SIBE 2017

The Third International Conference on Sustainable Infrastructure and Built Environment

Faculty of Civil and Environmental Engineering
Institut Teknologi Bandung

PROCEEDING BOOK

"Sustainable Infrastructure and Built Environment - **Past, Present, and Future**"

In collaboration with:

KEMENTERIAN KOORDINATOR BIDANG KEMARITIMAN

Kementerian PPN/ Bappenas

National Taiwan University, Taiwan	Hokkaido University, Japan	Coordinating Ministry for Maritime Affairs, Indonesia	Ministry of Public Works and Housing, Indonesia	State Ministry of National Development Planning, Indonesia

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The Third International Conference on Sustainable Infrastructure and Built Environment

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*Sustainable Infrastructure and Built Environment – **Past, Present and Future***

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PREFACE

Infrastructure provides the basic needs of human beings, and sustainable infrastructure systems are essential for the survival, health, and well-being of a society. The civil, environmental, and ocean engineers are at the epicenter in seeking the means to enhance human life through modernization of infrastructure as evidenced by provision of shelter, water, and transport, amongst others.

The current fast rate of urbanization and industrialization has caused a rise in environmental issues, involving environmental mismanagement, which has been associated with unforeseen global catastrophes. The problems are further aggravated by the impacts of environmental degradation such as soil erosion, hurricanes, sea-level rise, depletion of water resources, etc. These issues have become the current focus of attention and studies of the world's academicians and professionals in infrastructure development. Relevant researches include not only hard infrastructure but also soft infrastructure aspects such as regulation, institution, and policy development framework.

In many developing countries, including Indonesia, lack of infrastructure has been the main obstacle of investment and development activities. Besides limited available fund, the acceleration of sustainable infrastructure development still has to face the challenges of, among others, knowledge, human resource management, best practices, and capacity development. On the other hand, developing countries generally possess abundant local natural resources, sufficient carrying capacity, and local wisdom. Therefore, developing countries should reflect from the past and understand the current situation to have a better, sustainable infrastructure development in the future.

In order to meet these multifaceted challenges, not only proper planning, design, implementation and verification exercises, but also clear policy and strategy direction of sustainable infrastructure development are required, via an integrated, multidisciplinary and holistic approach.

The global momentum for sustainable development must now lead to practical applications of the engineering and science of sustainability – an optimization – which allows a comprehensive planning with maximum attention on sustainability aspects.

The conference provides an opportunity for professionals and researchers to learn, share and exchange the latest development and research in civil engineering, ocean engineering and environmental engineering. The scope of the conference covers all aspects of civil, ocean, and environmental engineering practices.

Participants of the conference include researchers, academic staffs, students, industries, public and local governments. The keynote presentations during the conference are as follows:

Keynote speakers:

- Jenderal TNI (Purn.) Luhut Binsar Pandjaitan, MPA, Indonesian Coordinating Minister for Maritime Affairs
- Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D; Minister of Public Works and Housing - represented by Dr. Ir. Danis Hidayat Sumadilaga, M. Eng., Sc, as the Research and Development Body of Ministry of Public Works and Housing
- Prof. Dr. Bambang P.S. Brodjonegoro, as the Minister of National Development Planning.

Invited speakers:

- Prof. Shang-Hsien Hsieh, National Taiwan university, Taiwan
- Prof. Takashi Matsumoto, Hokkaido University, Japan
- Prof. Chen Hanbao – represented by Dr. Zhou Zibou, Tianjin Research Institute for Water Transport Engineering, M.O.T., China

- Prof. Ryo Kohsaka, Graduate School of Environmental Studies, Tohoku University, Japan.

The objectives of the conference are:
1. To provide a platform for exchange of ideas and information among academics, researchers, consultants, engineers, manufacturers and post graduate scholars in civil, ocean, and environmental engineering
2. To discuss and evaluate the latest approaches, innovative technologies, policies and new directions in infrastructure development, pollution prevention and eco-friendly technologies adapted to developing countries
3. To promote cooperation and networking amongst practitioners and researchers involved in addressing infrastructure and built environment issues.

The oral presentations are subdivided into 8 major sections as following:
1. Structure and materials
2. Transportation system and engineering
3. Water resources engineering and management
4. Water and waste engineering and management
5. Ocean and maritime engineering
6. Construction management
7. Geotechnical engineering
8. Environmental protection and management

There are 120 contributors in oral presentation.

Finally, the organizing committee wishes that the conference is able to provide beneficial scientific information to the participants and other concerned readers.

Bandung, September 2017

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The Flexural Strength of Fiber Concrete Slabs with Various Reinforcing-Bar Spacing

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Abstract. The study applied the full-scale test on concrete slabs with an overall dimension of 200 x 200 9 cm. It aims at measuring the flexural strength of the slabs with the reinforcing-bar spacing of 15 cm, 20 cm and 25 cm. The fiber percentage of the slabs is 1 %, and the fiber used is wire bendrat length 5 cm. Each plate is then given an evenly distributed static load, with loading method by making water bath and water filling added bit by bit. The deflection was measured by dial gauges placed underneath the slabs. The result indicated that the cracks at the fibred slabs did not follow the yield line theory. Meanwhile, the normal concrete cracks follow the yield line theory. The flexural rigidity of the fibred concrete slabs was higher than that of normal concrete slabs.

Keywords: *flexural strength, slabs, fiber.*

1 Introduction

Concrete engineering in principle always involves two things namely the method of calculation of reinforced concrete structures and concrete materials technology. Technological progress of structural materials is always followed by the development of structural calculation methods. Taking conservative permit voltage, along with the use of a straight-line working voltage method, produces large, rigid cross-sections with small deflections. The design of reinforced concrete structures does not pay much attention to deflection.

Concrete construction is used with consideration of various aspects of its advantages such as good flexibility, high compressive strength, enough resistance to fire and weather, its constituents are easy to obtain and so on. But keep in mind that the concrete has a weakness, mainly weak to its tensile strength and has a brittle properties. One technology that becomes an alternative to the addition of tensile strength of concrete and resistance to small cracks due to loading is the technology of fiber material or known as fiber concrete.

The reinforced concrete slabs used as objects in this study are predicted to be highly susceptible to deformation due to a much smaller thickness compared to other dimensions. Plate deflection is determined by two factors: (a). External factors, which depend on the type of plate placement, the shape and type of load assigned, the temperature / expansion, and (b) the inner factor, formulated as the bending resilience of the plate which is a function of the plate characteristics and thickness.

The focusing part of this research is the increase of tensile strength by making variation of reinforcement distance on fiber concrete plate. Assuming that there will be an increase in the strength of concrete fibers compared with ordinary concrete with relatively similar material composition, the possibility of reduced reinforcement volume may be considered.

2 Basic Theory

2.1 Fiber Concrete

Concrete Fiber or fiber reinforcement concrete is an ordinary concrete mixture into which it is inserted or added premises fibers distributed evenly with random orientation. Distributed fibers of both types, dimensions and quantities are determined first as needed before being mixed on the concrete mixture.

Fiber is generally a rod with a diameter between 5 - 500 µm, and a length of about 25 - 100 mm. Fiber materials may be: asbestos fibers, plant fibers (hemp, bamboo, fibers), plastic fibers (polypropylene) or pieces of steel wire.

Basically, the fiber acts as a crack retaining device, limiting the spreading of the crack and then transferring the brittle properties of concrete into a strong composite with resistance to large cracks, increased ductility and further cracks before collapse. Fibers can be classified into 2 large sections based on their high or less elasticity compared to concrete:

1. Fiber with high elasticity, such as: steel fiber, carbon and glass.
2. Fibers with low elasticity, such as: polypropylene and natural fibers

The mechanism of restraining and controlling / cracking of the wire fibers results in an increase in the strength of the crack associated properties such as strength, stiffness, ductility, energy absorption and resistance to impact, fatigue and heat. The characteristic of crack control of fiber has a great influence on the behavior of composite concrete, namely:

1. Fiber delaying the occurrence of flexible cracks, increased tensile strain.
2. Fiber gives a good behavior on the state after the crack.
3. The crack-resistant properties and due to increased ductility provide greater energy absorption properties.

In this study we used local fiber which we call fiber concrete wire. Concrete wire fiber in question is a wire fiber commonly used to tie concrete reinforcement on reinforced concrete structures. With its function as a follower it is expected that if this material is added to the concrete mix it will also provide a better bonding on the concrete materials so that it will provide increased tensile strength and the resulting concrete.

The steel fiber material used in this research is concrete wire fiber with diameter ± 1.0 mm, straight geometry and cut with specified length. With the aspect ratio of l / d, where l is the fiber length and d is the fiber diameter.

2.2 Differential equations of plate deflection

To obtain a deflection equation, review a plate of uniform thickness that carries a lateral load.

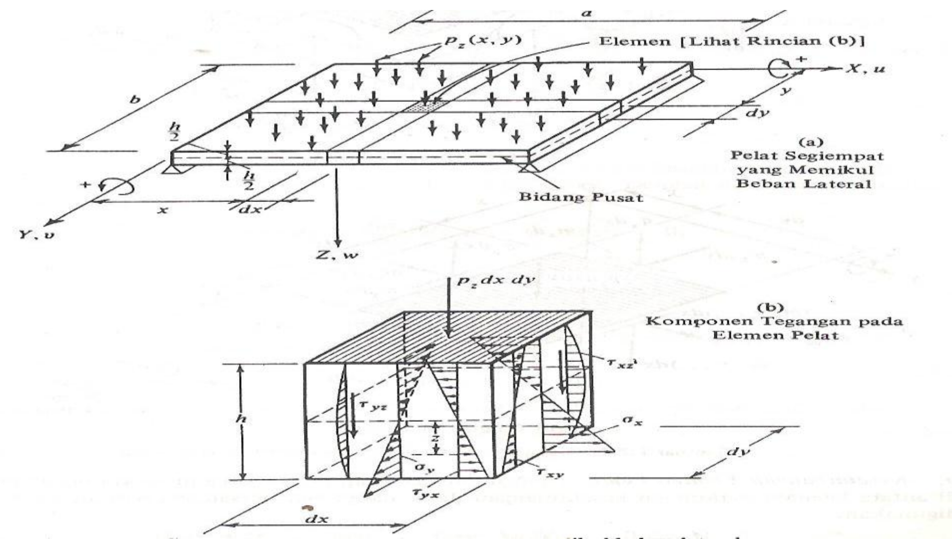

Figure 1 A rectangular plate that carries a lateral load

External forces and internal forces and the deflection components u, v and w are considered positive when in the direction of the positive axis coordinates.

