid and oleic acid concentration decreased to about 1.5 and 4%, respectively. The results will contribute to the application of ceramic filter as the pretreatment for biodiesel feedstock with high concentrations of FFAs.

Keywords: Biodiesel, ceramic filter, diatomite, free fatty acid, microfiltration

Introduction

The energy consumption is rapidly increasing in the world. Crude oil is the main source of fossil energy being consumed by the world's population which has been exceeding other types of energy source. The abundant use of oil reserves leads to severe problems for humanity. The concerns for security of fossil fuel supply and the environmental problem such as global warming (Atadashi, 2015) are given by the increasing amount of CO_2, which resulted from the combustion of fossil fuel. The dependence on petroleum based oil can be reduced by providing alternative fuels such as biodiesel, bioethanol, and biogas.

The biodiesel raw materials containing free fatty acids (FFA) such as non–edible crude oils, waste food oils, animal fats, and byproducts of the refining vegetable oils, are preferred for substitution of petroleum based diesel fuel (Enweremadu and Mbarawa, 2009). The waste cooking oil (WCO) is a promising feedstock for biodiesel because it is a cheaper raw material and can be collected from large–scale food processing (Bautista et al, 2009). Consequently, biodiesel production cost might be reduced by 60 to 90% when WCO is employed as feedstock. However, most of biodiesel feedstock such as Mahua (Ghadge and Raheman, 2005) have a high FFAs (19%) content, which is categorized as brown grease of the WCO (Kiakalaieh, *et al.*, 2013). The FFAs in the WCO will react with the base catalyst to form soap, which leads to loss of catalyst and ester product, and increasing the production costs (Encinar, *et al.*, 2011). Thus, the single–step process involving an alkali–catalyzed trans–esterification is insufficient for high FFAs biodiesel feedstock. The undesirable compounds in the WCO can be avoided by a pretreatment of the used cooking oil such as steam injection, neutralization, vacuum evaporation and vacuum filtration (Araújo, *et al.*, 2013). In the current experiment, ceramic filter was utilized as a treatment process for biodiesel preparation using waste cooking oil.

Experimental Methods

Material

Ceramic filter was made by using a mixture of natural clay, diatomite and iron powder. Ceramic filter designed as porous tube that has an outer diameter 10 cm, an inner diameter of 7.5 cm and a length of 25 cm. Natural clay and diatomite dried naturally by sunlight for 12 hours and grinding into 20 mesh of particle size. Iron powder from the local welding shop is sieved to 500 micrometers of particle size. Materials used in ceramic filter production was homogenized with clean water, molded, dried at room temperature for seven days and sintered at 900 °C for 12 hours in a local ceramic manufacturer. Two types of ceramic filter were designed in this experiment. The first type of ceramic filter which has a dominant composition of natural clay and the second type of ceramic filter contains diatomite as main component as shown in Table 1.

Table 1. Ceramic filter composition

Ceramic Filters		Natural clay (%wt)	Diatomite (%wt)	Iron powder(%wt)
Type 1	A	74	25	1
	B	79	20	1
	C	69	30	1
Type 2	D	25	74	1
	E	20	79	1
	F	30	69	1

WCO sample was transferred into a storage tank using centrifugal pump and filtered using a ceramic filter. The filtration time was 90 minutes and the samples were taken at an interval of 15 minutes for FFA analysis. The XRD (PanAnalytical Empyrean) was used to characterize the diatomite components. The GC–MS (Agilent 6890N) with semi–polar column, which has a length of 30 m and a diameter of 250 µm was performed to determine the WCO compounds. The initial temperature of the sample being examined by GC–MS was 40°C and the maximum temperature was 325°C. The Scanning Electron Microscope (JEOL–JSM6510 Japan) was performed to determine the surface morphologies of diatomite.

Results and Discussion

Effect of ceramic filter composition

Waste cooking oil was filtered using the ceramic filter to reduce the free fatty acid. Free fatty acid was adsorbed through two types of ceramic filters which are made from natural clay, diatomaceous earth, and iron powder. The concentrations of the FFAs in the WCO become an important factor in determining the quality of methyl ester as shown in Figure 1 and Figure 2, respectively. As can be seen, both the ceramic filter type could decrease the FFAs from WCO samples. As suggested, increase of contact time will decrease the percentage of FFAs in permeate. Among ceramic filter type 1, filter C was able to decrease the FFAs of WCO from 12 to 0.02% at contact time of 90 minutes. The results also showed among ceramic filter type 2 that Filter E able to decrease the FFAs up to 0.17%. However, the results show that the ceramic filter with dominant composition of natural clay is better compared to those of diatomite. A flux decline over the filtration time was attributed to the fouling of ceramic filter surface (Atadashi, 2015).

Effect of Ceramic Filter Composition to Flux

Figure 3 shows the flux of permeate for type 1 ceramic filter. Among the ceramic filters tested the lowest flux was found as 0.04163 L/cm^2.min at 90 min of contact time was obtained using membrane C. The same observation was also found in Figure 4 using membrane E which flux decreases to 0.02082 L/cm^2.minand maximum flux occurs at contact time 90 min. It was suggested that flux decreased cause by fouling on the ceramic filter surface after 75 minutes of contact time.
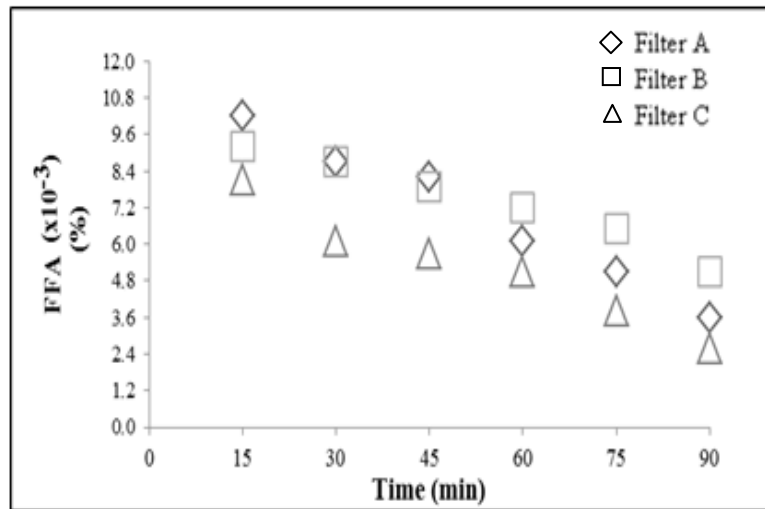
Figure 1. FFA quality using ceramic filter type 1
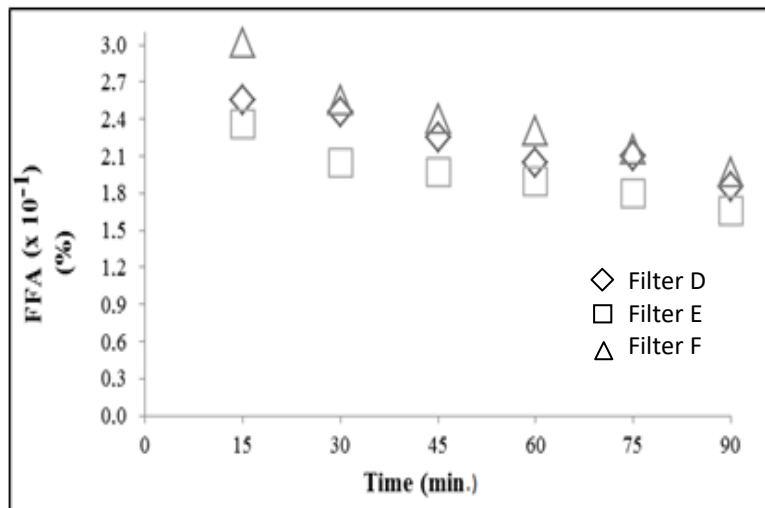
Figure 2. FFA quality using ceramic filter type 2
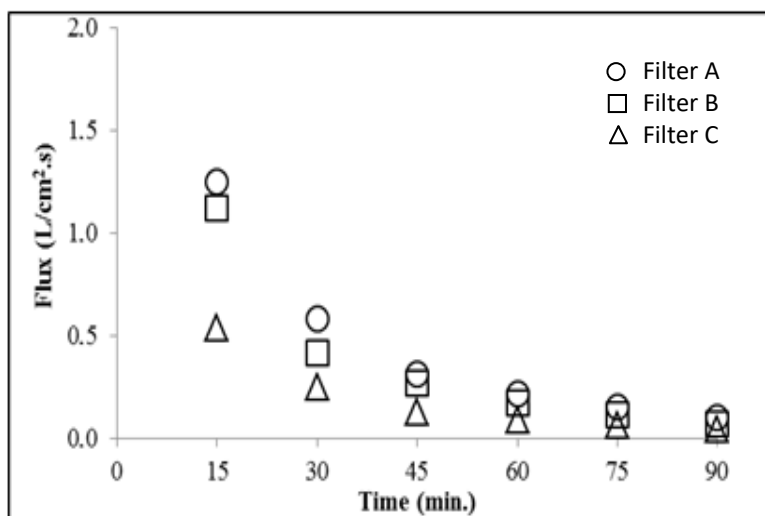
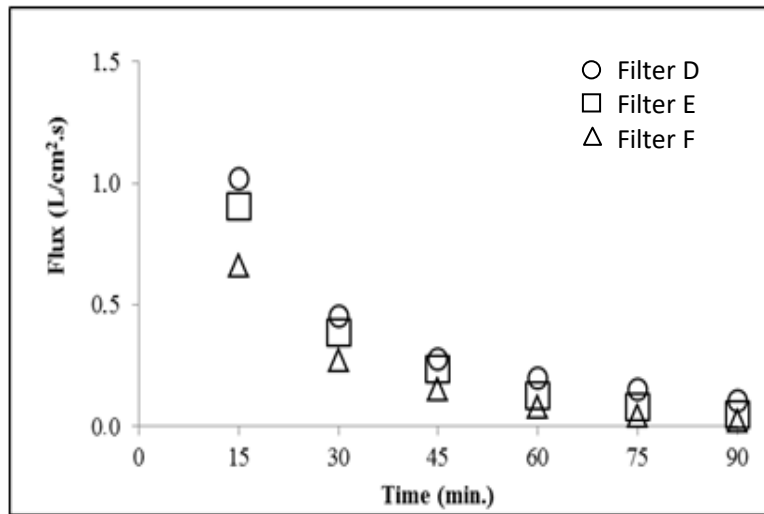Figure 3. Flux of ceramic filter type 1

Figure 4. Flux of ceramic filter type 2

Figure 4 showed the permeate flux of ceramic filter type 2. The flux decline is rapidly decreased and the permeate flow rate is very low because the decrease in driving force and an addition in the hydraulic resistance of the membrane due to fouling, which may be done by excessive accumulation of particulates at the membrane surface or in the pores. Figure 3 shows the SEM image of typical diatomite from Baturaja, South Sumatra. SEM analysis of diatomite showed that the major compound of diatomite were silica, aluminium, potassium and other impurities.
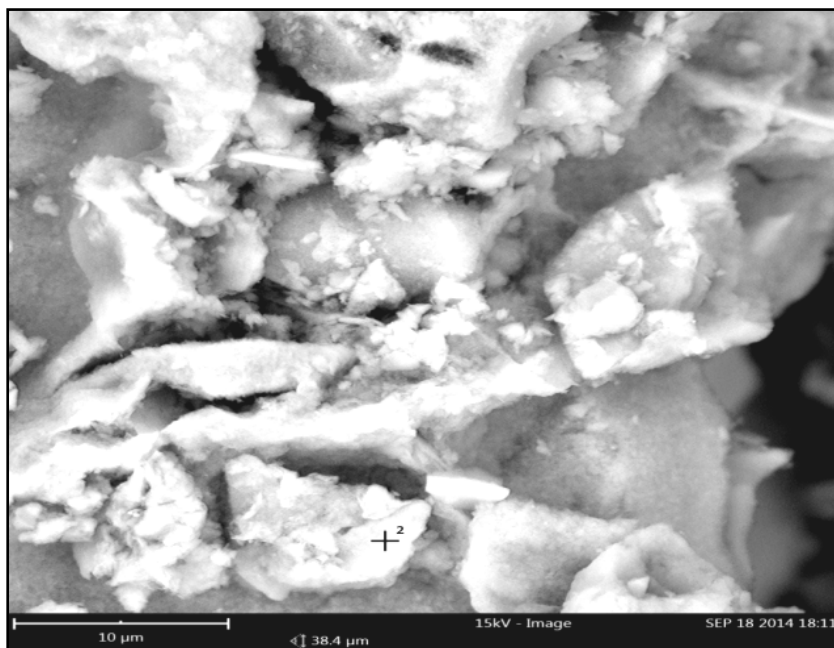
Figure 5. Diatomite SEM Micrographs (Magnification 500x)

Figure 6 shows the XRD pattern of diatomite from Baturaja, South Sumatra, Indonesia. In such area, the application of diatomite has been mostly just as an abrasive for cleaning household appliances. From XRD analysis, it was found that the main compounds of diatomite are 85.72% sillimanite (Al_2O_5Si) and 14.28% cristobalite (O_2Si). The pore size of diatomite was in the range of 0.02 μm to 20 μm that indicated this material is suitable for microfiltration process using ceramic filter.
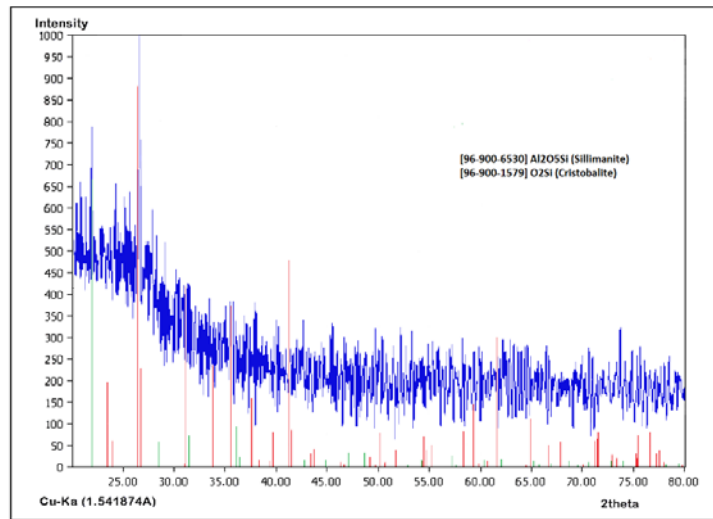
Figure 6. XRD pattern of Diatomite

In the current work, waste cooking oil compounds were analyzed using a GC–MS. The chromatograms of WCO can be seen in Figure 7 and Figure 8. The GC–MS results show that palmitic acid concentration is decreased from 48.70 % (before filtration) to 47.46 % (after filtration using ceramic filter).
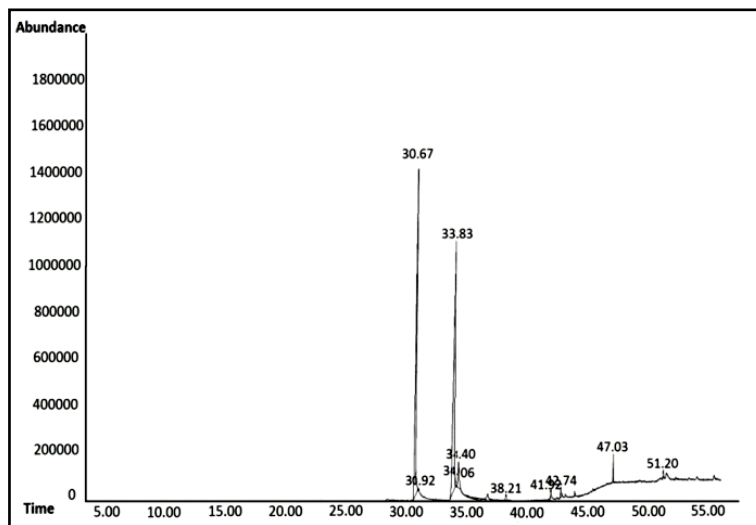
Figure 7. WCO Chromatogram before filtration
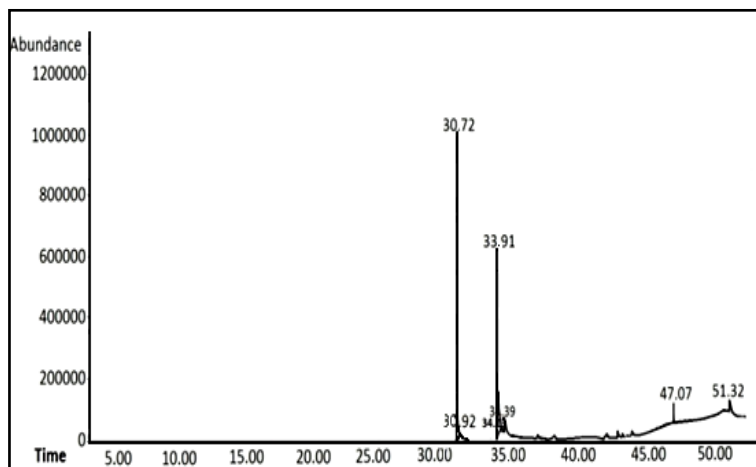
Figure 8. WCO Chromatogram after Filtration Process

Figure 8 showed that ceramic filter was able to decrease Palmitic acid and Oleic acid in the WCO. However, it was suggested that ceramic filter can reduce the others small compounds from WCO such as linoleic acid and phospolipid.