Differential equations of plate deflection which is partial differential equation, not homogeneous, linear and fourth order that is:

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial x^2 \partial y^2}{\partial^4 w} + \frac{\partial^4 w}{\partial y^4} = \frac{p_z(x,y)}{D} \tag{1}$$

2.3 Steel Fiber

Fibers have as much power relatively high elastic modulus. Besides, wire fiber does not steel fiber experienced a shape change the influence of alkaline cement, and its attachment to concrete can increase due to anchoring mechanically. Loading in time the old has no effect on the nature wire bending mechanics.

Administration of wire fiber with random distribution into concrete mixture, can withstand propagation and widening of crack in concrete. This factor will have an effect on increasing ductility and energy absorption capacity, as well as increasing tensile strength and compressive material.

3 Experimental Method

3.1 Concrete Material Test

3.1.1 Test of Compressive Strength

That is test of cylinder test object diameter 15cm x 30cm consist of 3 (three) pieces. Pressed with "Concrete Compression Testing Machine" tool. The compressive strength is determined by the magnitude of the load when the specimen is destroyed by the surface of the cylinder:

$$f' = \frac{P}{A} \text{ (kN/mm}^2\text{)} \tag{2}$$

3.1.2 Tests of Elastic Modulus and Poisson Ratios

Concrete using three cylinder test variables, using the "Concrete Compression Testing Machine" device and installing dial gauge and dial extensometer mounted on the specimen. The cylinders are loaded gradually, the dial reads every 50 kN load increase

The elastic modulus is calculated by the equation:

$$E = \frac{S_2 - S_1}{\varepsilon - 0.00005} \tag{3}$$

Poisson Ratio is calculated by using the equation :

$$\upsilon = \frac{\varepsilon_{12} - \varepsilon_{11}}{\varepsilon_2 - 0.00005} \tag{4}$$

3.1.3 Tensile Strength Test

Tested with "Concrete Compression Testing Mechine" by using some additional tools. Tensile strength can be calculated using the equation:

$$t = \frac{P}{\pi.r.l} = \frac{2P}{\pi.d.l} \tag{5}$$

3.1.4 Flexible Testing

Using concrete beam test beam size 15cm x 15cm x 65cm, each 3 (three) pieces for bending test for the loading of one and 3 (three) pieces for the loading of two.

3.2 Testing of Reinforced Concrete Slabs

The test object used is 3 (three) pieces of reinforced concrete fiber plate with dimensions of 2000mm x 2000mm x 90mm, variation of 15cm, 20cm and 25cm reinforcement range. The fiber used is wire bendrat length 5 cm, Each plate is then given an evenly distributed static load. To measure the deflection is done by using a measuring gauge with a precision of 0.01 mm. Loading starts from 2.5 KN / m^2 up to 15 KN / m^2.

4 Results

4.1 Test Results of Concrete Plates

Based on the result of the test, there is a graph of load and deflection relationship as shown in Figure 2 for normal concrete and figure 3 for fiber concrete.

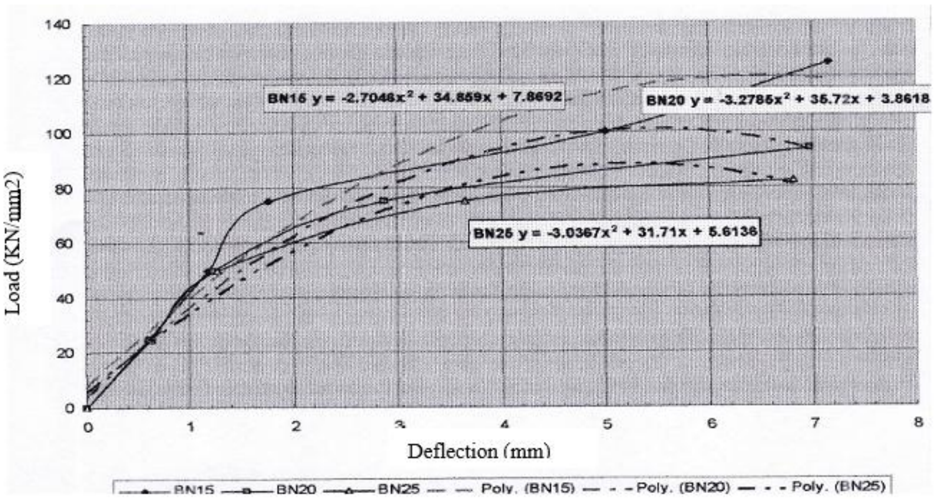

Figure 2 Load and deflection curves for normal concrete

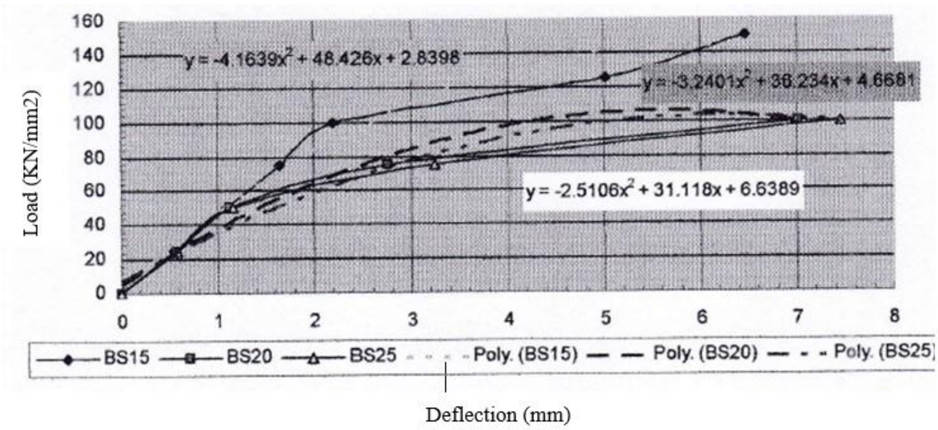

Figure 3 Load and deflection curves for fiber concrete

From Figure 2 we get the polynomial equation of the three normal concrete:

BN 15, $y = -2{,}7046\ x^2 + 34{,}859\ x + 7{,}8692$

BN 20, $y = -3{,}2785\ x^2 + 35{,}72\ x + 3{,}8618$

BN 25, $y = -1{,}8913\ x^2 + 27{,}077\ x + 7{,}5003$

Then it will be optimal at load and deflection for each plate

BN 15, $y = 12{,}02$ N/mm $x = 6{,}44$ mm

BN 20, y = 10,11 N/mm x = 5,45 mm

BN 25, y = 9,44 N/mm x = 5,17 mm

And from Figure 3 we get the polynomial equation of the three normal concrete:

BS 15, $y = -4{,}1639\ x^2 + 48{,}426\ x + 2{,}8398$

BS20, $y = 3{,}2401\ x^2 + 36{,}234\ x + 4{,}6681$

BS25, $y = -2{,}5106\ x^2 + 31{,}118\ x + 6{,}6389$

Then it will be optimal at load and deflection for each plate

BS 15, y = 14,26 N/mm x = 5,81 mm

BS 20, y = 10,59 N/mm x = 5,59 mm

BS 25, y = 10,31 N/mm x = 6,19 mm

4.2 Bending Analysis of Specimens

Flexural strength and maximum moment are obtained by using the following equation:

$$w_{\max} = \frac{0{,}01309.q.l^4}{D}$$

$$D = \frac{0{,}01309.q.l^4}{w_{\max}}$$

$$M_{\max} = 0{,}1225.q.l^2$$

On each fiber concrete plate obtained

BS 15	D = 514,047 kNm	Mmax = 6,987 kNm
BS 20	D = 396,775 kNm	Mmax = 5,189 kNm
BS 25	D = 348,841 kNm	Mmax = 5,052 kNm

And on each normal concrete plate obtained

BN 15	D = 390,882 kNm	Mmax = 5,889 kNm
BN 20	D = 388,766 kNm	Mmax = 4,957 kNm
BN 25	D = 354,643 kNm	Mmax = 4,116 kNm

Based on the above calculation shows that the maximum moment that can be achieved fiber concrete plate is higher than the normal concrete plate. Similar to the flexible bending value, the fiber concrete plates are higher than the normal concrete plates for bone spacing of 15 and 20.

Besides the comparison of deflection between normal concrete plates and fiber concrete can be seen in figure 4.

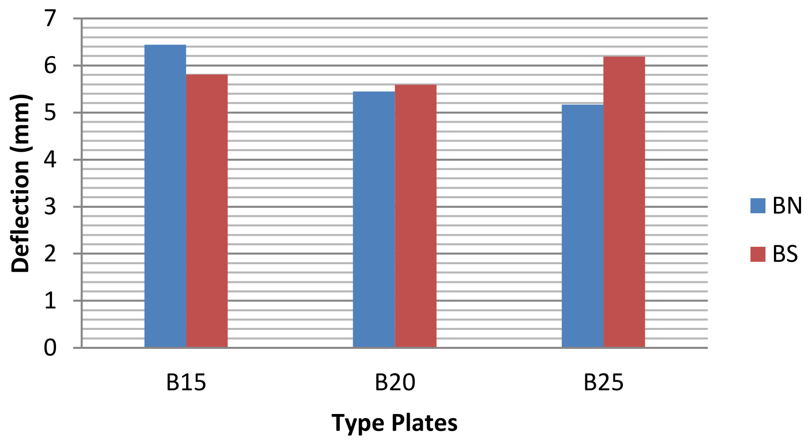

Figure 4 Comparison of concrete deflection of fiber and normal concrete

Of the graph shows the deflection on the BS15 plate is smaller than the BN15 plate, and the deflection on the BS20 plate is slightly larger than the BN20 plate, while the deflection on the BS25 plate is larger than BN25. This indicates that there is no linear addition or reduction in the reduction of the reinforcement distance, possibly because the manufacture of the specimen is not exactly the same as expected.

However, if the bending resilience is to be seen, the flexural strength value is significant only to the plate with the 20 cm spacing, so that it can be the base only up to 20 cm.

5 Conclusion

There is an increase in flexural flexibility between 6% - 8% in the fiber concrete compared with the resilient flexibility of the normal concrete which means that the fibers present in the concrete slows the partial transfer of tensile stresses on the bottom fibers of the plates. The tendency of the fiber concrete to survive not to melt faster on the reinforcement concrete.

By comparing the strength of concrete fiber plates with normal concrete from all three reinforced bars considered. At a distance of 20 cm reinforcement strength of concrete fiber plate is still slightly larger than normal concrete, so the distance of 20 cm reinforcement is still considered safe from the required rebars distance of 18 cm.

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U-Phase Characterization for Performance Evaluation Of Cement Systems In Sodium Sulfate Radioactive Waste Environment

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Abstract. Cementitious materials are extensively used for several purposes including deep geological repository for long-lived radioactive wastes. The low-level waste generated from boiling water reactor (BWR) power plant consists of very high concentration of sodium sulfate, higher than 25 mass% of Na2SO4. It is well known that sodium sulfate ions cause a serious chemical deterioration to cement matrix through either forming expansive products of ettringite and gypsum or sodium sulfate crystallization. In addition, a very high concentration of sodium sulfate solution could induce to form U-phase [(CaO)4(Al2O3)0.9(SO3)1.1 (Na2O)0.5:16H2O] and this may cause deterioration to cement. But the condition for U-phase formation and its stability in cement environments have not been understood due lack of studies. In this study, a pure U-phase was synthesized and characterized by various experimental techniques to propose its structure. The equilibrium constant was determined by analyzing equilibrated liquid composition. A chemical thermodynamic calculation for co-hydrating slag-blended cement with 25 mass% of Na2SO4 was performed to predict phase assemblage. The simulation results on the formation of U-phase were compared with experimental results. The model could not show the presence of U-Phase in the slag blended cement system though it is observed in the experiment.

Keywords: *low-level radioactive waste; slag-blended cement; U-phase; XRD; 27Al MAS NMR; PHREEQC*

1 Introduction

Cementitious materials have been using in many radioactive waste disposal facilities because of their cheapness, high strength and durability [1]. The low-level radioactive waste generated from boiling water reactor (BWR) power plant consists of very high concentration of Na2SO4, and for safety disposal of them, investigation on the influence of high concentration Na2SO4 on the cement matrix is necessary [2]. One of the causes of concrete deterioration in the presence of high concentration Na2SO4 is sulfate attack. It is well known that sodium sulfate ions cause a serious chemical deterioration to cement matrix through either forming expansive products of ettringite and gypsum or sodium sulfate crystallization [3,4]. In addition, it is reported that deterioration in a high concentration of Na2SO4 environment is due to the formation of U- Phase [(CaO)4(Al2O3)0.9(SO3)1.1 (Na2O)0.5:16H2O] and the phase change is changed to Ettringite and may induce crack in the system [5]. However, there are very limited studies on U-Phase and they fail to show conditions which the U-Phase forms and its influence on deterioration.

In this study, pure U-Phase is synthesized from the basic chemicals and characterized by XRD, XRF, 27Al MAS NMR to propose its structure. Further, liquid phase analysis is performed on the synthetic sample using ICP-AES or ion chromatograph to estimate its thermodynamic equilibrium. A chemical thermodynamic calculation for slag blended cement hydrated with 25 mass % of Na2SO4 was performed to predict phase assemblage, and the simulation results were compared with the experimental data focusing on U-Phase formation.

2 Experimental

2.1 Synthesis of U-Phase

Pure U-Phase was synthesized by Portlandite, Al2O3nanopowder and Na2SO4 in 1M NaOH at a liquid/solid mass ratio of 4.0. Mixing ratio of powder is given in Table 1. The synthesis was carried out at 80℃ for 20 hours, and then the sample was separated into solid and liquid phases using a membrane filter of ϕ =45 μm by vacuum. After separation, the solids were dried in a constant temperature at 40℃ for 1 hour and stored at RH 11%. Solid samples that reached a constant weight were pulverized in an agate mortar and used for various measurements.

Table 1 Composition of the mixtures for the U-Phase synthesis

Liquid/Solid		**Mole (%)**	
(ml/g)	Ca(OH)2	Al2O3	Na2SO4
4	37.48	13.11	49.11

2.2 Powder X-ray diffraction

Powder X-ray diffraction (XRD) was carried out to confirm the formation of U-Phase in the synthesized sample and to identify the presence of the initial additives and other products if they are. XRD was carried out using CuKα radiation on a Rigaku X-ray generator for Multi Flex an angular scan 5-75° (generator: 40kV and 40mA). Using a step size of 0.02° and a count time of 2s per step.

2.3 ^{27}Al MAS NMR

For determination of chemical shift and chemical composition of synthesized U-Phase, 27Al Magic Angle Spinning (MAS) Nuclear Magnetic Resonance (NMR) measurement was carried out. The 27Al MAS spectra were carried out on a JEOL ECA-600 II spectrometer (14.01T) at 182.4MHz. 27Al spectra were recorded at 12,5kHz spinning rate in 4mm ZrO2 rotors. All experiments employed width pulse of 1.6ìs and a 0.5s relaxation delay. The 27Al chemical shifts were referenced relative to a AlCl3 saturated solution at -0.1ppm. The detected FID signal was subjected to Fourier transformation to obtain an NMR spectrum. For the spectral fitting, a Gaussian/Lorentz mixing function was used and its ratio of the function, the position, width and height of the peak was manipulated to perform optimal fitting.

2.4 X-ray Fluorescence

Chemical compositions (CaO, Al2O3, Na2O, SO3) of the solid samples were determined by X-ray fluorescence. Ca, Al, S and Na elements were measured by the FP mode under the vacuum atmosphere. The conditions of the measurement were as follows: an excitation voltage of 50 (kV), a thbe current of 1000(ìA), and a tube target element of RH.

2.5 Liquid phase analysis

A pH electrode (As One AS800) was used to measure the OH- concentrations in the solution. Ca, Al and Na ion concentration were measured by ICP-AES (SHIMADZU ICPE-9000). SO_4 ion concentration was measured by ion chromatograph (Thermo Scientific Dionex ICS-90).

2.6 U-Phase formation in cement based system

Two types of materials were used in this experiment: white Portland cement (WPC) and blast furnace slag (BFS). Table 2 shows chemical compound of the materials. The materials, WPC and BFS, were hydrated in 25% Na2SO4 solution. Table 3 shows the mix proportions and curing condition. After the curing time, the sample was immersed in acetone for 1 day to stop reaction. The sample was dried at 40℃ in oven after removing the sample from acetone. These samples were measured by XRD to observe the formation of U-phase.

Table 2 Chemical composition of WPC and BFS used (%)

mass %	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	P_2O_2
WPC	20.8	5.4	0.2	67.5	1.56	2.78	0.6	0.36	0.44
BFS	34.03	14.36	0.83	43.28	6.51	0	0.18	0.31	0.46

Table 3 Mixing composition

Materials	BFS (%)	Mixing water	W/B (%)	Temperature (℃)	Time(days)
WPC	0	Na_2SO_4 25%	60	20	50
				80	14,50
WPC+BFS	42			20	50
				80	14,50
WPC+BFS	70			20	50
				80	14,50

3 Model description

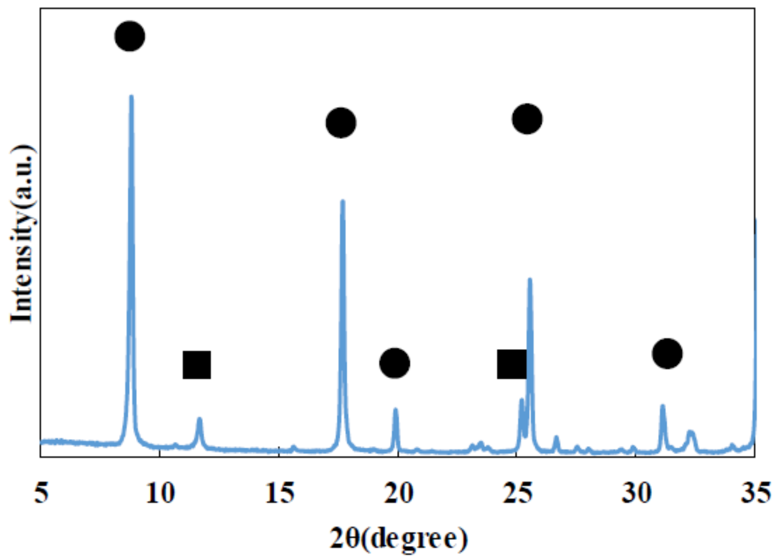
In this study, hydration model proposed by Elakneswaran [6] was employed to carry out thermodynamic equilibrium calculations. By using the U-Phase equilibrium constant calculated by equilibrated ionic concentration, the hydration products in the hydrated cement and slag with Na_2SO_4 were determined.

4 Results and Discussion

4.1 Characterization of sample

4.1.1 Powder X-ray diffraction

Figure 1 show the XRD patterns of synthesized U-phase. U-phase is detected as the peak at 8.8° (2θ), and Monocarboaluminate also detected at 11.6° (2θ).



(●: U-Phase ■: Monocarbonaluminate)

Figure 1 XRP pattern of the sythesized sample

4.1.2 ^{27}Al MAS NMR

Al_2O_3-nanopowder was used for U-phase synthesis and it is difficult to detect in XRD peak because of amorphous. Therefore, $_{27}$Al MAS NMR was used to quantify the unreacted Al_2O_3-nanopowder. Figure 2 shows $_{27}$Al MAS NMR spectra of Al_2O_3-nanopowder and synthesized mixture. The peak of Al_2O_3 nanopowder can be identified at -10 to 20ppm and 50 to 80ppm. As shown in the Figure 2, synthesized mixture does not contain Al2O3-nanopowder. Figure 3 shows the spectra of 27Al MAS NMR for synthesized sample. Four peaks were detected and identified as Monocarboaluminate at 12.3ppm, an unknown peak at 10.9 ppm, C4AH13 at 10.8ppm [7] and Monosulfoaluminate at 9.5ppm. The peak of C4AH13 and Monosulfoaluminate can be detected in 27Al MAS NMR although it cannot be idenfied by XRD pattern. It is difficult to consider the presence of these minerals as amorphous because it was synthesized in a dilute system. Therefore, the spectra without Monocarboaluminate is considered as peak of U-phase. The peak of U-phase consists of three peaks. This can be explained that if three ions were intercalated between the layers, the results of 27Al MAS NMR can reflect the structure around Al atom. Therefore, it is considered the kind of ions intercalated between the layers is equal to the number of peak. As for U-phase, it is reported that Na+ and SO42- is intercalated in the layers [1]. Monosulfoaluminate and C4AH13 are Ca-Al-LDH intercalated SO42-

and OH- relatively. These facts indicate that U-phase is Ca-Al-LDH intercalated Na+, SO42-, OH-. The peak of U-phase intercalated SO42-, OH- and Na+ can be identified as chemical shift at 9.5, 10.8 and 10.9 relatively. Therefore, the unknown peak at 10.9 ppm is defined as that of the part of U-phase intercalated Na+. By separating four spectra of each peak, the fraction of the SO42-, OH- and Na+ intercalated between Ca-Al sheet is 35, 30 and 35% respectively. The ratio of Na+ to SO42- equal to 1 indicates the presence NaSO4- between Ca-Al sheets.