Conclusions

The best ratio of ceramic filter composition among clay, diatomite, and iron powder is 69%: 30%: 1%, which is can reduce the free fatty acid compund in waste cooking oil from 12% to 0.03% in 90 minutes of contact time. However, flux will significantly decreased after 45 minute of contact time. Methyl ester which can be produced by waste cooking oil through the ceramic microfiltration filter has 90.6% of purity. ceramic filter can be used as pretreatment for methyl ester production to replace the esterification process.

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Pangium edule reinw Biodiesel Production: Kinetics Study and Physicochemical Properties

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Abstract

This paper presents the kinetics study of base–catalyzed *Pangium edule reinw* oil alcoholysis and the characterization of biodiesel product. The acid pre–treatment is required due to the initial free fatty acid content of crude *Pangium edule reinw* oil is 6.7%. Then, tansesterification process is carried out under the fixed reaction temperature of 60°C, based on the previous study. The kinetics study of base–catalyzed *Pangium edule reinw* oil alcoholysis is conducted under the three reaction temperatures (50, 55 and 60°C). Determination of physicochemical properties such as density, viscosity, iodine value, acid number, pour point, cloud point, flash point, and moisture content of *Pangium edule reinw* biodiesel is performed using ASTM D6751.

Keywords: *Pangium edulereinw* oil, biodiesel, kinetics study, alcoholysis.

Introduction

The escalating price issue of petroleum based fuel due to more declining reserves of crude oil and the growing environmental concerns have induced the biodiesel attraction as the alternative fuel increasing significantly. Edible and inedible vegetable oils are being used as the feedstock of biodiesel. Nowadays scenario, using inedible oils such as *Jatropha curcas* (Syam, *et al.*, 2012), *Pongamia pinnata* (Rathore and Madras 2007), *Jojoba* (Canoira, *et al.*, 2005), *Madhuca indica* (Ghadge and Raheman, 2005) and *Brassica carinata* (Bouaid *et al.*, 2005) as the second generation feedstock is encouraged for avoiding endless competition with food supply. Besides, it is an effective way to overcome entire the related problems with edible oils.

The selection of a simple and inexpensive technique for producing biodiesel from inedible feedstock is aim at alleviating the production cost and maintaining the lowest customer price. For that reason, alcoholysis (transesterification) is chosen among whole the presently applied ways for biodiesel production. Based on the stoichiometry, the alcoholysis process requires one mole of triglycerides and three moles of alcohol (methanol) to produce three moles of methyl esters and one mole of glycerol. However, excess of alcohol is necessary to maintain the reaction proceeds to the right side (Figure 1). In terms of catalyst, the homogeneous alkali catalysts such as hydroxide and methoxide compounds are commonly used. However, during the alcoholysis in the presence of alkali with water/moisture will reduce the conversion of triglycerides to methyl esters. Therefore, it is essential to minimize the effects which resulted in the reaction unable to convert the reactant completely to product (Canakci, 2007). One of which is also due to a high content of free fatty acid (FFA) in feedstock. Another method that can be applied without considering the level of FFA namely heterogeneous–catalyzed transesterification, but, this process is highly cost.
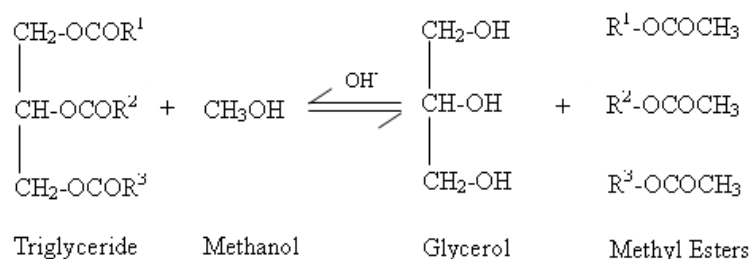

Figure 1. Mechanism of methanolysis overall reaction

To overcome the reaction process forms a less beneficial product (such as: soap), a feedstock post lowering the percentage level of FFA is applied. Otherwise, saponification reaction would occur and cause the difficulty of product separation (Schuchardt, *et al.*, 1997; Syam, *et al.*, 2016).

The objectives of study are to determine the parameters of reaction kinetics such as reaction rate constant, reaction order, and Arrhenius activation energy at various temperatures of reaction. The characterization of *Pangium edule reinw* biodiesel such as density, viscosity, iodine value, acid number, pour point, cloud point, flash point, and moisture content is done according to International Standards of ASTM D 6751.

Experimental Methods

Material

Pangium edule reinw oil was purchased from the local company. The chemicals employed were methanol (99.8% purity), sulphuric acid (95–98% purity), isopropanol (99.7% purity), phenolphthalein (1%), and potassium hydroxide (85% purity). The equipment was batch reactor, graham condenser, thermometer, hot plate completed with magnetic stirrer, separating funnel, oven, gas chromatography, pour and cloud point tester, flash point tester, viscosity & density analyzers, burette, and other glass wares.

Method for acid pre–treatment

The crude oil was heated in the three necks reactor until temperature reached about 60°C. The sulfuric acid (H_2SO_4) catalyst was then poured into reactor simultaneously with methanol at various concentrations as specified previously. Once the reaction has completed, the product was allowed into separation funnel to settle down for 2 h and the methanol water fraction at the top layer was removed. The treated oil was further analyzed on its final value of FFA using conventional titration method.

Kinetics Study

The treated oil as feedstock was introduced into the reactor and heated at the specified temperature. The mixture of methanol and catalyst was then added to the reactor at which the reaction was assumed to commence. When the reaction was running, the kinetics samples was provided at every specified times (1, 5, 10, 15, 20, 30, 40, 50, and 60) min. The samples were then prepared for Gas Chromatography (GC) injection. All obtained data were plotted in the graph of kinetics order.

Analytical Procedure

GC analysis was performed for identifying the hydrocarbon compounds such as fatty acids and methyl esters. The separation is carried out by using capillary column Rtx–5MS 30m x 0.25mm ID, 0.25μm with helium at 137.7 ml/min as a carrier gas and 1:100 of split ratio.

Results and Discussion

The *Pangium edule reinw* –based oil were used in the synthesis to investigate the effect of fatty acid methyl esters conversion rate. The molar ratio of methanol to oil was fixed at 6:1, the percentage of catalyst was 1.0% w/w, and the reaction temperatures were varied. The samples were collected at intervals time from 1 to 60 min. The experiments were designed to determine the reaction order, the rate constant and activation energy for the reaction.

To correlate experimental data and to quantify the reaction temperature and time effects, the results were further analyzed for the reaction kinetics of *Pangium edule reinw*–based oil (triglycerides) to be methyl esters. In this matter, the transesterification reaction to be divided into three steps (Diasakou, *et al.*, 1998)as shown in equations (1–3). Triglycerides (TG) react with methanol to produce diglycerides (DG), and then DG reacts to produce monoglyceride (MG). Finally, MG reacts with methanol to produce glycerol (by–product). At each reaction step, one molecule of methylated compounds is produced for each molecule of methanol consumed (Vicente *et al.*, 2006)

$$TG + MeOH \longleftrightarrow DG + ME \tag{1}$$
$$DG + MeOH \longleftrightarrow MG + ME \tag{2}$$
$$MG + MeOH \longleftrightarrow ME + GL \tag{3}$$

In this study, because of the relatively faster rates of intermediate reactions shown in equations (1–3), the reaction is limited by the last reaction as shown in Figure 1. This is called the limiting step reaction and will be the one which control the kinetics of the reaction. Based on those assumptions, a simpler mathematical equation for this reaction can be defined by ignoring the intermediate reactions involving MG.

Determination of Reaction Rate Constant.

Figure 2 showed the first order kinetics model for transesterification of *Pangium edule reinw*–based oil. The reaction rate constant can be determined based on the decrease amount of the limiting reactant that occurs in some reaction time interval or alternatively based on the increased amount of the product, i.e. methyl esters.
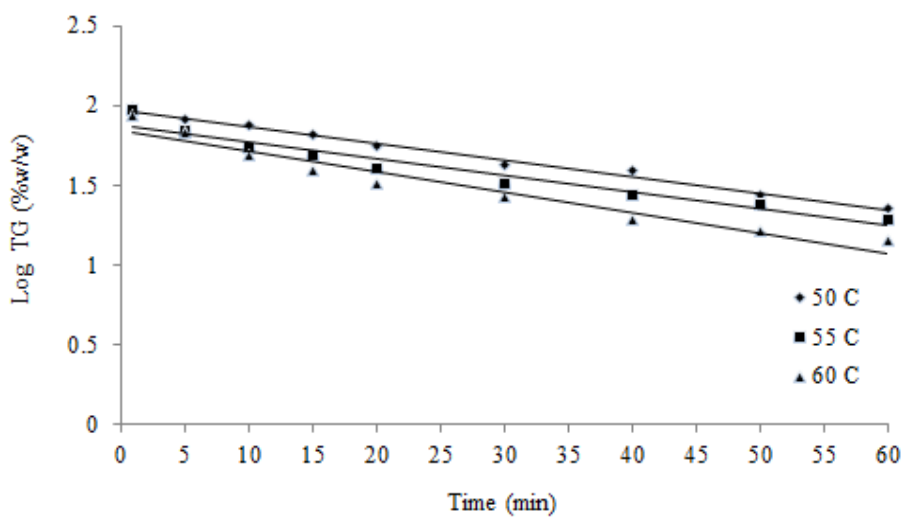
Figure 2. First order kinetics model for transesterification of *Pangium edule reinw*–based oil

The determination of reaction rate constant also depends on the reaction order. Employing experimental data, the correct order would be determined by which function of rate equation best fit the linear requirement. Once the order of reaction was established, the reaction rate constants were estimated from the slope of the linear plot. Based on the overall transesterification reaction scheme as showed in Figure 1, the rate of reaction at any time is given by the equation (4).

$$r = -\frac{d[TG]}{dt} = k[TG] \tag{4}$$

where k, r and t denote the overall reaction rate constant, rate of reaction and time of reaction. However, in this study, the transesterification of *Pangium edule reinw*–based oil with methanol in the presence of potassium hydroxide as catalyst was occurred very rapidly. Therefore, in this work, the negligible of intermediate reactions need to be considered. This phenomenon was proved from the GC chromatograms. In addition, the use of excess methanol will minimize the rate of backward reaction.

The best kinetics model for this study appears to be a first order model for the initial stages of the transesterification as shown in Figure 2. In order to test these experimental data, a model was developed based on the kinetics of alcoholysis TG. As prior discussion, it defined the mathematical model for this reaction by ignoring the intermediate reaction of MG. The first order rate is assumed as a function of the concentration of triglycerides. The reaction rate constant can be estimated based on the decreased amount of the limiting reactant in certain reaction interval time. In this study, TG are chosen as the decreased amount of limiting reactant. Therefore, the reaction rate constant can be given by equation (8).

$$-\int_{TG_0}^{TG} \frac{d[TG]}{[TG]} = k\int_0^t dt \tag{5}$$

$$-\ln[TG]_{TG_0}^{TG} = k[t]_0^t \tag{6}$$

$$k = \frac{1}{t} \ln \frac{[TG_0]}{[TG]} \qquad (7)$$

Thus, the formula of reaction rate constant can be determined using logarithms

$$k = \frac{2.303}{t} \log_{10}\left(\frac{TG_0}{TG}\right) \qquad (8)$$

where TG_0 is the initial concentration of TG. For the alcoholysis of TG, a plot of reaction time (t) versus log (TG_0/TG) should be a straight line if the first order model as equation (9) is valid. Figure 2 shows such plots at temperatures (50, 55, and 60) °C. The slope is 2.303/k with the units of min^{-1}. The values of reaction rate constant for TG (k_{TG}) and its corresponding correlation coefficient are shown in Table 1. Thus, other researchers stated that the values of k increased when the temperature was escalated (Om Tapanes*et al.*, 2008). However, if the data is plotted in the second order model, the graph doesn't form a straight line. Therefore, the reaction doesn't match that for second order model. A similar calculation method is applied for determining the rate constant for DG as tabulated in Table 2.

The rates of reaction are very sensitive to change in temperature. It is normally necessary to carry out kinetics experiments in a vessel maintained in a thermostatically controlled bath the temperature. Also, according to other researchers, reaction rates constant almost always increase with temperature for elementary irreversible reactions. Multiple and reversible reactions occasionally exhibit an optimal temperature with respect to the yield of a desired product (Noureddini and Zhu, 1997). Thus, indirectly, these findings prove that our assumption of irreversible reaction is valid since the rate increases with temperatures. Rate constants for the first two reactions increase with temperature for the forward reactions. The kinetics study on rates of reaction for MG could not be performed because it occurs so fast that MG could not be detected on GC chromatogram.

Table 1. Reaction rate constant (k_{TG}) for intermediate reaction of *Pangium edule reinw*–based TG

Temperature (°C)	k_{TG} $(min)^{-1}$
50	0.23
55	0.25
60	0.27

Table 2. Reaction rate constant (k_{DG}) for intermediate reaction of *Pangium edule reinw*–based DG

Temperature (°C)	k_{DG} $(min)^{-1}$
50	0.15
55	0.16
60	0.18

Determination of Activation Energy.