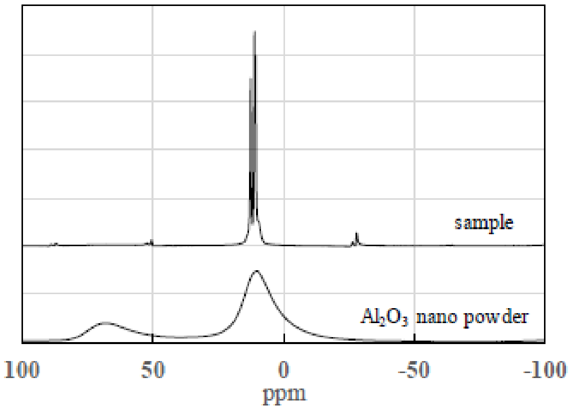


Figure 2 ^{27}Al MAS MNR spectra of sample and Al_2O_3nanopowder

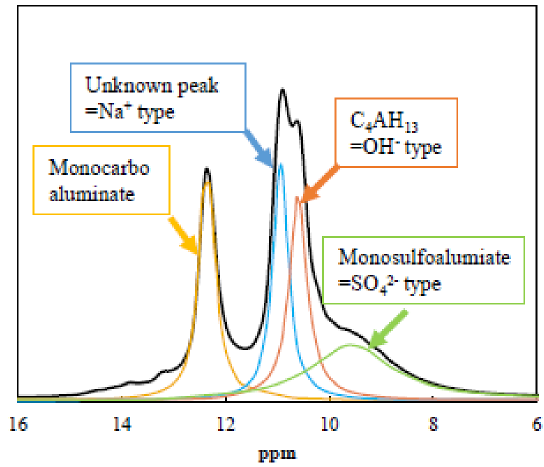


Figure 3 ^{27}Al MAS NMR spectra of synthesized sample (ppm=6~16)

4.1.3 X-ray Fluorescence

The composition such as S/A, C/A, and N/A of U-phase was calculated by XRF. Based on these results, the determined composition of U-phase is as follows: C/A=4, S/A=1.5, N/A=0.75. Furthermore, Na^{+}/SO_4^{2-} is equal to 1 by ^{27}Al MAS NMR which corresponds to XRF results. Therefore, the chemical equation of U-phase is defined as $(CaO)_4(Al_2O_3)(SO_3)_{1.5}(Na_2O)_{0.75} \cdot 16H_2O$.

4.1.4 Liquid phase analysis

Table 4 shows the concentration of each ion in the equilibrated solution during the synthesis. It was used to calculate the equilibrium constant.

Table 4 Ion Concentration

Ions	Ca^{2+}	Al^{3+}	SO_4^{2-}	Na^{+}	pH
Concentration (mM)	0.235	26.46	311.6	1370	13.51

4.2 Calculation equilibrium constant

Equilibrium constant of U-Phase is calculated from chemical composition obtained by solid phase analysis and ion concentration obtained by liquid phase analysis. It is estimated from the XRF results that C/A=4.0, S/A=1.5, N/A=0.75 and H/A=16.0 in U-Phase. H/A was adopted from the previous study. The chemical formula of U-Phase having this composition is obtained as equation [1]. The equilibrium constant is expressed by equation [2] using each ion activity a, which can be obtained from equation [3].

$$\begin{aligned} &4CaO \cdot Al_2O_3 \cdot 1.5SO_3 \cdot 0.75Na_2O \cdot 16H_2O + 12.5H^+ \\ &= 4Ca^{2+} + 2Al^{3+} + 1.5Na^+ + 1.5SO_4^{2-} + 22.25H_2O \end{aligned} \quad [1]$$

$$K = \frac{a_{Ca^{2+}}^4 \cdot a_{Al^{3+}}^2 \cdot a_{Na^+}^{1.5} \cdot a_{SO_4^{2-}}^{1.5}}{a_{H^+}^{12.5}} \quad [2]$$

$$a_i = \gamma_i \times C_i \quad [3]$$

a_i = Activity of ion species i

γ_i = Activity coefficient of ion species i

C_i = Concentration of ion species i (M)

The formula for calculating the activity coefficient of each ion species depends on the ionic strength of solution. The ionic strength of the solution in this system can be calculated as equation [4], which is equal to 1.59.

$$I = \frac{1}{2}\Sigma C_i \cdot z_i^2 \approx 1.59 \qquad [4]$$

When 1<I<2, the Truesdell-Jones equation [5] can be applied to calculate the activity coefficient:

$$\log \gamma = -Az_i^2 \frac{\sqrt{I}}{1 + Ba^0\sqrt{I}} + bI \qquad [5]$$

A, B	=	T-dependent coefficient (A=0.0542, B=0.3273 at 20°C)
a	=	ion size
b	=	Semi-empirical parameter
I	=	Ionic strength
z_i	=	Charge of species

By applying the activity coefficient of the ion species to the equation [3], the activity of each ion can be calculated. Based on this, the equilibrium constant K of U-Phase can be calculated from equation[2] as follows.

$$K = \frac{a_{Ca^{2+}}^{4} \cdot a_{Al^{3+}}^{2} \cdot a_{Na^{+}}^{1.5} \cdot a_{SO_4^{2-}}^{1.5}}{a_{H^{+}}^{12.5}} = 7.97*10\text{^}156$$

$$\therefore \log K = 156.90$$

4.3 Formation of U-Phase in Slag blended paste

Figure 4 shows XRD pattern of slag-blended cement paste in 25% Na_2SO_4 solution. The formation of U-phase is detected in the sample of 14 days curing at 80℃ regardless of slag substitution ratio. For the samples cured for 50 days at

20℃, formation of ettringite and Afm were observed, but not U-phase. It can be inferred that U-phase is changed to other phases with curing time.

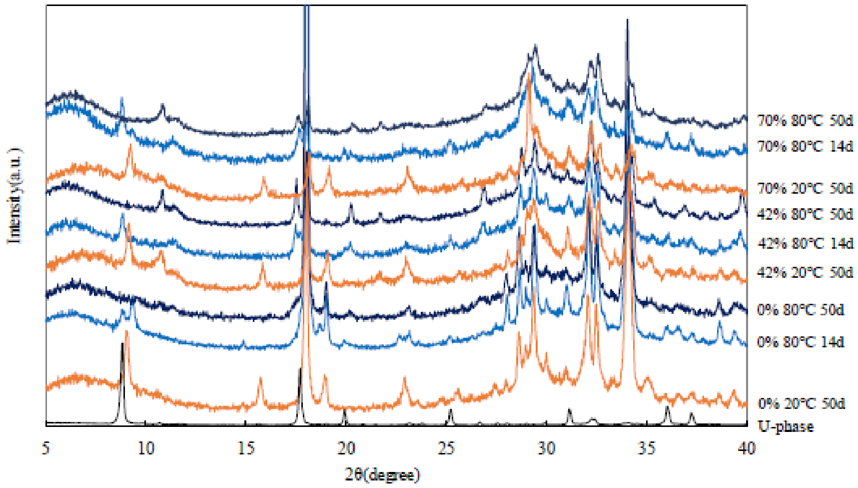


Figure 4 XRD pattern of slag blended paste in 25% Na_2SO_4 solution.

The calculated composition of hydrates and the remaining of unreacted slag and clinker of the slag cement system, which consists of 30% OPC and 70%slag, as a function of hydration time is shown in Figure 5. In the simulation, the equilibrium constant value, logK=156.90, calculated in section 4.2 was used. Since the slag replacement rate was high as 70%, CASH and Ettringite were confirmed as main products. However, the formation of U-Phase did not predict in this calculation, but the experimental results (Figure 4) show the presence of U-Phase.

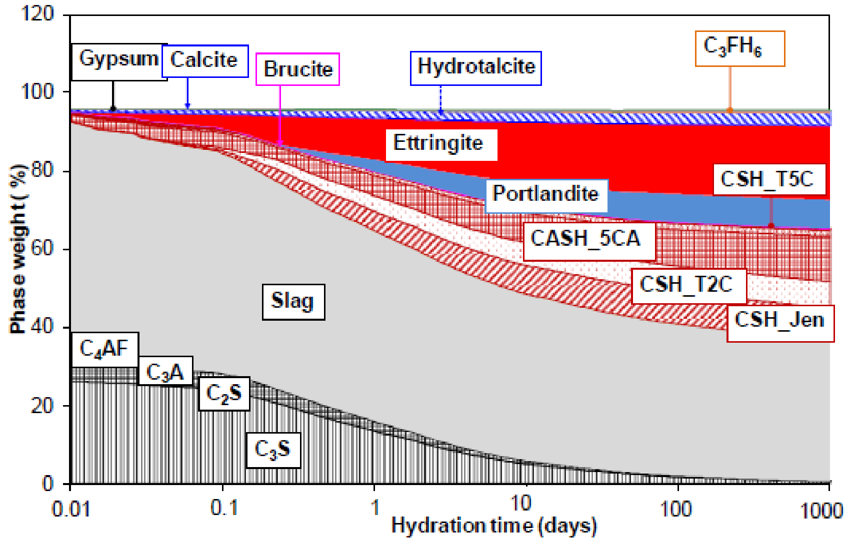


Figure 5 Simulated phase changes as a function of hydration time for slag blended cement (the equilibrium constant of U-Phase is logK=156.9)

With the equilibrium constant calculated from liquid phase analysis, it was impossible to generate U-Phase. A simulation was performed by changing equilibrium constant of U-Phase until to form the phase in slag cement hydration. The simulation result is shown in Figure 6 with the equilibrium constant of logK = 62.0. The U-Phase can only be formed when the equilibrium constant value less than or equal to 62.0. The equilibrium constant value required for generation of U-Phase in the model greatly deviated from the value of the equilibrium constant calculated from the liquid phase analysis. Therefore, it is necessary to review the calculation method for equilibrium constant in the synthesis experiment.

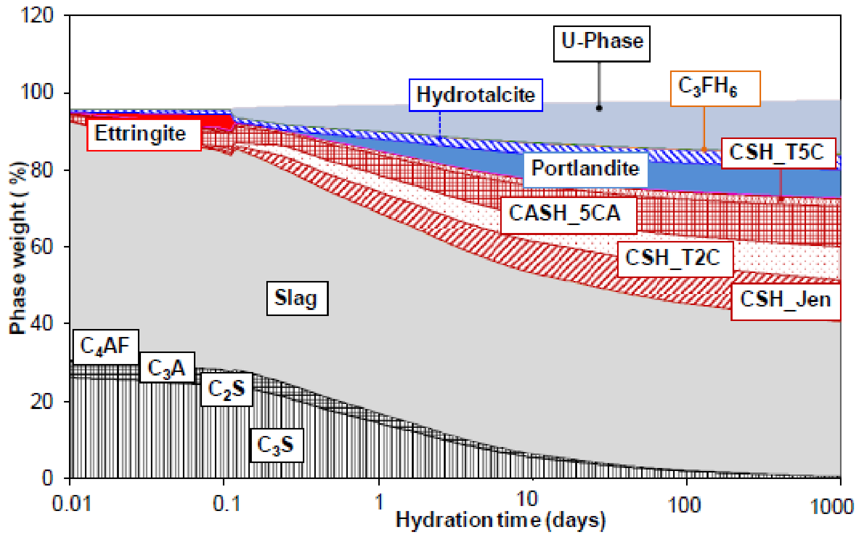


Figure 6 Simulated phase changes as a function of hydration time for slag blended cement (the equilibrium constant of U-Phase is logK=62.0)

5 Conclusion

In this study, synthesis and characterization were performed to obtain thermodynamic data of U-Phase. The U-Phase was successfully synthesized and confirmed by various experimental techniques. The chemical formula was estimated as "4CaO・Al2O3・1.5SO3・0.75Na2O・16H2O" from the solid phase analysis of synthetic U-Phase. Based on the estimated chemical formula and the liquid phase analysis, the equilibrium constant of U-Phase was calculated as logK=156.90. In the blast furnace cement hydrated with 25% Na2SO4 solution, formation of U-Phase was confirmed regardless of slag substitution ratio. The equilibrium constant calculated from the U-Phase synthesis experiment was used in the hydration model to predict hydration reaction of the slag cement in the 25% Na2SO4 solution. The production of U-Phase was not confirmed for the equilibrium constant value, and the value below 62.0 is needed to form U-Phase. More detail study on the determination of equilibrium constant of U-Phase will be done in the future work.

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Seismic Behavior of Steel-Plate Composite Walls

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Abstract. This paper summarizes the results of in-plane cyclic tests of three steel-plate composite (SC) walls with boundary elements. The tests were executed in the laboratory of National Center for Research on Earthquake Engineering (NCREE) in Taiwan. Thick steel plates were used as boundary elements of the three specimens. To study two kinds of failure modes, we included in the test 1) two shear-critical walls with an aspect ratio of 0.75 and a thickness of 3 cm for boundary elements; and 2) one flexure-critical wall with an aspect ratio of 1.22 and a thickness of 2 cm for boundary elements. The failure mode and cyclic behavior of each specimen are reported. The test results are compared with the recommendations of AISC N690s1 and predictions of selected literatures. The impact of wall aspect ratio on in-plane shear strength of SC walls with boundary elements is discussed.

Keywords: *steel-plate composite wall; boundary element; cyclic loading test; aspect ratio*

1 Introduction

Steel-plate-concrete (SC) composite walls are being constructed in nuclear power plants (NPPs) in the United States and China. These walls are composed of steel faceplates, infill concrete, welded connectors that tie the plates together and provide out-of-plane shear reinforcement, and shear studs that enable composite action of the faceplate and the infill concrete and delay buckling of the faceplate. The use of SC walls in safety-related nuclear facilities in Korea, Japan, and the United States has been studied (e.g., Ozaki et al. 2004, Epackachi et al. 2014, Varma et al. 2014) for the past 20 years. In earlier days, most of numerical studies and test data in the studies of SC walls have focused on the elastic range of response, because NPPs are designed to remain elastic under design basis shaking. Since a decade ago, the nonlinear behavior of SC walls has drawn more and more attention.

A SC wall is very often connected with perpendicular SC walls at the ends. The perpendicular walls become the boundary elements of the longitudinal wall. Ozaki et al. (2004) and Varma et al. (2014) developed an approach to predict the yield point of an SC wall subjected to in-plane later force using composite shell theory. The approach was simplified and codified in AISC N690-12s1 (AISC 2015) for the purpose of design. Booth et al. (2015) further proposed that the in-plane shear strength of a SC wall with boundary elements should include two parts: the shear force required to yield the steel plates and an incremental shear resisted by the concrete in diagonal compression up to the failure of the wall. The study on the nonlinear flexural-critical behavior of SC walls with boundary elements is relatively rare.

This paper addresses the inelastic response of three SC walls with boundary elements subjected to reversed, in-plane cyclic loading. In this study, thick steel plates, termed endplates, attached at the ends of a SC-wall specimen are used to represent the boundary elements of the specimen. To study two kinds of failure modes, we included in the test 1) two shear-critical walls with an aspect ratio of 0.75 and a thickness of 3 cm for boundary elements; and 2) one flexure-critical wall with an aspect ratio of 1.22 and a thickness of 2 cm for boundary elements. The following sections of the paper describe the testing program, present key experimental results, and the predictions of the strength of SC walls with boundary elements.

2 EXPERIMENTAL PROGRAM

2.1 Test Specimen Description

Three SC walls with boundary elements (SC1 through SC3) were constructed and tested under displacement-controlled, reversed cyclic loading. The tests were performed at the National Center for Research on Earthquake Engineering (NCREE) in Taiwan. The design variables considered in the testing program were aspect ratio and concrete strength. The aspect ratio (height-to-length, *H/L*) is 0.75 for the two shear-critical walls, SC1 and SC2, and 1.22 for the flexural-critical wall SC3. To study the impact of concrete strength on the lateral strength of SC walls with boundary elements, we used very different strength of concrete for SC1 and SC2 (237 and 431 kgf/cm_2, respectively). The strength of concrete for SC3 is similar to that for SC1. Table 1 presents the key parameters for the three specimens.

In Table 1, T is the overall thickness of the wall; tp is the thickness of each faceplate is; 2tp/T is the reinforcement ratio; and S/tp is the slenderness ratio of faceplate; and tie rods serve as connectors for all three specimens, spaced at distances. The tie rods had a diameter of 13 mm and a length of 8 cm for all walls, and were fabricated using ASTM A490 carbon steel. The steel faceplates had a thickness of 4.5 mm and were fabricated using JIS G3131 SPHC steel. The thickness of endplates for SC1 and SC2 was 3 cm and that for SC3 was 2 cm. All endplates were fabricated using SN490B steel. The yield and ultimate strengths of the faceplates, endplates and tie rods are listed in Table 2.

Table 1 Table 1. Test specimen details

Specimen	Wall dimension ($H \times L \times T$) (cm×cm×cm)	Concrete strenth (kgf/cm^2)	Tie rod spacing (cm)	Reinforcement Ratio (%)	End-plate thickness (cm)
SC1	90×120×25.9	237.3	11	3.5	3
SC2	90×120×25.9	430.8	11	3.5	3
SC3	146×120×25.9	226.3	11	3.5	2

Table 2 . Yield and ultimate stresses of steel faceplates, endplates and tie rods

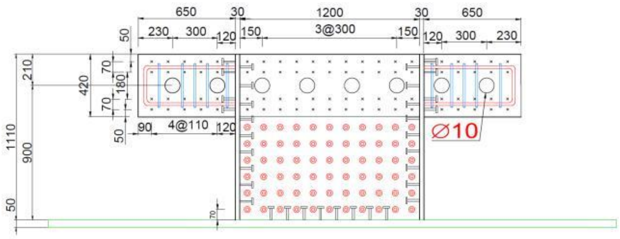
Steel	Yield stress (MPa)	Ultimate stress (MPa)
Faceplate (4.5 mm)	300	350
Endplate (20 mm)	371	541
Endplate (30 mm)	362	531
D13 tie rod	880	1097

Panel a of Figure 1 presents an elevation view of SC1 and SC2 and panel b presents that of SC3. The base of each wall included a 50-mm thick A572 Gr.50 steel baseplate. Endplates and faceplates of a specimen were welded to the baseplate. Two rows of 19-mm diameter headed studs were welded to the baseplate to improve the transfer of shearing and tensile forces. Transverse reinforcement (tie rods) was passed through holes in the embedded sections of the faceplates to further anchor the faceplates.

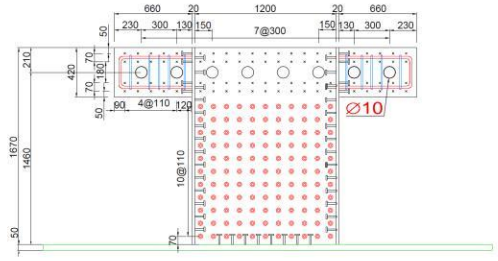
2.2 Test Setup and Loading Procedure

Figure 2 presents the test setup. Six 100-tonne actuators were used to apply quasi-static cyclic lateral loads horizontally to each specimen via loading brackets. The foundation block was post-tensioned to the NCREE strong floor with 16 number 69-mm diameter (M69) threaded bars to prevent foundation movement during testing. The loading brackets were attached to the specimen using 8 M69 bars post-tensioned to 160 tonnes per bar.

The displacement-controlled, reversed cyclic loading protocol is presented in Figure 3. Two cycles of loading, with a speed of 0.2 mm/sec, were imposed at each displacement increment. In each loading cycle, a push was exerted first, followed by a pull, where push was defined as the loading in the positive direction to the east (+). Testing was terminated after peak strength had been achieved, at a displacement corresponding to a 50% reduction in resistance.



(a) SC1 and SC2



(b) SC3

Figure 1 Elevations of the specimens of this study

Figure 2 SC wall test setup

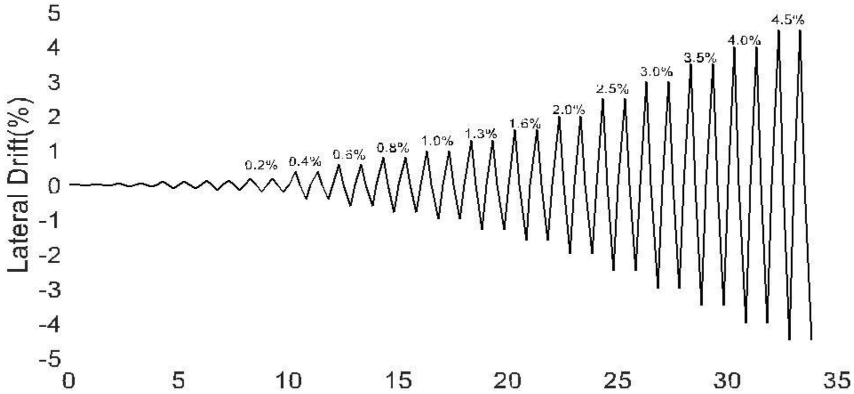
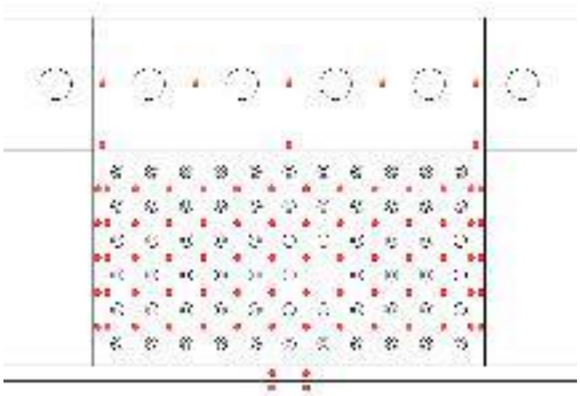


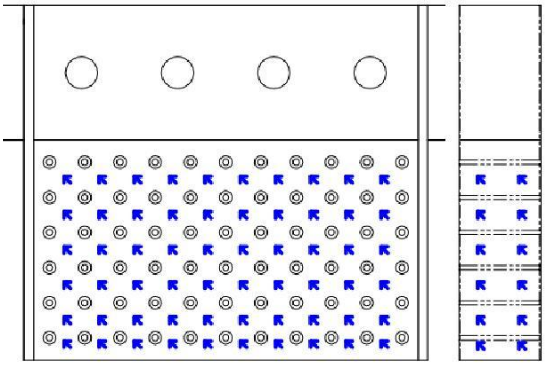
Figure 3 Loading History

2.3 Instrumentation

An optical measurement system, strain gauges, linear variable displacement transducers, and dial gauges were used to monitor the response of the wall piers. Linear variable displacement transducers were attached to the ends of the walls to measure in-plane displacement. The movements of 1) the foundation block relative to the strong floor and 2) the loading block relative to the specimen were monitored using dial gauges. The trackers of the optical measurement system were attached to one steel faceplate as presented in panel a of Figure 4 to measure in-plane and out-of-plane deformations. Strain gauges were installed on the other faceplate and both endplates as presented in panel b of Figure 4 to directly measure strains.