The dependency of reaction rate constant (k) on temperature follows the Arrhenius equation as shown in equation (9)

$$\log_{10} k = (-E^{\pm}/2.303RT) + \log_{10} A \qquad (9)$$

where T is expressed in °K and R is the universal gas constant. The activation energy $(E^{\pm})$ was estimated from the slope of a plot of $\log_{10} k$ versus 1/T. In this term, k is equal to k_{TG} and k_{DG}. The frequency factor, A was determined from the y–intercept. The plot is shown in Figure 3 for *Pangium edule reinw* methyl esters synthesis at 50–60 °C. These data were used to determine the Arrhenius energy of activation. The activation energy for the transesterification reaction are comparable with other study as shown in Table 3.
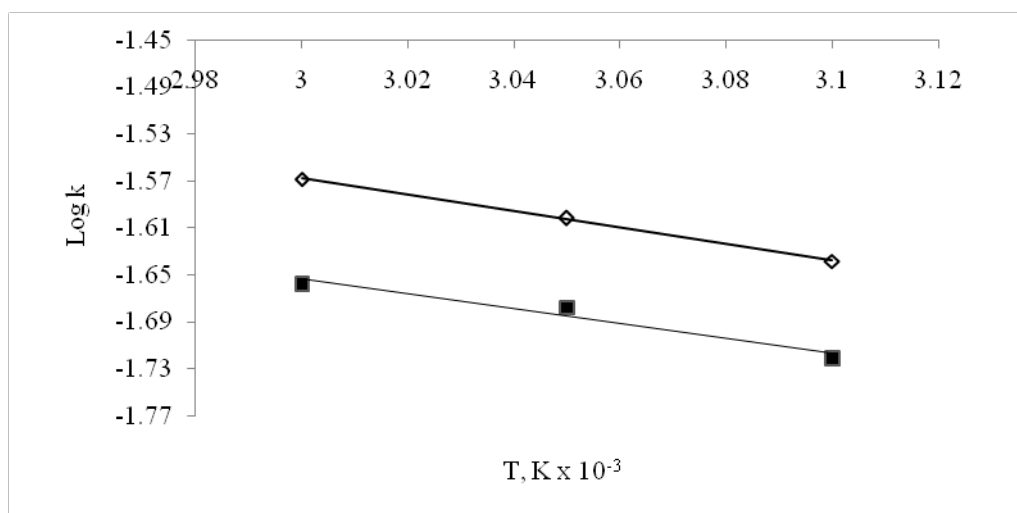
Figure 3. Arrhenius plot showing the temperature dependency of reaction rate constants

Activation energy which was determined for each step of the reaction mechanism, not considering the pre–step is common for all of the reactions. According to Syam*et al.*, (2009), the reaction scenario is described as follows. In the first step, the reaction passes through an initial complex and after a transition state with low activation energy forms the tetrahedral intermediate as the main product. In the next step, the tetrahedral intermediate dissociates via a second transition state with larger activation energy leads to the methyl esters and the glycerol. This phenomenon was considered that the break of the tetrahedral intermediate to form the final product may play a key role in the base–catalyzed transesterification of TG. Furthermore, Noureddini and Zhu, (1997) reported that normally, with multiple reactions, a high temperature favors the reaction of higher activation energy, and a low temperature favors the reaction of lower activation energy. In this study, the experimental data is comparable to other similar work.

Table 3. Activation energy for transesterification of *Pangium edule reinw*–based oil

Step–wise reaction	$E^{\pm}(kJmol^{-1})$	$E^{\pm}(kJ\ mol^{-1})^{a}$
TG $\rightarrow$ DG	19.48	27.38
DG $\rightarrow$ ME	45.63	46.72

[a] Yunus and Syam, (2011).

Characterization of Pangium Edule Reinw Methyl Esters.

Since *Pangium edule reinw* methyl esters (biodiesel) as fuel for the diesel engine application, it should fulfil the standard quality of International specifications. In this study, some physicochemical properties of *Pangium edule reinw* methyl esters such as density, viscosity, iodine value, acid number, pour point, cloud point, flash point, and moisture content are analyzed using ASTM method as shown in Table 4. All physicochemical properties comply with the values of standards specification.

Table 4. Physicochemical Properties of *Pangium edule reinw* methyl esters (ASTM D 6751)

Parameters	Unit	Method	Values	Limitation
Density (15°C)	kg/m^{3}	ASTM D 40	865	–
Kinematic viscosity (40°C)	mm^{2}/s	ASTM D 445	5.43	6.0 (max)
Moisture content	% volume	ASTM D 95–05	0.008	0.05 (max)
Iodine value	–	PORIM	92	–
Pour point	°C	ASTM D 97	–2	–
Cloud Point	°C	ASTM D 2500	5	–
Flash point	°C	ASTM D 93	143	130 (min)
Acid number	mg KOH/g oil	ASTM D 974	0.75	0.80 (max)

Conclusions

The kinetics of transesterification of *Pangium edule reinw*–based oil and methanol to methyl esters was investigated. The mechanism of reaction is believed to occur via two step–wises irreversible elementary reactions to form intermediates and final product of methyl esters. However, the first reaction is too fast and doesn't control the reaction. The conversion of TG and DG into methyl esters appeared to be first order up to 60 min of reaction time. The rate constants for the formation of intermediate DG and the final product of methyl esters were determined at various temperatures. The values of k_{TG} ranges from 0.23 to 0.27 and the values of k_{DG} are from 0.15 to 0.18, respectively. The activation energy for step–wise reaction in transesterification of *Pangium edule reinw*–based TG and DG with alcohol is 19.48 and 45.63 kJmol^{-1}. The whole physicochemical properties of *Pangium edule reinw* biodiesel meet the diesel engine specification.

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Development of PC–Based FMCW Radar for Ranging Application

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Abstract

This paper presents a report on the development of a Frequency Modulated Continuous Wave radar for ranging application. The ranging function becomes the main focus of the research as this particular function is the most important capability of any radar system in various applications, such as vessel traffic service radar, maritime radar, as well as naval navigational radar system. The FMCW radar was developed on a PC based platform using the ISM frequency band of 2.4 GHz. Experimental testing and evaluation revealed that the developed radar system can be successfully used to detect the distance of a moving target. The future research work would be to improve the ranging accuracy by narrowing the radar antenna beamwidth, as this parameter significantly determines the radar ranging resolution.

Keywords: FMCW, ISM, Radar

Introduction

Radar stands for radio detection and ranging. It is an electromagnetic system that is generally used to obtain some information about one or more target(s). Some common radar applications are ranging, velocity measurement, spatial mapping, weather detection, etc. Among all of the target detection tasks that a radar system can do, ranging is one of the most important tasks as this function directly relates to the position of the target being detected.

In the case of target detection, radar is the most promising technology among other available options such as infrared, ultrasound, laser, video/camera, etc. This is due to the high target detection resolution that can be provided by a Frequency Modulated Continuous Wave (FMCW) radar system, especially when the conventional Fourier transform ranging function is also integrated with radar phase processing (Priandana, *et al*., 2014). Moreover, unlike the other competitive technology, a radar system can work well under the extreme weather conditions.

The use of radar for target detection has been reported in various works. However, because most of the applications were as coastal radar, the radar systems were generally developed using the High Frequency (HF) and Very High Frequency (VHF) with frequencies between 3–30 MHz and 30–100 MHz, respectively. As a result, the radar resolution that can be achieved is very limited due to the limited bandwidth of the radar. In addition, the size of the radar antenna would be large enough, because the wavelength is of the order of 3–100 meters. Fernandez, D.M. *et al*. (1998) developed a system with four HF radar pulse frequencies of 4.8 MHz, 6.8 MHz, 13.4 MHz and 21.8 MHz, which was used to detect and monitor the activities of marine vessels. The results obtained from this multi–frequency HF pulse radar were then compared with the results of the Coastal Ocean Dynamics Applications Radar (CODAR) SeaSonde® system. Another use of HF pulse radar was also discussed by Leong, H. *et al*. (2008) and it was concluded that large vessels can be detected without being affected by sea conditions. However, small boats at a distance farther than 105 km (for 3.1 MHz) and more than 95 km (for 4.1 MHz) could not be detected in very rough sea conditions, where the sea wave height is 4–6 meters. Bistatic HF and VHF radar was also used by Trizna, D.B. (2008) to track the ships and map the ocean currents. Low Power High Frequency Surface Wave Radar (HFSWR) (Dzvonkovskaya, *et al*., 2008) (Gurgel, *et al*., 2010) was also developed to detect and track ships. The results of detection ware then compared to the Automatic Identification System (AIS) database and the obtained deviation was below 1 km. Review of the algorithms for the detection and tracking of multiple targets with HFSWR was explained in detail by Liu, *et al*. (2013).

High resolution radar was recently developed by using high frequency. As an example, a Linear Frequency Modulated Continuous Wave (LFMCW) scanning radar in the X–band frequencies have been developed for the management of shipping lane (Vivone, *et al*., 2015). Target detection and tracking was

done by processing multiple radar images with multi–frame algorithms joint detection, where each radar image can be obtained after the radar scans 360°. This method worked well and has been proven by some experiments. However, the utilized frequency is quite high, e.g. 9–10 GHz so that it is not easy to be developed in Indonesia due to the limited availability of components.

This study aims to develop a PC–based FMCW radar operating at ISM frequency band of around 2.4 GHz. This frequency was chosen by considering the high availability of the required components. The radar was developed using can antennas and its main processor is a PC (Charvat, 2011). Then, the radar ranging function was tested on a moving vehicle as the target. This study is expected to support the development of simple and cost effective radars in Indonesia.

Development of 2.4 GHz PC–Based FMCW Radar

The developed radar is a simple PC–based FMCW radar at ISM frequency of 2.4 GHz. The two main tasks of radar development are the design and fabrication of the can antennas and the assembly of radar hardware.

Design and Fabrication of Can Antennas

The radar system requires two antennas for transmit and receive at the frequency of 2.4 GHz. Can–antennas which is an aperture antenna version of a cylindrical array antenna (Priandana, *et al.*, 2010) were designed by considering this frequency requirement through several calculations as well as trial–and–error experiments. The result of the can–antenna design is depicted in Figure 1. The obtained return loss value for the first and second can–antenna at 2.4 GHz was –25.395 dB and –22.554 dB, respectively. The bandwidths of both antennas were 85 MHz. These measurement results showed that the two fabricated can–antennas can satisfy the radar system requirement.
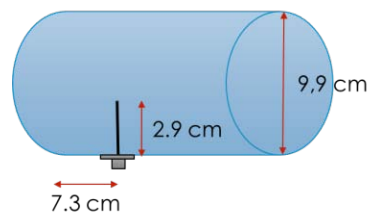
Figure 1. Dimension of the 2.4 GHz can antenna

Antenna gain measurement was done by using a 2.4 GHz dipole reference antenna. The result shows that the gain of the first can–antenna was 10.03 dB, whereas that for the second can–antenna was 10.66 dB. The radiation patterns of both can–antennas are depicted in Figure 2 (a) and (b), respectively. The figure shows that the vertical 3dB beamwidth of the first can–antenna was around 60°, whereas that for the second can–antenna was around 55°. These beamwidth values are too wide for accurate target detection. Microstrip array antennas which are expected to have a much narrower beamwidth are currently under investigation.
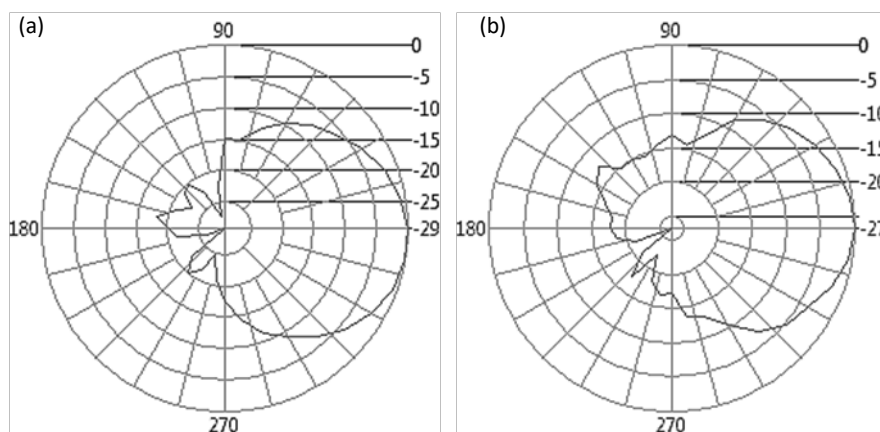
Figure 2. Vertical radiation pattern of the can antennas, (a). First can antenna (b). Second can antenna

Assembly of Radar Hardware

The general block diagram for an FMCW radar system block diagram is shown in Figure 3. There are 5 major system components which consist of an FMCW generator, a low–noise RF amplifier, a mixer, a low–pass filter, and a signal processing. Explanation of each of these components is as follows:

1. *FMCW generator*: to generate the FMCW signal, $T(t)$, to be transmitted to the target.
2. *Low–noise RF amplifier*: to increase the amplitude of the received (echo) signal, $R(t)$.
3. *Mixer*: to combine the transmitted signal and the received (echo) signal.
4. *Low Pass Filter*: to filter the high frequency signal component to obtain a low frequency beat signal, $S(t)$.
5. *Signal processing*: to process the beat signal and extract some information about one/multiple target(s).
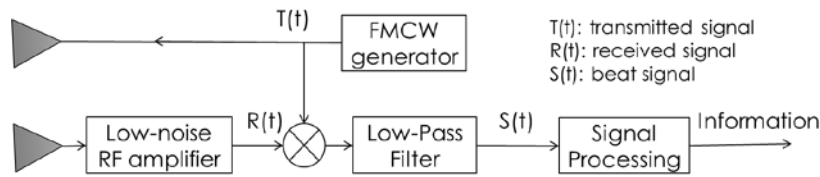
Figure 3. General block diagram of an FMCW radar

The assembled FMCW radar consists of three main blocks, namely the RF block, the video amplifier, and the function generator (Charvat, G. L., 2011). The system also has a Voltage Regulator to maintain the voltage and current supply to each of the three main blocks. The developed FMCW radar hardware and the detailed RF block are shown in Figure 4 (a) and (b), respectively. The system utilizes a stereo jack to transfer the radar data to the PC.

(a)   (b)
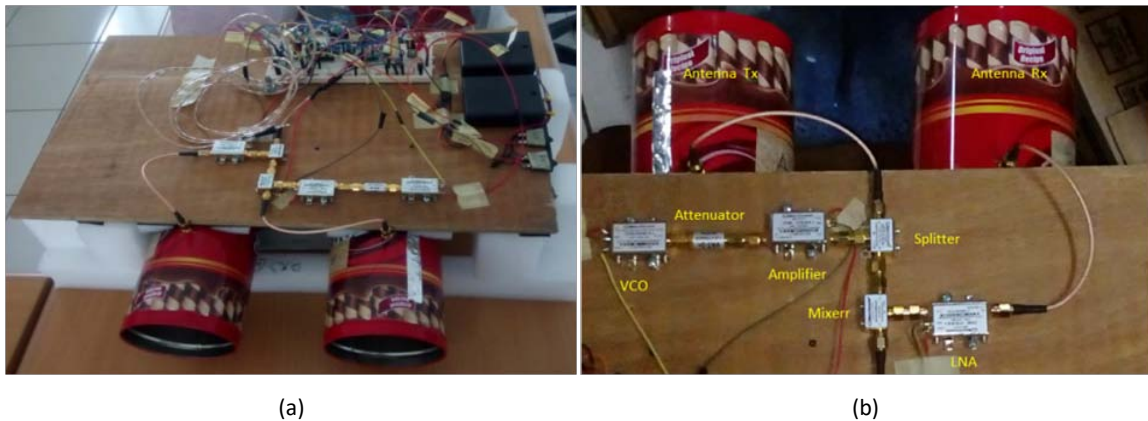
Figure 4. The developed FMCW radar hardware (a). Radar system hardware and (b). RF block of the radar system.

Experimental Results and Discussion

Two experiments were conducted at University Indonesia to verify the radar ranging functionality. First, the developed PC–based FMCW radar system was utilized to detect the relative distance information of a human walking by carrying a metal target as shown in Figure 5. In this scenario, the object is walking towards and away from the radar system for 8m and 12 m.