(a) Optical trackers of the optical measurement system



(b) Strain gauges

Figure 4 Measuring the strain fields on the faceplates of SC1 and SC2

3 EXPERIMENTAL RESULTS

3.1 Summary of Test Results

Key test results are presented in Table 3. The initial stiffness of the SC wall piers, calculated at drift angles of less than +0.1%, are presented in the column 2 of Table 3. The values of the lateral force and drift angle corresponding to the onset of endplate (faceplate) yielding are listed in columns 3 and 4 (columns 5 and 6) of Table 3. First yielding of the faceplates was identified using strain gage data. Columns 7 and 8 present the lateral force and drift angle corresponding to the onset of faceplate buckling. Columns 9 and 10 present the peak loads and the corresponding drift angles in the positive and negative directions.

Both the initial stiffness and peak load for SC2 are greater than those for SC1 because although the two specimens have the same dimension, the strength of concrete for SC2 is greater than that for SC1. For the two shear-critical walls (SC1 an SC2), the yielding of endplates and faceplates occurred at the same time and earlier than the onset of faceplate buckling. For the flexural-critical wall (SC3), the yielding of faceplates occurred much later than the yielding of endplates since the flexural behavior dominated the demand of the wall.

Table 3 . Summary of test results

Specimen	Initial stiffness (ton/cm)	Onset of endplate yielding		Onset of faceplate yielding		Onset of faceplate buckling		Peak load	
		Load (ton)	Drift ratio (%)	Load (ton)	Drift ratio (%)	Load (ton)	Drift ratio (%)	Load (ton)(+/-)	Drift ratio (%) (+/-)
SC1	1333.4	-311.3	0.4	-311.3	0.4	-428.4	1.6	461.5/-449.8	2.0/-2.0
SC2	1543.7	-338.2	0.4	-338.2	0.4	497.7	2.0	541.2/-537.2	1.3/-1.6
SC3	537.8	200.1	0.4	-254.0	1.0 (1st cyc.)	-289.0	1.0 (2nd cyc.)	336.3/-327.3	2.0/-1.6

3.2 Sequence of Damage to SC Walls

Figure 5 illustrates the sequence of damage to the faceplates and endplates of SC1, including (1) the yielding of the endplates and faceplates, (2) welding rupture between the faceplate and endplate, (3) buckling of the faceplates, and (4) rupture of the faceplates. Figure 6 illustrates the sequence of damage to the faceplates and endplates of SC3, which is different from that for SC1 and SC2, including (1) the yielding of the endplates (first) and faceplates (later), (2) welding rupture between the faceplate and endplate, (3) buckling of the faceplates near the toes of the specimen, and (4) rupture of welding between the endplate and baseplate. The lateral-load capacity of SC3 dropped significantly after the brittle failure of the welding between the endplate and baseplate, which terminated the test.

A steel faceplate was removed from each of the three specimens for the purpose of documenting damage to the infill concrete. The shear-critical and flexural-critical walls show entirely different damage mechanism. Panels a and b of Figure 7 presents the result for SC1 and SC2, respectively. Infill concrete was severely damaged along the diagonal lines of the specimens. Panel c of Figure 7 presents the result for SC3. Although some diagonal cracks in the lower half of the wall and crushing of concrete near the toes of the wall were observed, most of the infill concrete stayed undamaged.

Panels a and b of Figure 8 presents the pictures of faceplates of SC1 and SC2, respectively, after the test. The faceplates were buckled and ruptured severely. Panel c of Figure 7 presents the result for SC3. Outward buckling of the steel faceplates close to the base of the specimen was observed. The brittle rupture of the welding at the base of the endplates took away the ability of the wall to further dissipate energy.

(a)Yielding of steel endplates and faceplates
(b)Welding rupture between faceplates and boundary elements
(c)Buckling of faceplates
(d)Rupture of faceplates

Figure 5 Sequence of damage of SC1

(a) Yielding of steel endplates and faceplates
(b) Welding rupture between faceplates and boundary elements
(c) Buckling of faceplates
(d) Welding rupture between baseplate and boundary elements

Figure 6 Sequence of damage of SC3

(a) SC1 (b) SC2 (c) SC3

Figure 7 Damage of in-fill concrete after the test

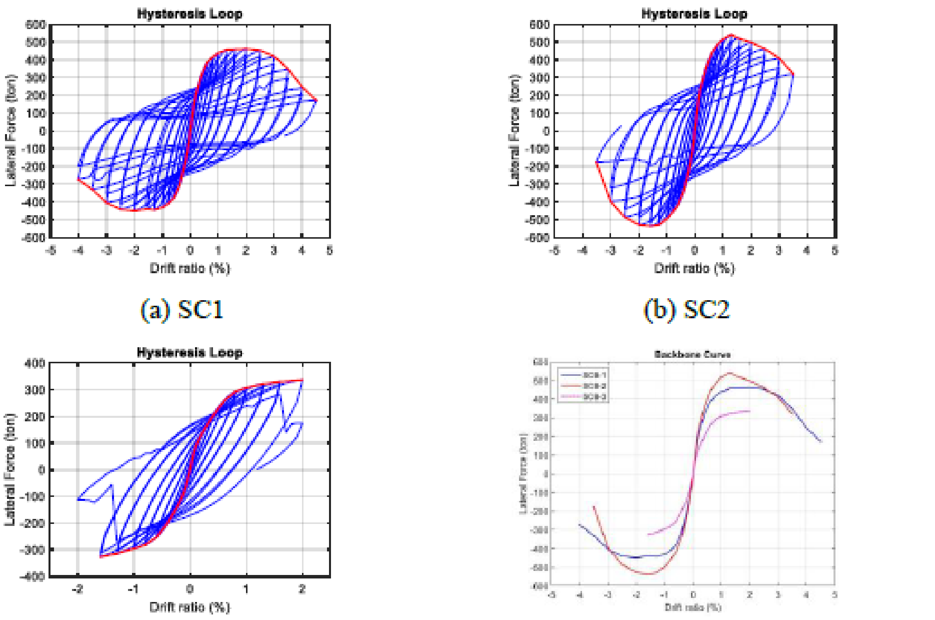
(d) SC1 (e) SC2 (f) SC3

Figure 8 Damage of faceplates after the test

3.3 Force-Displacement Cyclic Response

Panels a, b, and c of Figure 9 present the hysteresis loops for SC1 through SC3, respectively. SC1 has the best ductility among the three. The strength of SC1 did not show degradation and the pinching of the loop was not obvious before a draft ratio of 2.5%. After a draft ratio of 2.5%, the faceplates buckled significantly and cannot provide enough confinement to the infill concrete. The strength of SC1 began to degrade and the pinching in the loop became more obvious. However, the specimen still maintained 80% of its peak lateral-load capacity until a draft ratio of 3.5%. The strength of SC2 began to degrade right after the specimen reached its peak capacity. A possible reason is that the specimen was subjected to higher shear and moment demands than SC1 and the increasing moment in the specimen reduced its shear capacity. SC2 maintained 80% of its peak strength until a draft ratio of 3%.

Panel d of Figure 9 presents the backbone curves of the hysteresis loops of panels a, b and c. SC3 has the worst ductility among the three since the failure mode for the specimen is the brittle failure of welding at the bottom of the endplates.



(a) SC1 (b) SC2

(c) SC3 (d) Backbone curves for SC1, SC2, and SC3

Figure 9 Lateral loading-displacement behavior of the three SC wall specimens of this study

4 PREDICTIONS OF THE STRENTH OF SC WALLS WITH BOUNDARY ELEMENTS

4.1 Shear-Critical SC Walls

As described earlier, Booth et al. (2015) proposed that the in-plane shear strength of a SC wall with boundary elements should include two parts: the shear force required to yield the steel plates (Vy) and an incremental shear resisted by the concrete in diagonal compression up to the failure of the wall (ΔV).

$$V_{ub} = V_y + \Delta V \tag{1}$$

$$\Delta V = 0.33 \cdot 0.5 \cdot (f_c' - f_{cy}) \cdot A_c \tag{2}$$

$$f_{cy} = \frac{E_c' \cdot S_{xy} \cdot (v_s + 1)}{2 \cdot t_p \cdot E_s + t_{sc} \cdot E_c'} \tag{3}$$

where Vy can be computed per the recommendations of AISC N691-12s1; fc' is the concrete compressive strength; fcy is the diagonal concrete compressive compressive stress occurring when the applied shear is equal to Vy; Ac is the concrete area; Ec' is an effective elastic concrete stiffness; SXY is the unit element shear force at yield; vs is the Poisson's ratio for steel; tp is the thickness of faceplate; Es is the elastic modulus of steel; and tsc is the thickness of the SC wall. The authors of this paper evaluated the effectiveness of the model of Eqs. (1) through (3) using the experimental data from literature and found that the model can be further improved by taking into account the impact of the aspect ratio of a wall:

$$V_{ub}' = V_{ub} \times \frac{\cos(\theta)}{\cos(45^\circ)} \tag{4}$$

where θ is the angle between the diagonal line of a wall and the horizontal line. The peak strengths of SC1 and SC2 from the test (Vexp) and the predictions of Eq. (1) and Eq. (4) are presented in the 2nd, 3rd, and 5th columns of Table 4. The model of Eq. (4) improves the accuracy of the prediction of Eq. (1). The value of θ used in the computation of Vub' in Table 4 is the angle between the blue line of Figure 10 and the horizontal line. Since the upper part of the specimens were clamped by the loading beams, we recalculated the predictions of Eq. (4) using the angle of the red line of Figure 10 rather than the blue line and the results (termed Vub") are presented in the 7th column of Table 4. The ratio of Vexp to Vub" is 1.05 for SC1 and 1.0 for SC2.

Table 4 Test results and the prediction of models on the strength of SC1 and SC2

Specimen	V_{exp} (ton)	V_{ub} (ton)	$\frac{V_{exp}}{V_{ub}}$	V_{ub}' (ton)	$\frac{V_{exp}}{V_{ub}'}$	V_{ub}'' (ton)	$\frac{V_{exp}}{V_{ub}''}$
SC1	461	397	1.16	422	1.09	440	1.05
SC2	541	490	1.11	521	1.04	542	1.00

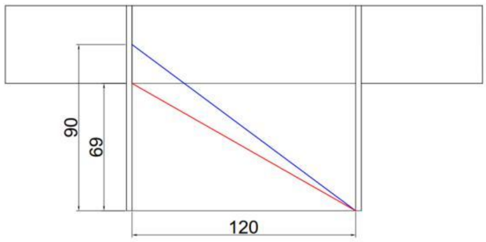


Figure 10 The definition of θ

4.2 Flexural-Critical SC Walls

Table 5 presents the peak strength of SC3 from the test (Vexp) and the prediction of simple section analysis using software XTRACT (VETRACT). The value of VETRACT was computed using the moment capacity of the section of SC3 divided by the height of the specimen. The ratio of Vexp to VETRACT for SC3 is 1.02. The strength of flexural-critical SC walls can be predicted using section analysis.

Table 5 Experimental results and numerical results using XTRACT on the strength of SC3

Specimen	V_{exp} (ton)	XTRACT	
		V_{XTRACT} (ton)	$\frac{V_{exp}}{V_{XTRACT}}$
SC3	336	330	1.02

5 CONCLUSION

Three SC walls with boundary elements, SC1 through SC3, were constructed and tested under displacement-controlled, reversed cyclic loading at the National Center for Research on Earthquake Engineering in Taiwan. The specimens were designed to be shear-critical (SC1 and SC2) and flexural-critical (SC3). Key conclusions of this study are listed as follows:

1. The shear-critical specimens of this study demonstrated very ductile behavior. Both specimens reached a drift ratio of 3% without losing 80% of their peak capacity.

2. The test of the flexural-critical specimen SC3 stopped at a drift ratio of 2% after the brittle rupture of the welding between the endplate and baseplate. The connection design for such SC walls is challenging and needs to be conducted carefully.

3. The model of Booth et al. (2015) in predicting the shear strength of a shear- critical SC wall with boundary elements can be improved by taking into account the aspect ratio of the wall.

4. The lateral-load strength of a flexural-critical SC wall can be predicted well using section analysis.

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Quantification of Hydrated Cement Matrix Pore Connectivity Through Tortuosity And Fractal Dimension

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Abstract. The chloride-induced corrosion of reinforcement embedded in concrete structures exposed to marine environments is one of serious threats to service-life of the structures. Diffusion is the dominant transport mechanism of chloride ingress into concrete. Therefore, clear understanding of chloride transport mechanism, particular the diffusion path, is important for designing the durability performance of reinforced concrete structures. The purpose of this study is to determine tortuosity of cement materials and threshold pore radius which controls chloride ion transport. The pore-structure model to obtain capillary pore was expanded by introducing fractal dimension which represents microstructural complexity. The fractal dimension was determined by fitting experimental data to simulation results considering wo types of C-S-Hs (low and high density) or two types of products (inner and outer), and it was used as tortuosity to determine effective diffusion coefficient of chlorides in the reactive transport model. The chloride ingress was simulated using the transport model and verified with experimental data for hydrated cement having different water to cement (W/C) ratio. A good agreement between experimental data and simulated chloride profiles demonstrate that critical pore radius exists in inner product of C-S-H. Furthermore, diffusion path is influenced by W/C and the pore in inner product controls diffusion of chloride ions in each case.

Keywords: *fractal dimension, tortuosity, calcium silicate hydrate (C-S-H), chloride ion, transport*

1 Introduction

Chloride induced steel corrosion is the greatest problem for the durability of reinforced concrete structures exposed to marine environment. The main cause of chloride induced reinforcement corrosion is fundamentally due to the diffusion of chloride ion into concrete. It is necessary to grasp the mechanism of chloride diffusion to predict the durability performance. Chloride ion transport is influenced by ion-ion interaction and adsorption to cement hydration products. In addition, chloride binding capacity is strongly dependent on physical adsorption to C-S-H than chemically bound chlorides [1]. Hydrated cement acquires an electrical charge when it contacts with polar medium and leads to formation of Electric Double Layer (EDL). Gel pores influence the transport of ions strongly due to overlapping of EDL [2]. Elakneswaran et al. [2] have developed an integrated transport model that includes precipitation/dissolution of cement hydrates and binding of multi-ions on cement hydrates using by phases-equilibrium model and surface complexation model in addition to multi-species transport to predict chloride ingress into cementitious materials.

The chloride transport is influenced by microstructural parameters such as porosity and tortuosity. The actual path for chloride transport in cement paste is very complex or tortuous in nanoscale. Chloride ion diffusion is significantly controlled by capillary pore and the C-S-H porous matrix. The C-S-H in cement paste can be considered as Low Density (LD) and High Density C-S-Hs [3]. Bary et al. [4] proposed percolation model which considers pore connectivity between these two types C-S-Hs and capillary pore. Based on the percolation threshold and the existence of C-S-H proportions, HD C-S-H controls the diffusion in low water to cement (W/C) specimens. Further, the model considers mixed component composed of capillary pore and LD-CSH for increasing W/C.

The HD C-S-H is a dense structure and has high tortuosity values, but it is low in LD C-S-H. Therefore, it is necessary to propose appropriate tortuosity values considering the type of C-S-H in cementitious materials for different W/C. The fractal geometry helps to describe and interpret complex microstructure of cement matrix. Based on fractal geometry modelling, pore structure of cement paste could be interpreted to describe ionic diffusion path. Fractal dimension represents the structural change of concrete components and hydration products and its value approaches 3 for the dense structure, but the structure has a large amount of fine pores [5]. Thus, ionic diffusion will be retarded and they should diffuse through micro pores. This crates longer diffusion path for ions and consequently increase the tortuosity. It can be inferred that fractal dimension represents the tortuosity values. In this study, fractal dimension was determined by extending the pore structure model [6] which shows a function of porosity to power factor, and the fractal dimension values were determined by fitting modelling results to experimental data obtained in Differential scanning calorimetry (DSC) measurement of cumulative fine pore diameters. A threshold pore radius which controls transport of chloride ion was determined by the integrated thermodynamic model and used with pore connectivity to evaluate diffusion path.

2 Materials and methods

2.1 Materials and sample preparation

The chemical compositions and physical properties of OPC are given in Table 1. Hydrated cement paste (HCP) was prepared with water to binder ratios (W/C) of 0.3, 0.5, and 0.7. Samples were cast in molds (φ50 mm × 100 mm or 40 mm × 40 mm × 160 mm) after mixing and continuous hand-mixing every 30 min to stop bleeding. Samples were sealed for 24 h at room temperature, and then cured in water for 91 days at 20 ℃. Total porosity was calculated from weight loss at 105℃. Hydration degree was calculated as the weight loss between 105℃ and 950 ℃.

Table 1 Chemical compositions of OPC

	Density (g/cm^3)	Blaine (cm^2/g)	Chemical composition (%)					
			SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2
OPC	3.16	3310	21.56	4.68	2.98	65.63	1.3	0.23
			Na_2O	K_2O	SO_3	P_2O_5	MnO	Cl
			0.33	0.39	1.9	0.27	0.14	0.005

Table 2 Total porosity and hydration degree at 91 days

	Porosity	α (Hydration degree)
W/C=0.3	0.135	0.768
W/C=0.5	0.200	0.903
W/C=0.7	0.331	0.997

2.2 Pore size distribution by thermoporometry

Differential scanning calorimetry (DSC) was used to measure the pore size distributions of hydrated samples. For each sample, approximately 28 mg of material was dried at 105℃ for 24 h and immersed in water for 3 h. After immersion, water adhered on the sample surface was wiped off and the samples were placed in an aluminum sample pan. Alumina powder was used as a reference specimen during measurement. The measurement range was 10℃ to -60℃, and the scanning speed was 2℃/min. The total moisture content was determined by the weight differences between measurements at 20 and 105℃. Pore size distribution was determined using a thermoporometry theory reported previously [7], [8].

2.3 Electron probe microanalyzer (EPMA) measurements

After curing, the cylinder samples were cut into two halves and all surfaces except the cutting face were coated with epoxy resin to ensure chloridepenetration in only one direction. The coated samples were exposed to 0.5 mol/l chloride for 28 days. After exposure, the specimens were cut into two halves parallel to the path of ionic ingress; one part was used for EPMA mapping while the other was used to determine the amount of chloride by a traditional method. An EPMA JEOL JXA-8900M apparatus was used to carry out element mapping. The measurement conditions were as follows: 15 kV accelerating voltage, 50 mA beam current, 60 × 30 µm pixel size, and 1000 × 50 points. The chloride profile was calculated from the mapping, but was expressed as X-ray counts of chloride. The counts were corrected by the determining the chloride concentration from a wet analysis as described in Japanese Industrial Standard (JIS) A 1154.