The second experiment was conducted to detect the relative distance of a moving vehicle. The vehicle was controlled to move away from and towards the radar system as shown in Figure 6. The vehicle moves forward for 10 seconds until it reaches 25 meters away from the radar system, then, it moves backwards again for 15 seconds closer to the radar system until the distance becomes 1 meter away.
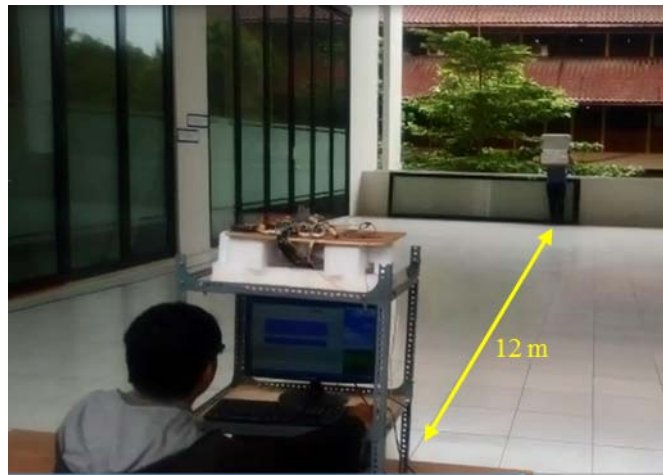
Figure 5. The scenario of the radar system ranging: first experiment

The FMCW radar signals were captured as an audio file in .wav format. Then, radar signal processing was conducted in the PC using fast Fourier transform in MATLAB software. The flowchart of the radar signal processing is depicted in Figure 7.
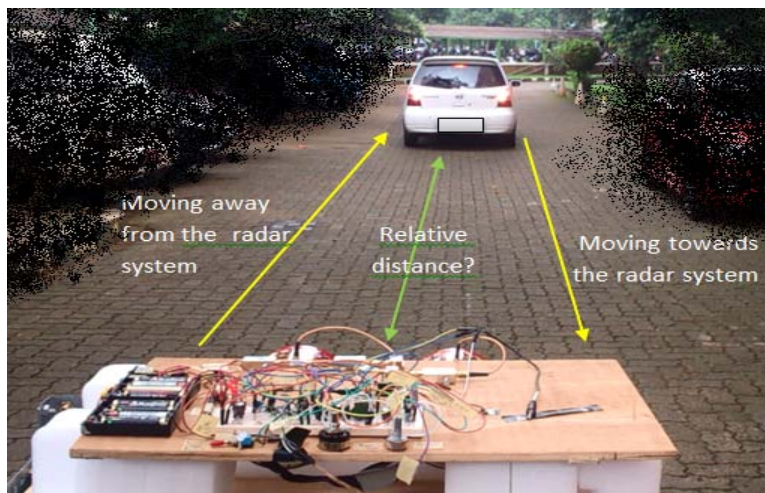
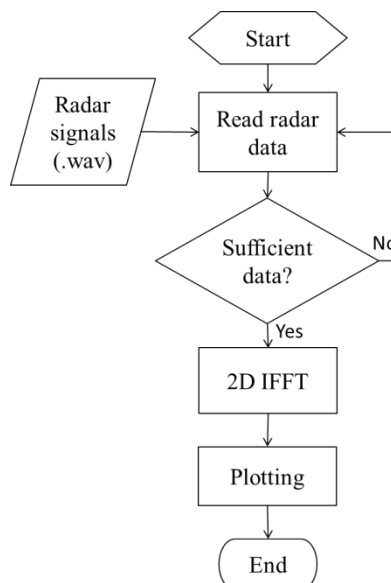Figure 6. The scenario of the radar system ranging: second experiment

Figure 7. The flowchart of radar signal processing for ranging application

The first ranging experimental result can be seen on Figure 8. The figure shows that the radar can detect the target movements in approximately 45 seconds. The first movement occurs during the first 15 seconds, where the target is moving away from the radar until 8 m away, and then moving towards the radar system again. From the 16th second onwards, the target is moving away again to a distance of around 12 m at 32 second and then back again towards the radar system at 45 second. This ranging measurement is in accordance with the experiment scenario.

The second ranging experimental result is depicted in Figure 9. Initially, the vehicle was detected by the radar system to move away from 0 to 25 meters in 10 seconds. Then, it moves closer until 1 meters away at $t = 27$ seconds. This measurement is in good agreement with the experimental setup, which proven that the radar system can successfully capture the relative distance of the vehicle.

From the two measurement results, it can be concluded that the radar system works well in detecting the relative distance of the target. Moreover, it can plot the distance measurement with respect to the correct timing. Thus, the relative velocity of the target can be calculated simply by taking the first derivative of the relative distance measurement.
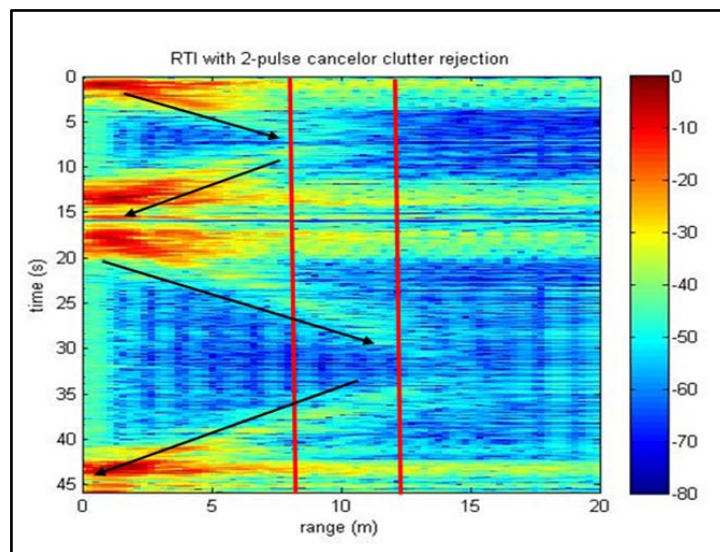
Figure 8. Radar system first ranging experimental result (target: human walking)
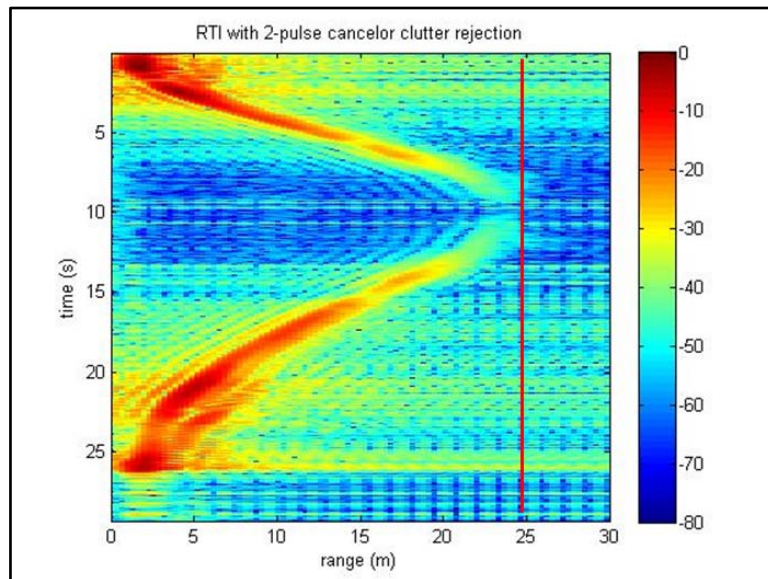
Figure 9. Radar system second ranging experimental result (target: moving vehicle)

Conclusions

A PC–based FMCW radar system at 2.4 GHz has been successfully developed and experimentally proven to be able to measure the relative distance of a moving target. Two experiments were carried out to justify the ranging functionality of the radar system. It was revealed from the experiment results that the radar system can successfully capture the relative distance of a target and plot it with respect to the correct timing. Thus, in the future implementation, the target's relative velocity can also be calculated by taking the first derivative of the relative distance measurement. The drawback of the radar system is the limited ranging resolution, which highly related to the 3dB beamwidth of the antennas, e.g. 55° and 60°. Antennas with narrower beamwidth are still under investigation.

Acknowledgements

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Online Feature Extraction Technique for Optical Character Recognition System

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Abstract

In this paper, we evaluated the performance of existing online Character Rcognition System (CSR) in extracting the feature from a standard testing image and a Roman character image. The rotating angle that use in the experiment are 90 and 180 of degree, and the scaling factors that use in the experiment are 0.5 and 2. Then, we compared the original image feature with the feature of scaled and rotated image. The result of the image feature was compared to the rotating and scaling image. We concluded that the application is succeeded to recognize with accuracy up to 95% in average.

Keywords:feature extraction, online OCR, character recognition system, Hu moment invariant

Introduction

Research in image processing field increases significantly. Now,communication is done not only through the text but also through an image. Letters, Checks, or other documents are transmitted by using computer applications. One of the ways to facilitate the storage and to distribute the documents is by digitalizing the document by photographing or scanning. Getting back or changing the image into the text format requires special technique. The technique should be capable to recover the text from the image. A system that can convert an image into a text is character recognition.

Character recognition is an interesting field in image processing research area. Character recognition has become popular research because increasing variation of characters. The main purpose of character recognition is to convert a character from digital image format become digital text format. The system that was developed for character called as Optical Character Recognition (OCR). To create an OCR application, at least we need four stages: pre–processing such as denoising (Arnia, et al., 2014), segmentation, feature extraction and pattern classification.

Feature extraction is an important step in the character recognition system. Feature extraction is performed for generating some features from an abjad or an alphabet. Each alphabet required having different and unique features. This feature will be assigned to pattern classifier for learning and classifying the feature into a particular character. Increasing the number of features that assign to a classifier, the pattern classification will get a better result.

Apart of feature extraction, to develop a character recognition system, we need a pre–processing procedure such as binarization (Fardian, et al., 2015), denoising (Muchallil, et al., 2015) and skew correction. Furthermore, segmentation and pattern classifier are also important procedure. Previous OCR techniques is developed based on an offline system. If we use the offline system, we require the reinstallation process, and it cost more times. On the other hands, the development of science and technology, many applications are developed and connected to the internet. This application was adequated to use without reinstallation process. All script commands and code will be processed by the browser through an application called a web server. This web server which will compile all of the client commands that are desired by the user then sends its result to the client. All offline application can be convertedto the online version including character recognition system.

In this paper, we evaluated an online feature extraction by using moment invariant techniques for Roman character and standard testing image. This online OCR system was proposed by Saddami for Jawi character (Saddami *et al.* , 2016). We implemented this system on local Apache server or known as localhost.

The rest of this paper is literature review on the second section. In the third section, we illustrate experiment method while in section fourth we present result and discussion. Finally, we give the conclusion on the fifth section.

Literature Review

Feature Extraction

An image feature is a value which represents identity or attribute from the image. The image feature should be extracted to get the attribute of the image, and we donate that the attribute should be different for each image object. There are two types of feature: syntaxial and statistical. Syntaxial is a feature that represents boundary or shape of the image while statistical feature is the feature that based on the image statistic distribution. One of the benchmark statistical features is Hu moment or called as geometric moment invariant (GMI) (Hu, *et al.*,1962). GMI have been widely used for extracting an image feature. Noh proposed palmprint recognizing by using Hu moment invariant (Noh, *et al.*, 2005). Then, Munadi et al., used GMI to extract image features for secure online trading (Munadi, *et al.*, 2013). In 2015, Sun extracted speech emotion feature using Hu moment invariant (Sun, *et al.*,2015).

Hu Moment Invariant

Geometric moment invariant (GMI) was proposed by Hu in 1962. Hu assumed that the statistical distribution of an image could be seen as a set of statistical distribution. The moments are defined as follow:

$$m_{pq} = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} x^p y^q f(x, y) dx dy \qquad p, q = 0,1,2,\dots \tag{1}$$

for discrete image, the moment value are defined as:

$$m_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} x^p y^q f(x, y) \tag{2}$$

the central moment of the image is

$$\mu_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (x - \bar{x})^p (y - \bar{y})^q f(x, y) \tag{3}$$

while the $\bar{x}$ and $\bar{y}$ is evaluated as follow:

$$\bar{X} = \frac{m_{10}}{m_{00}} , \bar{y} = \frac{m_{01}}{m_{00}} \tag{4}$$

the normalize central moment is defined as:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu^\gamma_{00}} \quad \text{where } \gamma = \frac{p + q}{2} + 1 \tag{5}$$

then Hu moment value was camputed as:

$$\phi_1 = \eta_{20} + \eta_{02}$$

$$\phi_2 = (\eta_{20} + \eta_{02})^2 + 4\eta_{11}^2$$

$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$

$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$

$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$\phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + 3\eta_{12})^2 - 3(\eta_{21} - \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$

$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$\tag{6}$$

Experimental Methods

In this section, we describe the experimental method. The experimental method consists of three sub–section: Dataset creation template, creating the online application and assessing the application.

Dataset Creation Template

In this experiment, character images and standard testing images was tested on online OCR. We use lena, cameraman, coins, rice and moon image for the standard image digital. The standard image digital was obtained from Signal Image Processing Institue (SIPI) (SIPI, 2005). Examples of the standard digital image showed in Fig. 1 and Fig. 2.

The character image was created by following steps:
1. Write all Roman alphabets by using font size 60.
2. Print the characters.
3. Scan the character document to change it into image format
4. Split each alphabet into a single image file.
5. Change the size of image character into 256x256.

Total Roman characters that we used in the experiment were 27 characters. Fig. 3 showed examples of Roman alphabets in image format.

| Figure 1. Lena image | Figure 2. Cameraman image |
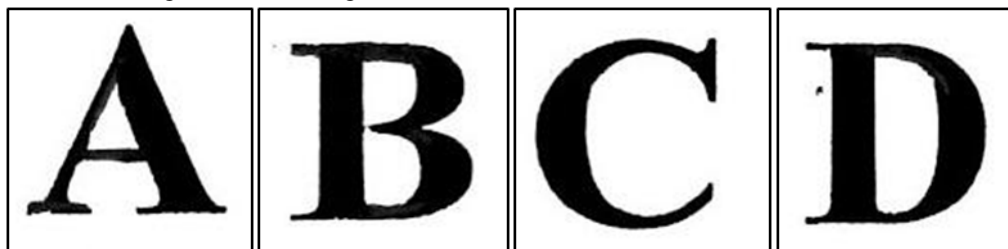
Figure 3. Roman character image

Creating The Online Application

The online OCR for character recognition was developed using PHP programming. In this paper, we rebuilt and evaluated the online OCR system for binarizing and feature extraction stages. The online application was accomplished by performing following step:

A.   Binarization Phase

The binarization process was run by applying these steps:
1. Read the image
2. Determine the image thresholding.
3. Convert the image pixel value lower than the threshold into zero and higher than the threshold into one.

B.   Feature Extraction Phase

The feature was extracted by using equation 2 to equation 6. The steps below are the process of extracting an image feature (Gonzalez *et al.*, 2004).

1. Compute m_{pq} value of the object by using eq. 2.
2. Determine the central moment from the picture by using eq. 3.
3. Calculate the $\bar{x}$ and $\bar{y}$.
4. Determine the normalized central moment
5. Establish the moment value based on eq. 6.

Assessing The Application

To ensure the application performance in extract moment feature, we assess the application by performing on transformation image and character. The transformations that applied to the character are scaling and rotation. The image and the character were scaled by a half and two–factor scaling. The rotation degrees were 90^0 and 180^0. The recognition rate is used to approach the the result of the testing method to the untransformed character. The recognition rate is as described below (Saddami, *et al*., 2016).

$$Rr = \frac{sm}{tme} \qquad (2)$$

while *Rr* is recognition rate, *sm* is similarity moment with a basic image, and *tme* is the total moment that was extracted. The basic image is the image that not transform by using scaling nor rotating.

Results and Discussion

In this section, we described the result of the experiment. The result of experiment was analyzed using recognition rate equation that noticed in eq.3.

Transformed Image and Character

The result of transformed image and character was presented in Table 1 and Table 2. Table 1 demonstrates the result of seven moments feature from standard digital image The standard image was transformed by using two scaling factors: 0.5 and 2, and rotated by using two angles: 90 and 180 degrees. Table 2 showed the outcome of Hu moment features from character image. The character image was also transformed by using the scaling factor and angle of degree as in the standard image.

In the image which was scaled by using 0.5 scaling factor, we found that only one moment from 35 extracted moment which has different from the basic image. Furthermore, the image which was scaling by using 2 scaling factor had two moments that differ to the basic image. The result showed that the image which was scaled by 0.5 scaling factor had 97.1% of recognition rate, while the 2 factor scaling image had the accuracy of 94.3%. We established that eight images had the dissimilar moment from the basic image for the image that we rotated by using angle of 90 degrees. In the image that rotated by using angle of 180 degrees, we obtained five moments that differ to the basic image moment. Based on Table 1, the image that rotated by angle of 90 degrees had 77.1% of accuracy and the image that rotated by angle of 180 degrees had recognition rate 90.0%.

In the image that we transformed by using angle of 90 degree, we found that 19 moments from 756 extracted moment which has different from the basic image character. Furthermore, the image which was rotated by using angle of 180 degrees had 14 moments that differ to the basic image characters. The result showed that the image that scaled by angle of 90 degrees had 97.5% of recognition rate, while the accuracy of the character image with angle of 180 degrees increase to 98.1%. We established that eighty images had dissimilar moment from the basic image character for the image that we transformed by using 0.5 scaling factor. In the image that rotated by using 2 scaling factor, we obtained 66 moments that differed to the basic image character moment. Based on Table 2, the image that rotated by 0.5 scaling factor had 89.4% of accuracy and the image that rotated by 2 scaling factor had recognition rate 91.3%.

The similarity level of the standard image is less than thatthe character image. It is caused by difference number of object in an image. In the standard image there are many objects in an image frame but in the character image, there is only one object in one image frame. To increase the recognition rate in extracting Hu moment feature, we suggest to segment objects in an image to be a separate object.

Table 1. Result of scaling and rotating image feature extraction

No	Scaling					Rotation				
	Scaling factor	Similar moment	Dissimilar moment	Total	Accuracy	Angle	Similar moment	Dissimilar moment	Total	Accuracy
1	0.5	34	1	35	97.1%	90	27	8	35	77.1%
2	2	33	2	35	94.3%	180	30	5	35	85.7%
	Average				95.7%	Average				90.0%

Table 2. Result of scaling and rotating character feature extraction

No	Scaling					Rotation				
	Scaling factor	Similar moment	Dissimilar moment	Total	Accuracy	Angle	Similar moment	Dissimilar moment	Total	Accuracy
1	0.5	737	19	756	97.5%	90	676	80	756	89.4%
2	2	742	14	756	98.1%	180	690	66	756	91.3%
	Average				97.8%	Average				90.4%

Conclusions

In this paper, we evaluated online OCR system for Roman character. This system uses Hu moment as feature extractor. This online OCR tested for rotating and scaling image. The rotating angle that use in the experiment are 90 and 180 of degree, and the scaling factors that use in the experiment are 0.5 and 2. The result of this research showed that the feature extraction process of Hu moment by using the online application was successfully applied. The value of Hu moment in variant that was extracted after scaling and rotating had recognition rate reached 60.8% of scaling and91.75% of rotating respectively. The result onthe character image is better than the standard images because in the standard image there are many objects in one image meanwhile in character image there is only one object.

Acknowledgements

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Design of Interaction Model for Interactive E–Book

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Abstract

E–books as a learning media have been widely known and used for learning process. The presence of e–books can be accepted because of its potential for aiding the learning process. They include a variety of interactivities to engage readers and deepen the impact of the written word. As such, they transform traditional books in creative ways that help bring content to life. However, e–books are available today are still have a static feature. They only allow learners to interact with e–Book itself. While, in the context of learning, a learner may be interacting with other learners or even the teacher/professor (in a discussion forum, for ex–ample) related to the topics in the book. E–book feature today has not been able to engage the learner with the learning environment in the construction of interaction in order to make a learner–centered learning activity. Based on this characteristic of the e–book, we do a research to propose a new model of the e–book. In this research, a digital book is more than the digital version of the traditional books. In this paper, we enhance the functionality of e–book not only as a learning content viewer. We propose a framework for introducing an interaction model in the e–book. The framework can be used as a platform for a development of the dynamic feature e–book which incorporating the learner and the dynamic learning environments. This platform allows the e–Book was developed with the addition of personalized learning aspect in the application. We illustrate this interaction model with scenarios that shows how the interaction model has been applied to increase collaboration and an effectiveness of learning using the e–book.

Keywords: Dynamic learning environment, Interaction model, Learner–centered, Learning media.

Introduction

E–Book as an integral part of the evolving technological developments come as the media used in the learning process. As a medium of learning, the e–book is interpreted differently by users. Most users perceive e–Book as the transformation of books in physical form to digital form. However, the actual e–Book was developed as an electronic–based system which includes the functions related to the learning process. In this context, the e–Book is not merely a collection of digitized content as a source of learning, but rather e–Book as the adoption of technologies that can be optimized to support learning activities and provide internal motivation for learners, both individually and collaboratively.

As an illustration, we can see how people use social media in daily activities (interaction and communication). Features in social media applications allow users to interact comfortably and unwittingly arise internal motivation for users to socialize. Based on this phenomenon, there is an assumption that the same model could be applied in the e–book. In this case, we can add some features into e–Book that support both behavioral and learning styles of the learners. Model of e–Book today is limited as a collection of digitized content containing text, images or videos. E–Book delivers multimedia–based information in the form of a compact and dynamic form. When one reads the e–Book, they just see the difference in the representation of the book, but the behavior of the learners in the learning activities have not been represented digitally. For example, when a person learns, she could have added notes on the book. Or may interact with other people who read the same book to discuss the topic being read.

E–book as a medium of learning not only as a learning content viewer but in an e–Book, it is possible to add other functions such as the interaction model to support collaborative learning aspect. Our research will define the interaction model as a platform to expand the functionality of the e–Book. This platform allows the e–Book was developed with the addition of personalized learning aspect in the application.

This paper will present the proposed interaction model and design process of e–book application which is developed based on the interaction model as the e–book platform.

Literature Review

Unified Process

The techniques presented in this research are the Unified Process (UP), which is heavily based on UML. UP was proposed by Grady Booch, James Rumbaugh, and Ivar Jacobson (Jacobson, *et al.*, 2005) as the result of their research and experience.

Schelling (Schelling, *et al.*, 2005) states Unified Process is an integrated process for building interactive system that has the same phase as RUP (inception, elaboration, construction and transition) (Kruchten, *et al.*, 2001). In the process of development, the stage of the evaluation conducted by the Unified Process or UPI (Sousa, et al., 2007) and follow the approach depends on the UI design prototype device developed (Coyette, *et al.*, 2004; Bjørner, 2009).

Object Oriented Analysis Design

The Object Oriented Analysis Design (OOAD) is a development method that checks the system requirements in a class and objects encountered within the scope of the problem, to develop a software architecture that is based on the manipulation of objects the system or subsystem (Wazlawick, 2014). OOAD includes the analysis and design of an object–based system, including object–oriented analysis (OOA) and object–oriented design (OOD). OOA is an analysis method that checks for the requirements (requirements/specifications/preferences) to be met a system from the viewpoint of classes and objects found within the scope of the problem. While OOD is a method to review the software architecture is based on the analysis of objects systems or subsystems.

Methodology

The process of developing an interaction model in interactive e–book consists of the following stages:
1. Defining interaction model specifications
2. Determine the structure of interaction
3. Designing the functional model
4. Designing the system architecture of e–Book

Unified Process (UP) is used as an approach to the development of the system. UP includes the steps as follows:

*Inception.*The Inception phase of the Unified Process (UP) consists of a period of time when the analysts are looking to gather information about the business to be automated or restructured (Jacobson, *et al.*, 2005; Wazlawick, 2014). In this phase, we discover the relevant information and define the interaction model specification. The interaction model specification is a conceptual model as a platform of e–book which will be developed.

Elaboration. The Elaboration phase of UP is performed as a sequence of iterations. Each iteration has a set of use cases assigned for development (Jacobson, *et al.*, 2005; Wazlawick, 2014). In this phase, the conceptual model will be refined and completed with the structure of interaction. We also start to define the functional model.

Construction. The Construction phase concentrates on producing code for the whole application and implementing change requests. During the Construction phase most of the code production and test activities are performed. It is expected that the Elaboration phase produces an architecture sufficiently stable so that its refactoring will be minimized during this phase (Jacobson, *et al.*, 2005; Wazlawick, 2014). In this phase, we focus on develop the prototype of the e–book.

Transition. The Transition phase consists typically of the final tests and the delivery of the system to its users including possibly its installation and data migration. During this phase, the system will be deployed, possibly replacing an existing system (manual or automatic) (Jacobson, *et al.*, 2005; Wazlawick, 2014). In this phase we will conduct product testing related to educational usefulness aspect and UI usability aspect.

Result and Discussion

Interaction Model Specification

The main contribution of this study is an interaction model that is added to the e–Book. The interaction model is represented in several functionally associated with the use of e–Book as a medium for collaborative learning. This model is described using formal specification. Based on (Nugroho, 2015), domain model in the e–book system can be expressed as follows:

Ti (Topic) represents the real object of the domain model of discussion. In this case, the objects in the domain model can be a book or a section of a book (chapter) and even a smaller part of the chapter (can be text, images, video and etc). A Topic (Ti) can involve multiple Actor (Ai) and any Actor can perform some action or Operation (Oi) associated with the topic (Ti) is restricted in Context (Ci); Structure of Interaction

Ci (Context) is a boundary of a topic that binds the scope of the interactions that occur between users (Actor) through action or activity called Operation which carried by the actor.

Ai (Actor) is the subject/user involved in a Topic (Ti).

Oi (Operation) represents any action or activity that can be performed by Actor (Ai) in a Context (Ci).

The Structure of Interaction

In order to explain the implementation of the proposed interaction model, we used the following scenario to illustrate the structure of interactions. The following scenario represents an overview of a class discussion. In a class, there are 15 students, three mentors, and one teacher. The teacher divides the class into three groups, each group consisted of five students and one mentor. Each group is asked to organize discussion of one chapter in the e–book. At the end of a group discussion, they were asked to make a conclusion in a class discussion that is followed by all students and teachers. The illustration of this scenario can be seen in Figure 1.
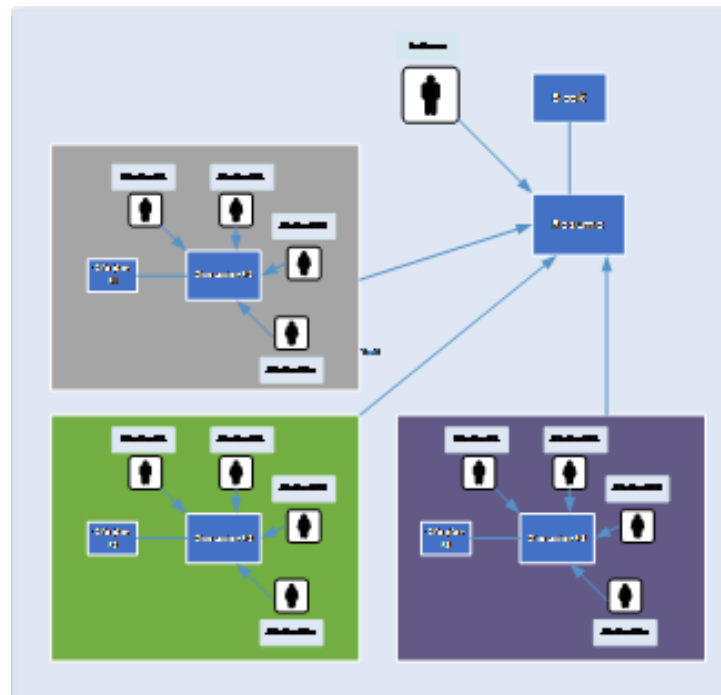
Figure1.The scenario for the structure of interaction

The scenario (Nugroho, L.E., 2015) can be expressed as follows:

chapter_one_Context: {Student1..Student5, Tutor1;
  on send(*;*;discussionMessages)
  send(*;*;discussionMessages) ∨ null)
    }
chapter_two_Context: {Student6..Student10, Tutor2;
  on send(*;*;discussionMessages)
  send(*;*;discussionMessages) ∨ null)
    }
chapter_three_Context: {Student11..Student15, Tutor3;
  on send(*;*;discussionMessages)
  send(*;*;discussionMessages) ∨ null)
    }
resume_Context: {Student1..Student15, Teacher;
  on send(*;*;discussionMessages)
  send(*;*;discussionMessages) ∨ null)
    }
tag(Book) : {
  tag(Chapter1) : {chapter_one_Context}
  tag(Chapter2) : {chapter_two_Context}
  tag(Chapter3) : {chapter_three_Context}
  on allGroupDiscussionCompleted
    send(Teacher;*;summaryMessages) ∧
  on send(*;*;discussionMessages)
    on send(*;*;discussionMessages) ∨ null
}

The Functional Model Design

The functional model is used to describe the functionality that was developed in the e–Book. The functional model in this study is described using use case diagrams. Each component in the use case representing the functions in the model.
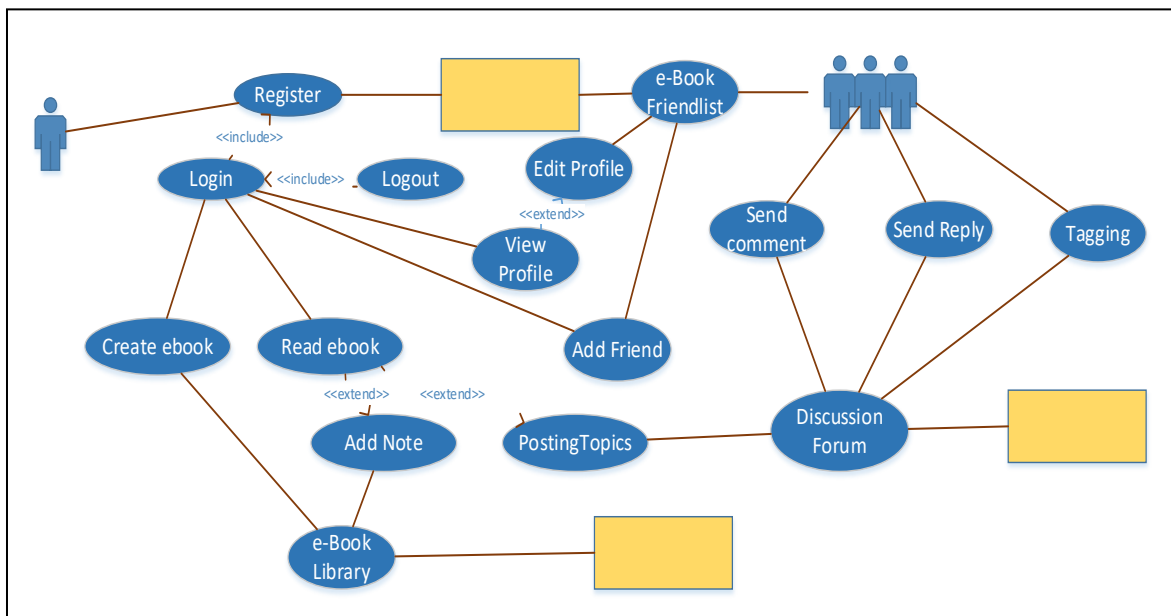
Figure 2. The functional model

Figure 2 displays the use case diagram for the proposed interaction model. In the diagram, there are four components to build a model of interaction, namely **Content Component**, **Interaction Component**, **Activity Component**, and **User**. Content Component is a component that was developed to manage the content (the object: book, chapter, part). Interaction Component is a component that was developed for the management of interaction such as discussion forums, leave a comment (comment), tagging or mention

defined in the e–Book. Activity Component is a component that was developed to manage the activities associated with the learning process such as adding a note in the content, create links, and for further development can be used for evaluation of learning management and other assessments. The last component, User is a component that acts as an actor in interaction models are made. In this case, the actor can do interactions through specific operations are conducted in an environment or context. An interaction can involve many actors (as in the previous scenario, actors involved are students, lecturer, and mentor).

In an interaction (e.g. a discussion), Users that are involved in the interaction must have been registered in the system of e–Book. Through this registration operation, a user will have an account that will be associated with another account through the mechanism of friendship. A user can add friends or confirm friendships, create discussion groups, manage and edit the profile, and view profiles of other users.

The System Architecture of e–Book

The architectural design describes the components that build the e–Book and interactions between components as well as defining the functionality of the e–Book. As described in the previous section, the design of the e–Book consists of four components: User, Activity Component, Component Content and Interaction Component. The architectural design of the e–Book is shown in Figure 3.
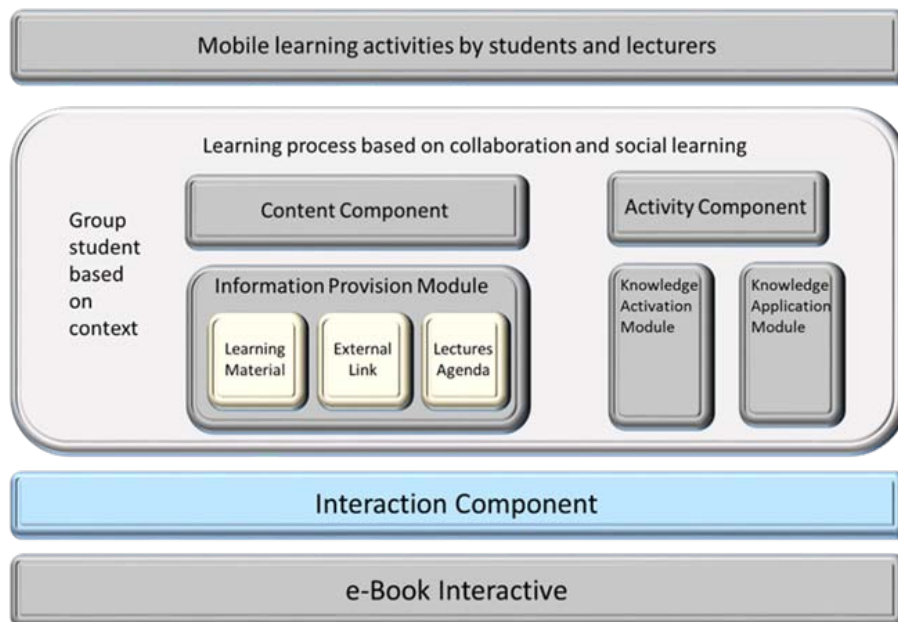
Figure 3.The e–book architecture

Figure 3 shows a section that becomes contribution of this study is a layer of Interaction Component. This component is a framework that is added to the e–book system to accommodate aspects of interaction which is not supported in the existing e–book.

The e–Book Prototype

In order to demonstrate the functionality of the proposed interaction model, we developed an e–Book prototype that has been added component interaction in it. The prototype developed is focused on interaction features that can be done in the context of learning or reading of e–books. Some snapshots prototype e–book can be seen in Figure 4.
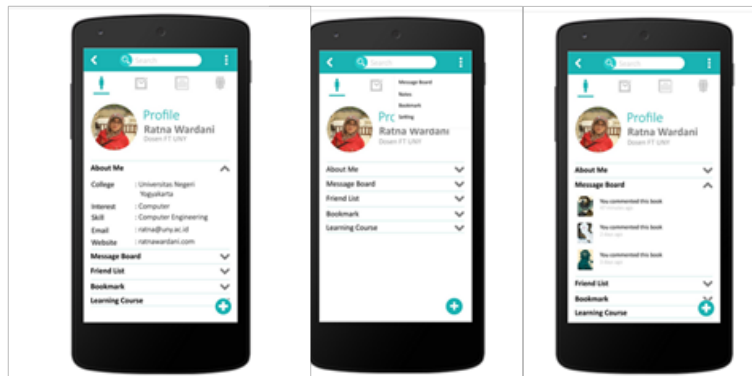
Figure 4.The e–book prototype
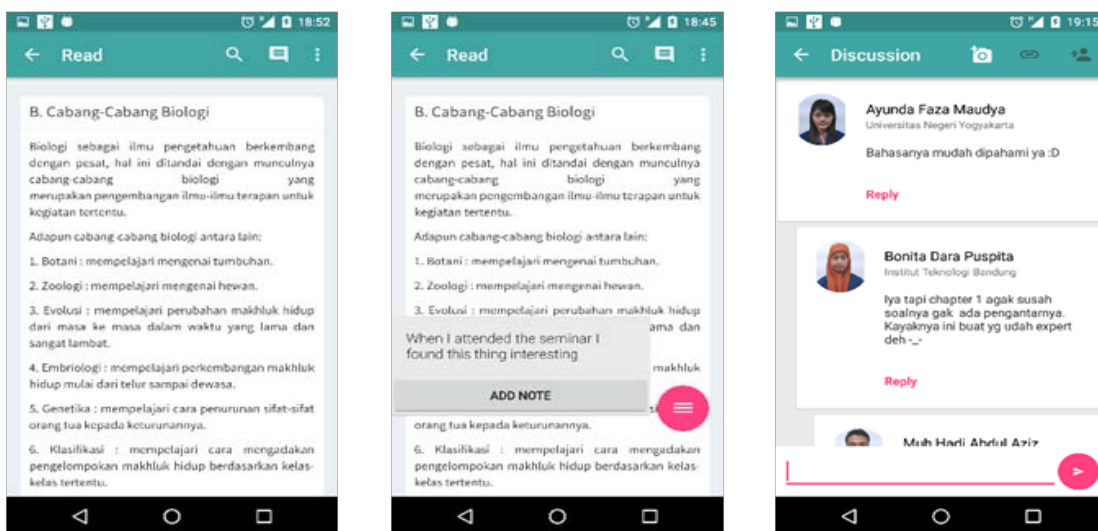
Figure 5.The e–book prototype

Figure 4 and Figure 5 show a dashboard where there are several features for users to perform some of the activities and interactions with other users who are reading a book or chapter or are interested in the topics of discussion are posted by users.

Conclusions

The e–Book system in this study is a new concept. Interaction models added to the e–Book is intended to improve the functionality of the e–book as a medium of learning. Interaction model was developed based on the patterns of interaction in social media, the difference is the interaction in the e–book will be more focused in the context of an e–book that is being read. The proposed interaction model allows the user to interact with other users in terms of sharing, discussion, and collaboration.

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Design and Realization Gas Control System in Closed Room Based on Fuzzy Logic

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Abstract

The air quality is one factor that determines a person's health. This study uses a sensor that is sensitive to cigarette smoke gas and CO gas is MQ–2 sensor and MQ–7 sensor and the entire system is controlled by an Arduino Uno working based on fuzzy logic. The system was implemented for a closed room using fans. Fuzzy logic method with two inputs from the sensors, an output of pulse width modulation (PWM) and nine rules was used control fan speed. Fuzzy logic output is divided into five conditions. In PWM, value of 43 represents the condition slowly while the PWM value of 203 representing the conditions very quickly. Voltage at the output of the system under test with a calculation based on the duty cycle and measurement using a multimeter has a difference that is not constant in each condition. The greater the voltage generated, the greater the difference between the results of measurements and calculations. However, the input value is directly proportional to the value of output.

Key words: gas control system, fuzzy logic, PWM, Arduino Uno.

Introduction

The air is healthy to be one of the factors that determine a person's health. Both were in open spaces or in an enclosed space air quality affects the quality of healthcare. In a closed room with a quantity of people in the room, affects the air in the space.

Gases such as carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4),are harmful gases if breathed in by humans. The simplest result of excess gas is blown, and the most dangerous is that it can cause death. With a certain level of effect would a person experiences can occur in a vulnerable time.

Therefore, a room must set air inside. The setting is meant to be directly proportional to the air condition in the room. Fans are used to circulate air in the room, will rotate according to the changing content of the gas that is read by the sensor. In this study, a system that will control the composition of the gas in the room was designed. The system used two sensors as detecting the presence of CO gas and smoke. This system was be controlled by fuzzy logic, was have fans and circulate air in the room.

The previous research has been conducted by Febriantono (2014) had made an arrangement designing gas in the smoking room to be controlled by PID. In other one, it had been realized a system that can monitor a room against the gas CO (Liangdo & Wibowo, 2008). We were motivated to develop a system which is controlled by fuzzy logic. The advantages of using fuzzy logic has also been demonstrated (Roswaldi & Mooduto, 2004). Here, we enhanced to the existing work, in addition to gas sensor smoke, we also add sensors that are specifically sensitive to CO gas. Due to the addition of sensors and control of the fuzzy logic, it is expected the system can be controlled better.

This paper is organized as follows. In the next section we will present a brief theory of devices used in this research including gas sensors (MQ–2 and MQ–7), Arduino Uno, motor driver (L298N), direct current (DC) fan, fuzzy logic system, and pulse width modulation (PWM) system. In third section, we describe the methodology for design and realization of gas control system based on fuzzy logic which is addressed in this study. We present the result and discussion in fourth section. We end with the conclusion.

Theory

MQ–2 Gas Sensor

MQ–2 gas sensor is used to detect gases that are considered by sensors as cigarette smoke. When the sensors detect the presence of smoke is the resistance of the sensor will change and affect the value of the sensor output.

The sensor consists of ceramic Al_2O_3, SnO_2 as the sensitive layer, as well as a silver electrode. Sensor MQ–2 has a 6–pin, there are 4 pins for reading gas and two for current providers. Additionally, these sensors can work up to 24 hours. These sensors can work at a temperature of −20 °C to 50 °C. MQ–2 sensor characteristics can be seen in Figure 1 below.
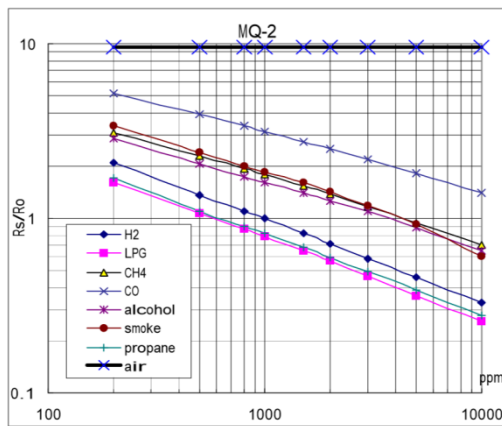
Figure 1. Characteristics sensor MQ–2 (Hanwei, 2009)

MQ–7 Gas Sensor

MQ–7 gas sensor is used for sensing carbon monoxide (CO). The sensor with SnO_2 material is sensitive to CO gas with CO gas concentration susceptible from 20 ppm to 2000 ppm. The sensor consists of ceramic Al2O3, SnO2 as the sensitive layer, as well as a silver electrode.

If the CO gas is detected, the output voltage on the sensor will go up, so that the gas concentration will decrease and the process deoxidized. As a result, the surface of negatively charged oxygen will be reduced, the height of the barrier joint surfaces will also be happening. This resulted in a decrease in resistance of the sensor also has a heater, which serves as the cleaning of indoor air contamination sensor (Pradika, *et al.*, 2010). Figure 2 following is a characteristic MQ–7 sensor.
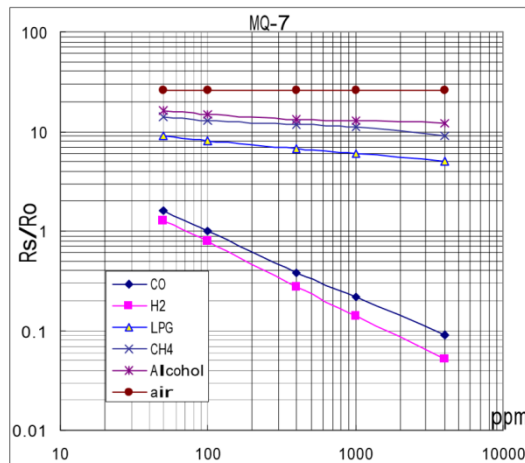
Figure 2. Characteristics sensor MQ–7 (Hanwei, 2002)

Arduino Uno

Arduino Uno is one kit of Arduino. ArduinoUno is a microcontroller board based on the ATmega328. This board has 14 digital input/output pins (of which 6 pin can be used as PWM outputs), 6 analog inputs, 16 MHz crystal oscillator, a USB connection, power jack reset button. Pin–pin contains everything needed to support the microcontroller, simply connect to your computer with a USB cable or a voltage source can be

obtained from the AC–DC adapter or battery to use it (Arduino, 2011). Figure 3 below shows the physical form of the Arduino Uno.
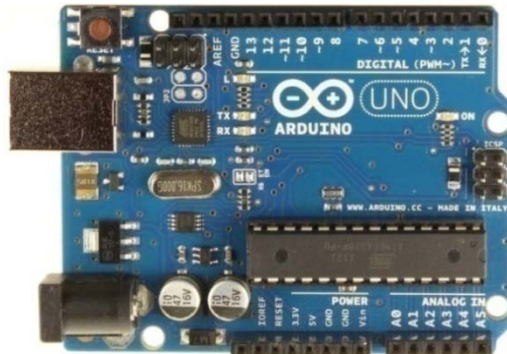

.
Figure 3. Arduino Uno Board

In Table 1 below shows the characteristics of Arduino Uno.

Table1. Characteristics of Arduino Uno

Microcontroller	ATmega328P
Work Voltage	5V
Input Voltage	7–12V
Pin Digital I/O	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	40 Ma
Arus DC untuk pin 3.3v V	50 Ma
Flash Memory	32KB(ATmega328P)of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Wide	53.4 mm
Weight	25 g

L298N Motor Driver

L298N driver module, using ST L298N chip can directly control two 3–12V DC motor, and provides a 5V output interface, we can easily control the speed and direction of movement of the DC motor. Figure 4 following is a physical form L298N driver.

Figure 4. Motor driver L298N

DC Fan

In the DC fan there is an electric motor, the electric motor converts electrical energy into mechanical energy. DC motors work on the principle of interaction between the two magnetic fluxes. Where will field coils generate magnetic flux, which is directed from the north pole to the south pole and coil would anchor a circular magnetic flux (Saputra and Amien, 2013). To adjust the rotating speed of a DC motor can be done by increasing the armature voltage, fan rotation speed will increase and by reducing the field current, the fan speed will drop. Pictures of a DC fan used in the system of us can see in Figure 5 below.

Figure 5. DC fan

Fuzzy Logic

In 1965, Lotfi A. Zadeh modified the set theory in which each member has a membership degree valued continuously between 0 and 1. This set is called the fuzzy set (Kusumadewi, 2002). Fuzzy logic is a rule–based decision–making process that aims to solve the problem, in which such systems are difficult to model or there is an ambiguity and vagueness are plentiful.

Fuzzy logic provides the possibility of a state in the interval between 0 and 1. Boolean simply dividing a state into two states 0 and 1 (Timur, 2015).To more clearly seen in Figure6 below.
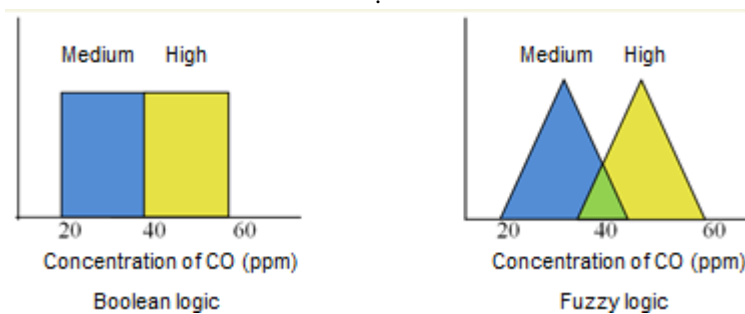
Figure 6. Boolean logic and fuzzy logic

Some advantages of using fuzzy logic, among others (Banks & Hayward, 2002):
1.   Normalized number system.
2.   Natural smooth transition between different strategies.
3.   Focus on problem solution, not problem analysis.
4.   Works well on conventional embedded microprocessors.
5.   Can easily be combined with conventional software

To form a fuzzy system, should be done three phases, namely fuzzification, rule evaluation, and defuzzification. Fuzzification is processing the crisp input into the form input Fuzzy membership function, for example, the amount of CO 25 ppm crisp will be transformed as a "moderate" in Fuzzy, and so forth.

Stages rule evaluation is the use of action Control Rule to determine what should be done in response to input. Defuzzification is the last step is defuzzification where the goal is to convert each of the inference engine results expressed in the form of fuzzy sets to a real numbers. The result of such conversion is the action taken by the fuzzy logic control system (Timur, 2015). Defuzzification step in this research using centroid method.

Pulse Width Modulation

Pulse width modulation (PWM) is a modulation technique by changing the pulse width (duty cycle) with a fixed amplitude and frequency.
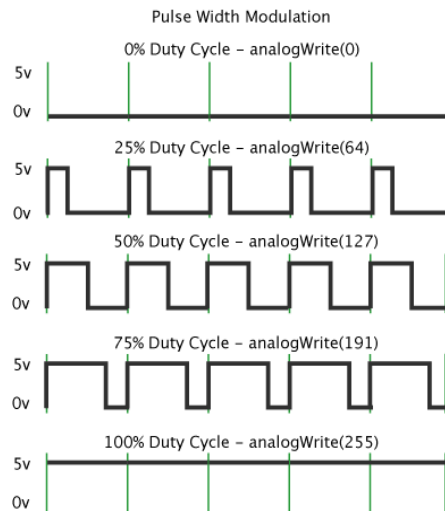
Pulse Width Modulation

0% Duty Cycle – analogWrite(0)

25% Duty Cycle – analogWrite(64)

50% Duty Cycle – analogWrite(127)

75% Duty Cycle – analogWrite(191)

100% Duty Cycle – analogWrite(255)

Figure 7. Pulse width modulation (PWM) signals

Figure 7 above is visualization PWM. One cycle pulses is high then the conditions are in the transition zone to a low state. Duty Cycle is the representation of conditions in a high logic signal period and in the state in the form of (%) with a range of 0% to 100%, for example if the signal is in a state of continuous high it means to have a 100% duty cycle (Timothy, 2011). By knowing the magnitude of the duty cycle of the output voltage can also be calculated with the following equation 3 below.

$$V_{out} = D \times V_{in} \tag{1}$$

where V_{out} is output voltage, D is duty cycle, and V_{in} is input voltage.

Methods

Block Diagram of System

In the system, there are two inputs, namely, MQ–2 sensors to detect smoke gas and MQ–7 sensor that detects CO gas. The input value is given both sensors will be used in the fuzzy logic. The input value in question is a lot of his or concentration of the gas detected by the sensor.

In fuzzy logic process input value will be taken by the fuzzification method value min. Then the membership output value is determined by the method of max. So it can be seen how the output of the system. Shape output of this system is a round DC fan used to circulate air in the room. The fan rotation set by PWN that controls rotation using the percentage of duty cycle. A block diagram of a system that is designed from input to output can be seen in Figure 8 below.
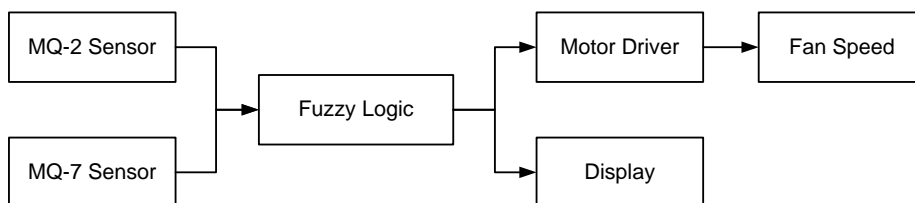
Figure 8. Block diagram of the system

Configuration of Arduino Uno Pins

Arduino particularly a major role in the system, as the receiver input, and fuzzy logic process as well as giving an output value to drive the fan. Port voltage of 5V is used for voltage sources for sensor and LCD and grounding port. Six digital port used for LCD and six digital port for L298N motor driver. Arduino works with the source voltagefrom the output voltage of 5V driver motor. Port A0 to read the signal from the sensor MQ–2 and port A1 to read the signal from the sensor MQ–7. For more details see Figure 9 below.
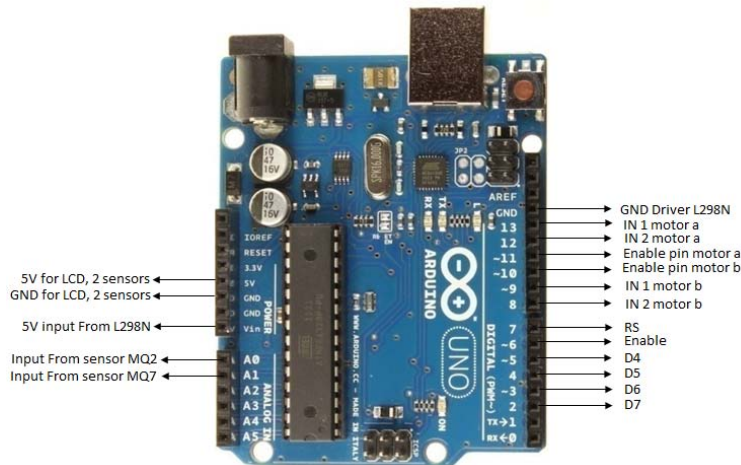
Figure9. Configuration of Arduino Uno Pin

Design of Fuzzy Logic Inference System

This system uses two inputs, i.e. the signal from MQ–2 sensor and the signal MQ–7 sensor, and gives an output i.e. PWM signal. The PWM signal would control the fan rotational speed in fuzzy logic process both inputs will affect the amount of output. the fuzzification stage, the input value will be used as input fuzzy. This stage has nine rules by the three membership functions of each input. output itself has five conditions. the rules used in this system can be seen in Table 2 below.

Table 2. Fuzzy rules in the system

No.	MQ–2 Sensor	MQ–7 Sensor	PWM
1	Little	Little	Slow
2	Little	Medium	Less Fast
3	Little	Much	Fast
4	Medium	Little	Less Fast
5	Medium	Medium	Fast
6	Medium	Much	Faster
7	Much	Little	Fast
8	Much	Medium	Faster
9	Much	Much	Very Fast

Figure 10 and 11 below show input membership function and Figure 12 show output membership function.
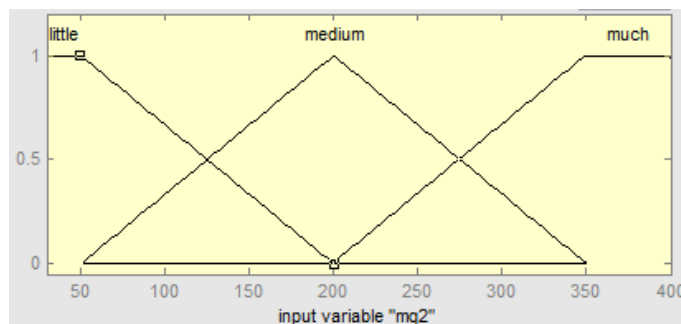
Figure 10. MQ–2 input membership function
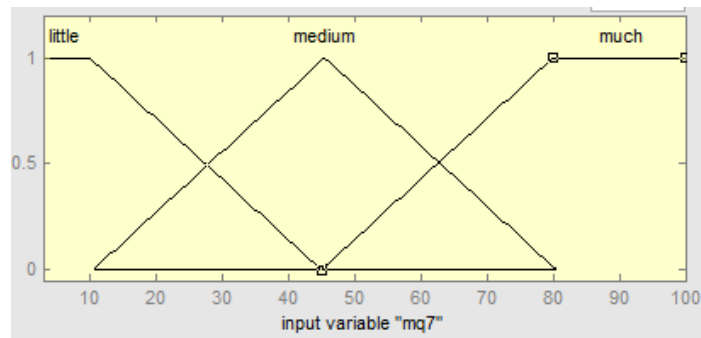
Figure 11. MQ–7 input membership function
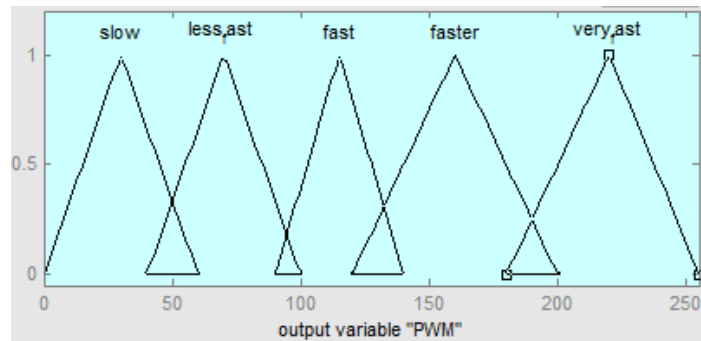
Figure 12. Output membership function

Results and Discussion

Testing of Fuzzy Logic

Tests on fuzzy logic is done through simulation using Matlab, mathematical calculations, and outputs Arduino. From the three ways, the results of testing the value of fuzzy shown in Table 3 below.

Table 3.Comparison of test results fuzzy

Output	Matlab	Arduino	Calculation
Slow	43	43,25	37,5
Less Fast	64	64,08	66
Fast	115	115,39	114,9
Faster	152	152,27	150,27
Very Fast	203	203,39	209,5

Figure 13 below shows a comparison chart of test results fuzzy logic value.
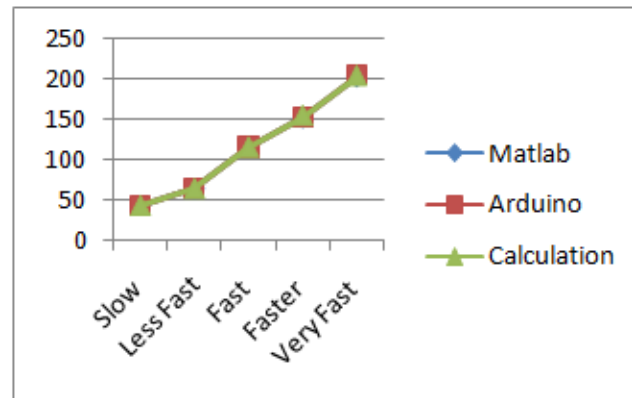
Figure 13. Fuzzy logic testing results

Testing of L298N Motor Driver

Tests on these drivers aim to look at the output PWM waveform that drives the fan rotation. The amount of duty cycle which affects the round will be used to calculate the voltage available at the output as well as its compare the measurement results using a multimeter. The following are shown in Figure 14 PWM waveform for overall conditions.
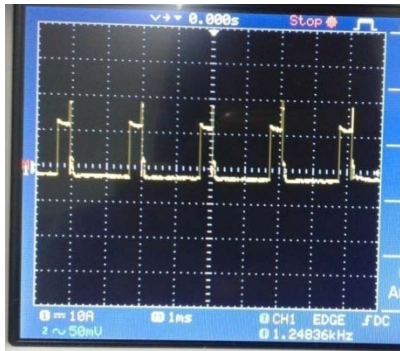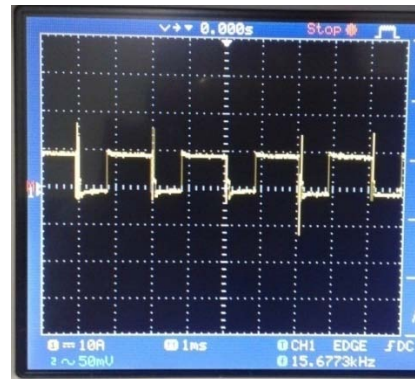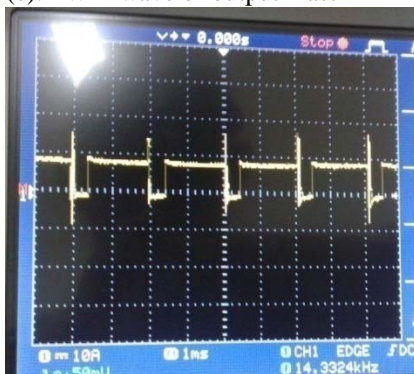

(a). PWM wave of output "slowly"
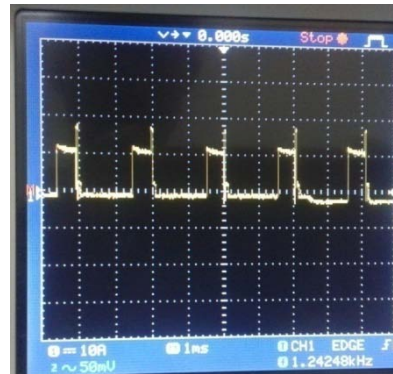
(b). PWM wave of output "less fast"
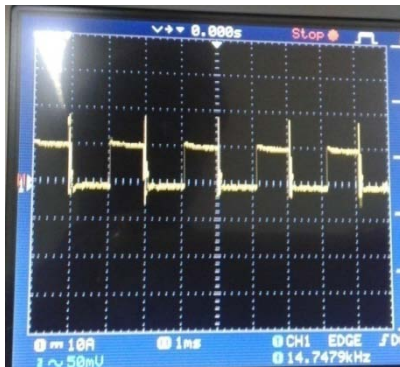
(c). PWM wave of output "fast"

(d). PWM wave of output "faster"

(e). PWM wave of output "very fast"

Figure 14. PWM waveform for overall conditions

Table 4 below shows the test results of L298N driver to measurement using a multimeter and a manulallycalculation based on the duty cycle.

Table 4.Comparison of test results L298N driver

Output	PWM	Duty Cycle	Meansurement	Calculation
Slow	43	16,8%	1,45V	1,5V
Fast Less	64	25%	2,2V	2,25V
Fast	115	45%	3,4V	4,05V
Faster	152	59%	3,95V	5,36V
Very Fast	203	79,6%	4,8V	7,16V

The following Figure 15 is a graph showing the difference in value PWM results of calculations and measurements.
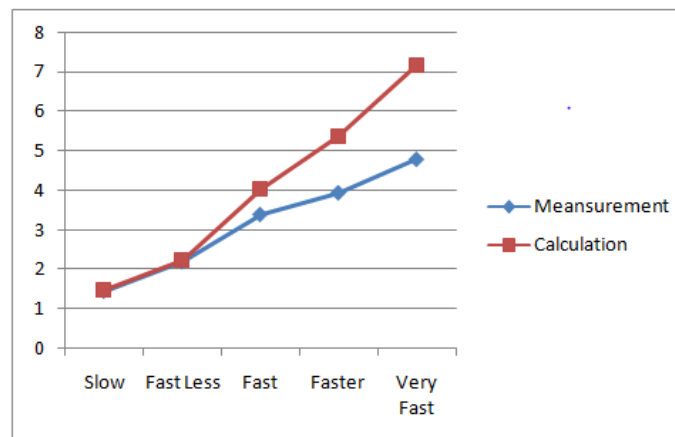

Figure 15. Curve comparisons between outputs

Conclusions

The design of control system of gas in the room based on fuzzy logic has been realized and correctly operated. This study uses two sensor input value MQ–2 and MQ–7 sensor and a single PWM output that would regulate the fan rotation with nine fuzzy rules. Each input value changes will alter the output value. In this study, input to slowly condition obtained by the value of MQ–2 at 60 ppm and 15 ppm MQ–7sebesar generate PWM output value of 43 and a voltage of 1.5 V. In conditions very quickly the value of the input MQ–2 at 345 ppm and MQ– 7 of 75 ppm generate PWM output value of 203 and a voltage of 7.16 V. The voltage at the output of the system under test with a calculation based on the duty cycle and measurement using a multimeter has a difference that is not constant in each condition. The greater the voltage generated, the greater the difference between the results of measurements and calculations.

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Circular Patch Microstrip Antenna Design for Wideband Communication

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Abstract

Microstrip antenna is one kind of antenna with small dimensions, light weight and compact. Microstrip and coaxially fed antennas are commonly used in various type of smart antenna.Typically, microstrip patch antennas have problems of low bandwidth. In this research a microstrip patch antenna was designed to have wider bandwidth and work on wideband communication. The patch shape is circular. It is feed by a coaxial probe which is located at the middle of the patch. The result of the simulation showed that the antenna gain of 0.23 dB and VSWR of 1.859 could be achieved, and the frequency centre was at 4.74 GHz with –10.51 return loss. In addition, the bandwidth gained in the simulation was 820 MHz on the working frequency from 3.1 to 7 GHz. Based on the simulation result, an antenna prototype was built. the simulation result above has shown that the designed antenna has a good performance and complied with FCC standard for wideband communication.

Keywords: wideband, microstrip antenna, circular patch.

Introduction

Wireless technology has become a ubiquitous technology in modern society in the information age today. Wireless devices have reached almost all the people not only in developed countries, even the people in the developing countries. Many applications continue to evolve and use a wireless platform as the device model. Therefore, it is not surprising that demand for wireless–based communications equipment that is easy to carry anywhere and supports data transfer rates continuing high anticipated by the user. Wireless devices that are produced must be accepted by users and convenient to use. Therefore, a compact shape and light is an attraction and the miniaturization of the antenna as a component in the communication is important to consider.

As it is progressing, many research on the area of wideband antenna have been conducted to meet the people demand of wireless communication. To make the wireless communication to be low cost and ubiquitous, a low profile and small dimension antenna is needed. Microstrip antenna is one of the most popular types of planar transmission lines that has characteristics that meet these requirements. Microstrip antenna is low profile and has small dimension, easily fabricated and integrated to the electronics devices (such as IC, active and passive device, etc.) and has low fringing effect. The focus of this research was to design and analyze the characteristics of microstrip antenna with circular patch form, working on the frequency of 3.1 to 7 GHz

Microstrip Antenna

Microstrip antenna is an antenna that is designed and fabricated on the printed circuit board and generally works at microwave frequencies. Compare to other antennas model, microstrip antenna which is most widely used in telecommunications equipment. Its accomplishment starts from very well known advantages such as: light weight, low profile, easy and low cost fabrication. In applications, microstrip antenna is one of microwave antenna that is used as an efficient radiator in many modern telecommunication systems such as *Global Positioning System* (GPS), *Personal Communications System* (PCS), and *Direct Broadcasting System* (DBS). This type of antenna is widely chosen in various applications for its simple shape, and other advantages described above. However, on the other hand, it has the limitation in bandwidth,

gain and the power handling capability. Therefore, many techniques have been developed to increase the bandwidth and very wideband microstrip antennas have been introduced (Wong, 2002; Chen, 2006)

Circular Patch Microstrip Antenna

Microstrip antenna with circular patch will have the same performance as the square one. For certain application, like array, the circular patch is more beneficial compare to others. The microstrip antenna with circular patch is easy to modify to yield certain impedance value, radiation pattern and working frequency. There are many methods available to analyze this antenna, including: cavity model, matching mode with side admittance, common transmission line mode, integral equation approach, coaxial probe and FDTD.

Substrate and Patch Radius.

Substrate used in a circular patch microstrip line is considered by selecting a suitable dielectric material by adjusting the thickness *(h)* and loss tangent *(δ)*. Thicker substrate, which obviously mechanically stronger, may increase radiated power, reduce conductor loss, and improve the bandwidth impedance. However, thicker substrate also increases the weight, dielectric loss, and ground wave loss. Dielectric constant of a substrate (ε_r) has the same function as substrate thickness. Lower ε_r value will increase the side area of the patch that will radiated power. For that reason, it is better to choose ε_r value < 2.5, unless if the smaller patch is desired. The increasing in substrate thickness has the same impact as the decreasing of ε_r value from antenna chareteristic. A high loss tangent will increase dielectric loss and in turn will decrease the efficiency of antenna, The materials that are commonly used as substrate include: *honeycomb* (ε_r = 1,07), *duroid* (ε_r = 2,32), *quartz* (ε_r = 3,8), dan alumina (ε_r = 10). So that, the substrate used has to be the one with low dielectric constant, in order to achieve higher radiation efficiency.

In the antenna design, the value of a_e on working frequency *fr* is calculated using equation (Balanis, 2016):

$$a_e = \frac{1,841}{k_0\sqrt{\epsilon_r}} = \frac{8,794}{f_r\sqrt{\epsilon_r}} \qquad (1)$$

Feeding Technique

Microstrip antenna can be fed with several methods that are classified into two categories, contacting and non–contacting method. In contacting method, RF power is fed directly to patch radiator using connecting element. While in no contacting method, RF power is fed by electromagnetic coupling from microstrip line to the patch. Some feeding techniques that are commonly used are microstrip line technique, coaxial probe, aperture coupling and proximity coupling, see Garg (2000).

There are many previous researches on circular patch microstrip line have been conducted. One of those is the research conducted by Nagalingam, in which he investigated and designed a circular patch microstrip line for Ultra–Wideband application (UWB) and analyzed it in time domain (Nagalingam, 2010). He was successfully found the antenna parameters required, using leveling microstrip line mode, in which the feeding line was directly connected to patch radiator.

Another research was conducted by Zani, *et al.* (2010), who investigated the effect of dielectric material on bandwidth. The microstrip line design was directly connected to patch radiator. Some other researchers also used microstrip line feeding technique by changing the shape and location of the feeding line. In this research, coaxial probe was used as the feeding technique. This technique was selected for it was the best method that can be used to increase the antenna bandwidth. The coaxial probe in this feeding technique was connected directly to the patch, so it may increase the effectivity of the antenna designed.

Method

Parameters of an antenna should be the main factors to be considered in designing an antenna, including the circular patch microstrip line antenna. Bandwidth and efficiency of microstrip depend on its dimension, shape, substrate thickness, substrate dielectric constant, type and location of feeding point. A thick substrate with low dielectric constant is suitable for a higher bandwidth, larger antenna with a better efficiency and radiation. Designing a small antenna, needs a big dielectric constant that may result in smaller bandwidth and efficiency, along with higher loss tangent (dissipation factor). This phenomenon can be avoided by modifying the feeding technique, see Balanis (2016). The design procedure of this circular patch microstrip was commenced by determining the material used, FR4 Epoxy (substrate) and calculating effective radius of the antenna. The model then simulated using the software chosen to find out the suitable parameters to build the antenna. The antenna specifications are tabulated on Table 1.

Table 1. Designed antenna specification.

Specification	Size/Dimension
Dielectric constant (ε_r)	4,4
tan δ	0,02
Thicknessh (y axis)	1,6 mm
Effective radius (a_e)	8,9 mm
Feeding point to substrate distance(D)	17,8 mm
Antenna width (W)	35,6 mm

Antenna Simulation Result And Discussion
Antenna Model Design
    The antenna model was designed using a simulator, following the procedures and calculations explained above. The model resulted from the simulation is illustrated in Figure 1 (a) and (b).

(a)

(b)
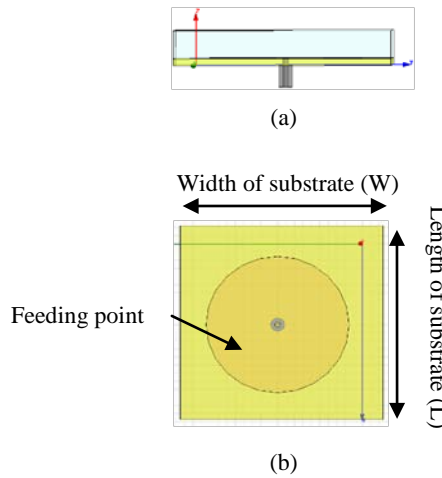
Figure 1. Circular patch microstrip antenna designed (a) side view; (b) top view.

Antenna Radiation Pattern.
    Radiation pattern is strongly related to energy distribution (gain) of the antenna. The simulation shows that the radiation pattern obtained was omnidirectional, as depicted on Figure 2. In order to get a wide coverage area, gain of omnidirectional antenna should focus its power on horizontal phase and ignore the radiation pattern at top and bottom direction. Having such radiation pattern, allowing the antenna to be put in the middle of the base station. This type of antenna has advantage in term of the number of user it may serve. However, it is difficult to allocate frequency for each cell to avoid interference.
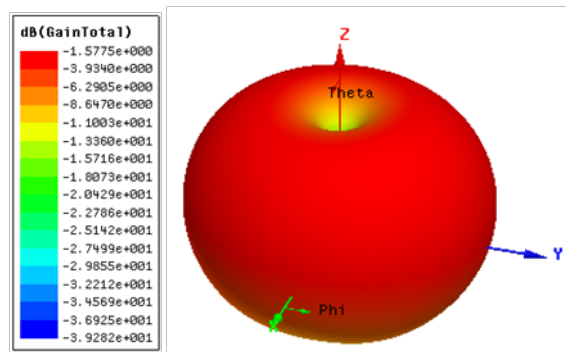

Figure 2. Antenna radiation pattern

Antenna Gain
    Other parameter that describe the performance of an antenna is antenna gain. Even though gain of antenna is closely related to directivity, its calculation is needed to measure the antenna efficiency and its directional capability. However, directivity calculation only describes the directionality of the antenna, so that directivity is mainly controlled by its pattern.

The antenna gain graph is shown on Figure 3 below. Total gain of the antenna designed is 0.23 dB. This total gain came only from the antenna designed without comparing it to any gain from another reference antenna. It is the absolute gain produced by the antenna.
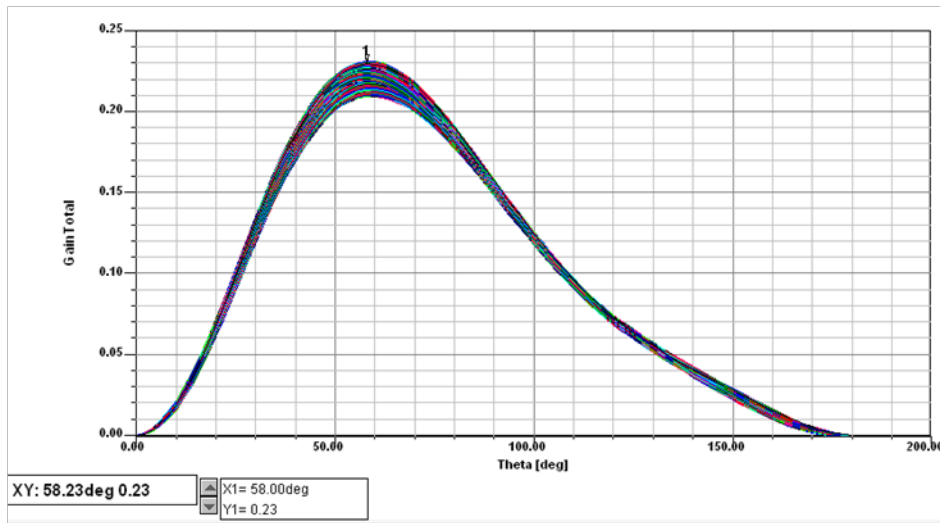

Figure 3. Antenna Gain

Antenna Input Impedance

The antenna port is normalized with 50 Ohm characteristic impedance *Zo* on specified frequency. The input impedance obtained from the simulation was 49.533 + j 0.462 Ohm.

VSWR of the Antena

Prior to calculate the VSWR value, the voltage reflection coefficient (Γ) shall be known, to understand the antenna feeding line condition. Mathematically, coefficient reflection is calculated by substituting 49,533 + j 0,462 Ohm to Z_L and 50 Ohm to Z_0 into the expression (2).
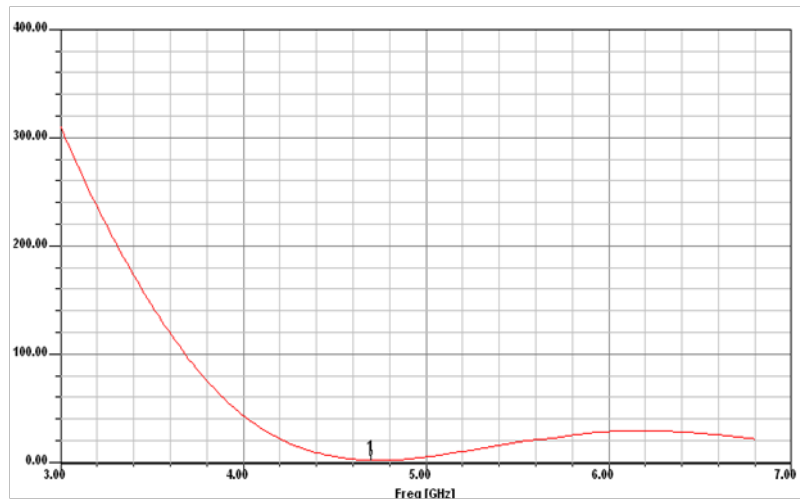

Figure 4. Antenna VSWR graph

The coefficient reflection of designed antenna is:

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{49.533 - 50}{49.533 + 50} \approx -0.0047 \qquad (2)$$

Based on this calculation, it is found that the voltage reflection coefficient is –0.0047 or approximate zero. With this condition, it is said that in the designed antenna, the feeding line is in match condition (no reflection). The graph of VSWR of the antenna is plotted in Figure 4, and its value was calculated using below expression:

$$\text{VSWR}=\frac{1+|\Gamma|}{1-|\Gamma|}=\frac{1+0.0047}{1-0.0047}\approx 1.0095\ (3)$$

As shown on the graph, the VSWR on center frequency f_c is 1.859. The discrepancy is observed between simulated and measured result that is due to design tolerance. However, these results are still within acceptable value.

Antena Bandwidth

To conform to FCC standard, the antenna was designed on frequency range 3.1 – 7 GHz. Bandwidth of the antenna was expected to be 500 MHz or greater, with fractional bandwidth characteristic was bigger or equal to 20 %. The simulation outcome is shown in Figure 5. In the graph shown that the measurement values obtained at the center frequency is –10.51 dB for return loss.
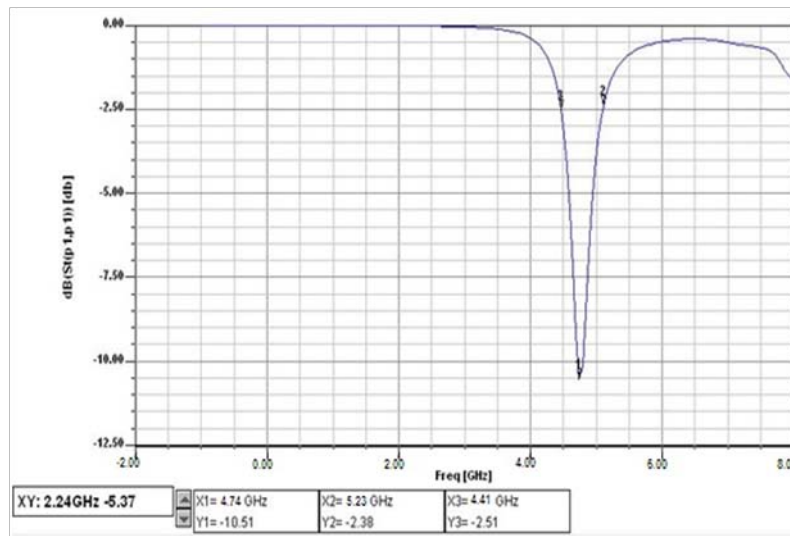

Figure 5. *Return Loss* antenna graph

It is shown on the graph above that the antenna highest frequency is 5.23 GHz, the lowest frequency is 4.41 GHz, and centre frequency is 4.74 GHz. These parameters were substituted into the equation (5) and (6) to calculate the antenna bandwidth:

$$\text{BW}=\frac{f_h-f_l}{f_c}\times 100\%=\frac{5.23-4.41}{4.74}\times 100\%=17.29\%\ (5)$$

And

$$\text{BW}=f_h-f_l=5.23\ \text{GHz}-4.41\ \text{GHz}=0{,}82\ \text{GHz}\approx 820\ \text{MHz}\ (6)$$

Based on calculation above, bandwidth of the antenna was 820 MHz with 17.29% fractional bandwidth. These calculation results showed that the antenna designed was capable of working on ultra–wideband frequency on the frequency range from 3.1 to 7 GHz.
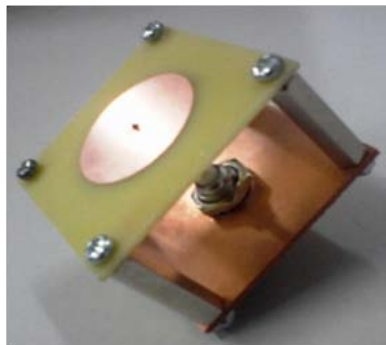

Figure 6. The prototype of microstrip antenna.

The antenna prototype

The prototype of the microstrip circular patch antenna designed was built using FR4 epoxy PCB. The model was drawn using Microsoft Visio, printed on the film paper and copied to the PCB. The feeder used on the antenna model is coaxial probe located right on the center of the patch as shown on Figure 6.

Conclusions

This research shows that the circular patch microstrip antenna designed using FR4 material with following dimension: a = 8,9 mm, h = 1,6 mm, ε_r = 4,4, f_r= 4,74 GHz, δ = 0,02, has complied to FCC regulation for ultra wideband communication. It can operate on the frequency range from 3.1 to 7 GHz with 820 MHz bandwidth. The gain, VSWR and radiation pattern resulted from the research proved that the antenna designed has a good performance. To validate the experiment results, the patch design has to be tested using proper equipment in the future.

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