3 Modeling approach

3.1 Expanded pore-structure model

Maekawa et al. [6] determined connectivity of capillary pore which exists between inner product and outer product using Eq. (1), (2). In this model, inner product forms within the original volume of reacting cement grains while outer product forms in the originally water-filled spaces. Capillary pore forms interlayer in CSH grains.

$$\varphi_c(x) = \frac{r}{D+r} = \left(\frac{\varphi_{ou}}{\delta_{\max}}\right)x \tag{1}$$

$$V_x = \int_0^x \varphi_c(x) 4\pi (x+x_0)^2 \, dx \tag{2}$$

$\varphi_c(x)$ = capillary porosity at location x
D = size of CSH grains (19 nm)
r = capillary pore size
φ_{ou} = porosity at the extreme radius of the unit cell
δ_{max} = distance between the extreme radius of unit cell and original boundary
x_0 = un-hydrated core

In this model, porosity of inner product is assumed to be constant, and outer product is varying linearly. However, ion transport occurs through micro-pores of HD- and LD-CSH. To evaluate measured micro-pore, this model is extended by introducing fractal dimension to function of porosity (Eq. (3),).

$$\varphi_c(x) = \frac{r}{D+r} = \left(\frac{\varphi_{ou}}{\delta_{\max}}\right)x^{3-F} \tag{3}$$

F = Fractal dimension

The size of un-hydrate is determined by hydration degree. Produced cement gel volume assumes to be 2.1 times of reacted cement volume when cement unit volume is reacted (Eq. (4), (5), (6)) [9].

$$D_i = D_0\sqrt{1-\alpha} \tag{4}$$

$$t_{gel} = \frac{2.1\alpha D_0}{4\sqrt{1-\alpha}} \tag{5}$$

$$x_0 = \frac{1-\alpha}{1+0.05\alpha} \tag{6}$$

D_i = particle size after reaction
D_0 = initial particle size
t_{gel} = product layer
α = hydration degree

From Eq. (2), (3) and (6), pore-structure model is expanded (Eq. (7)). When calculating fractal dimension of inner and outer product, affine transformation makes confirmation with self-similarity of multi-scale.

$$V_x = \int_0^x \varphi_c(x)4\pi(x+x_0)^2 dx = 4B\pi\left\{\frac{1}{6-F}A^{\frac{6-F}{3-F}} + \frac{2x_0}{5-F}A^{\frac{5-F}{3-F}} + \frac{x_0^2}{4-F}A^{\frac{4-F}{3-F}}\right\} \tag{7}$$

A = $A = \frac{1}{B}\frac{r}{D+r}$

B = $B = \frac{\varphi_{ou}}{\delta_{\max}}$

3.2 Reactive transport model

An integrated thermodynamic model considering ion–ion and ion–solid interactions was used to simulate multi-ionic transport. The model was implemented in the PHREEQC geochemical code using phase-equilibrium, surface complexation, and multi-component diffusion (MCD) modules. Thermodynamic properties for various phases and minerals present in the cement system were collected from CEMDATA07 [10] and other sources [11], and converted into a format suitable for PHREEQC. The converted data, together with the PHREEQC default thermodynamic database [12], were used in this study for each calculation. The details of the integrated thermodynamic model are described elsewhere [2].

The diffusive flux of a selected ion, *i*, considering concentration and electrical potential gradients and the chemical activity effects can be expressed by Nernst-Planck equation as follows [2]:

$$J_i = -D_{w,i}\left[\frac{\partial \ln(\gamma_i)}{\partial \ln(c_i)} + 1\right]\frac{\partial c_i}{\partial x} + D_{w,i} z_i c_i \frac{\sum_{j=1}^{n} D_{w,j} z_j \left[\frac{\partial \ln(\gamma_j)}{\partial \ln(c_j)} + 1\right]\frac{\partial c_j}{\partial x}}{\sum_{j=1}^{n} D_{w,j} z_j^2 c_j} \quad (8)$$

$D_{w,i}$ = diffusion coefficient
γ_i = activity coefficient
c_i = ion concentration

z_i = ion valance

The diffusion coefficient of ions in a porous medium is related to $D_{w,i}$, porosity and tortuosity by Archie's law [13]:

$$D_p = D_{w,i}\varepsilon_w^{\tau} \quad (9)$$

D_p = diffusion coefficient of ions in a porous medium
ε_w = porosity
τ = tortuosity

4 Results and discussions

4.1 Pore size distribution

The pore size distributions of HCP as determined by thermoporometry (91 days curing) are shown in Fig. 1. As assumed in a previous study, inner product contains fines pores while outer product has large pore spaces [14]. This is related to the types of C-S-H: the Low Density (LD) and High Density C-S-H [3]. HD

C-S-H and LD C-S-H are respectively similar to the inner- and outer- products. As shown in Fig. 1, high W/C produces a large amount of LD C-S-H and large pores.

4.2 Fractal dimension of HCP

In this paper, almost fully hydrates samples cured until 91 days were considered for the analysis. The characteristics and microstructure of two types of C-S-Hs (inner product or HD-CSH and outer product or LD-CSH) [3, 14] were

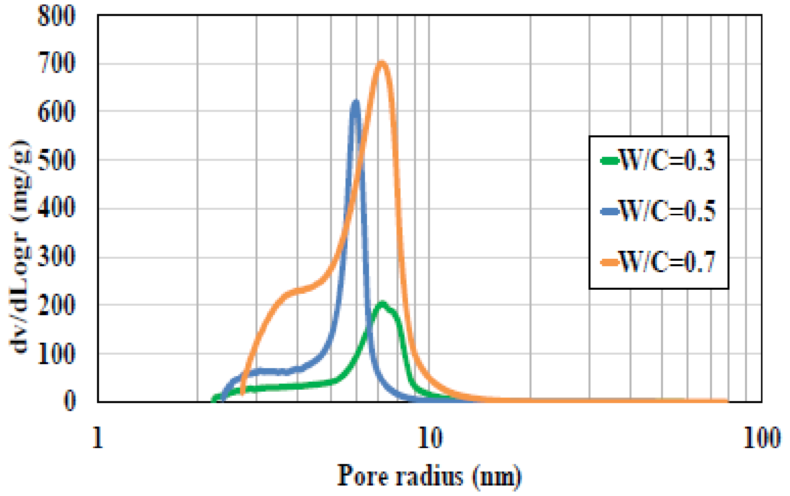


Fig. 1 Pore size distribution of HCP with several W/C ratios at age of 91 days

discussed using these samples. The fractal dimension of HD- and LD-CSH was determined by assuming the pores of inner product or HD-CSH has size less than 10 nm in diameter whereas pores of LD-CSH is greater than 10 nm. The enhanced model is used to evaluate pore size distribution and the results are shown in Figure 2, and the determined fractal dimension values are tabulated in Table 3 for each W/C. The value of HD-CSH in each sample is close to the real dimension of 3. The HD-CSH has very fine pore and ionic transport will be retarded or used a long path for diffusion and thus, tortuosity will increase in the C-S-H. On the other hand, the fractal dimension of LD-CSH is approximately 2 indicating two-dimensional plane structure. Therefore, the tortuosity of LD- CSH is lower than that of HD-CSH.

Table 3 Fractal dimension of HD and LD-CSH

	W/C=0.3		W/C=0.5		W/C=0.7	
	HD-CSH	LD-CSH	HD-CSH	LD-CSH	HD-CSH	LD-CSH
Fractal dimension	2.95	-	2.70	2.37	2.90	2.37

4.3 Modeling results for chloride ion transport

4.3.1 Influence of tortuosity

Tortuosity changes with porosity and influence on the transport of ions. Even though pore is connected, the diffusion path becomes large for high tortuosity values. In the thermodynamic integrated model, tortuosity influences diffusion coefficient of ions in a porous medium as given in Eq. (9). The simulated chloride ion concentration profiles with varying tortuosity values are shown in Fig. 3. The depth of chloride penetration strongly depends on tortuosity. Thus, it is important to choose appropriate tortuosity value considering pore structure and existence of HD-CSH and LD-CSH. Jennings and Tennis [3] has proposed an equation to estimate LD-CSH proportion. The calculated LD-CSH proportion for varying W/C is shown Fig. 4. The hydration degree of 0.3, 0.5 and 0.7 W/C pastes cured at 91 days are 0.76, 0.90 and 0.99 respectively, and thus, LD-CSH proportion is 0.20, 0.68 and 1.0 respectively. Because of the prediction of LD-CSH in the sample of W/C of 0.7 W/C projected higher than 1, it is assumed that the C-S-H in the sample consists LD-CSH only. The proportion of LD-CSH in the sample of W/C of 0.3 assumed to be negligible. Therefore, the fractal dimension of HD-CSH only for W/C of 0.3, both LD- and HD-CSH for W/C of 0.5, and only LD-CSH for W/C of 0.7 is assumed to predict chloride ion transport.

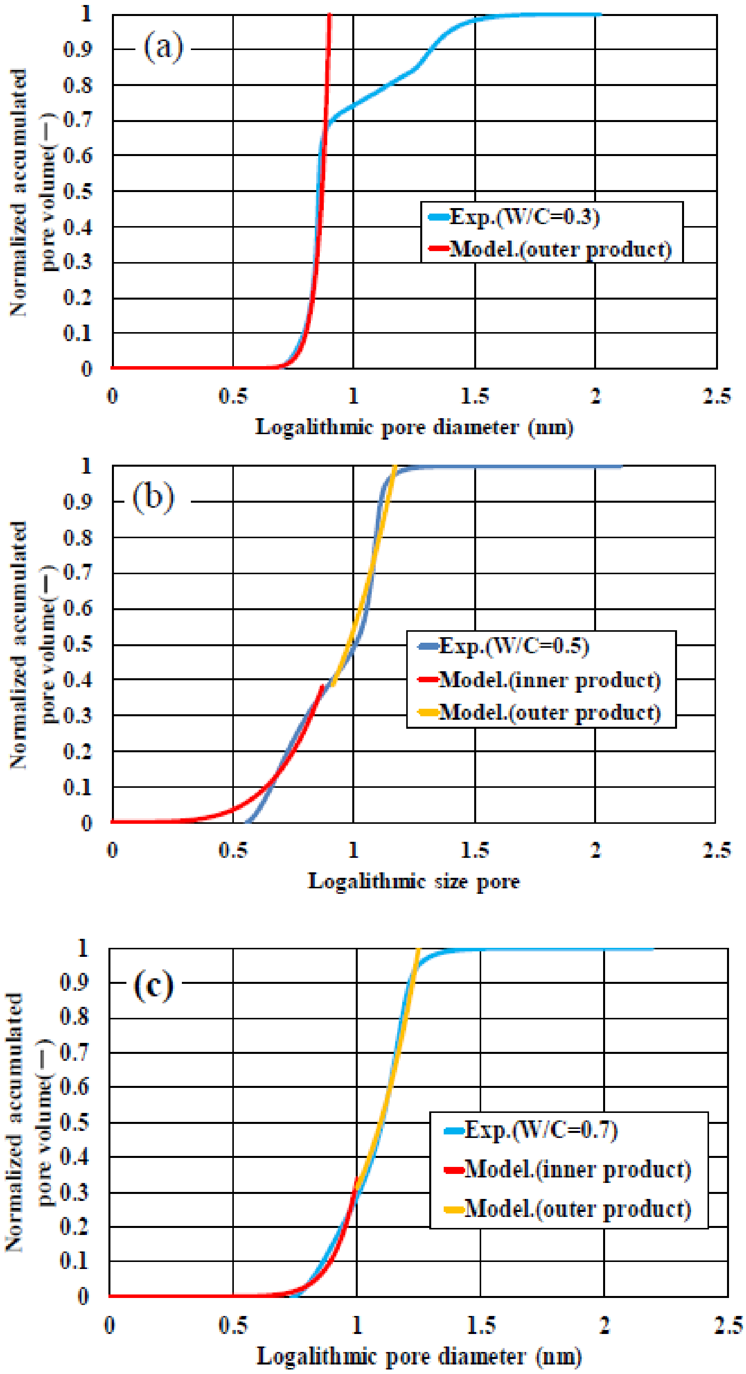


Fig. 2 Comparison between Expended pore-structure model and measured value
(a) : W/C=0.3 (b) : W/C=0.5 (c) : W/C=0.7 at 91 days

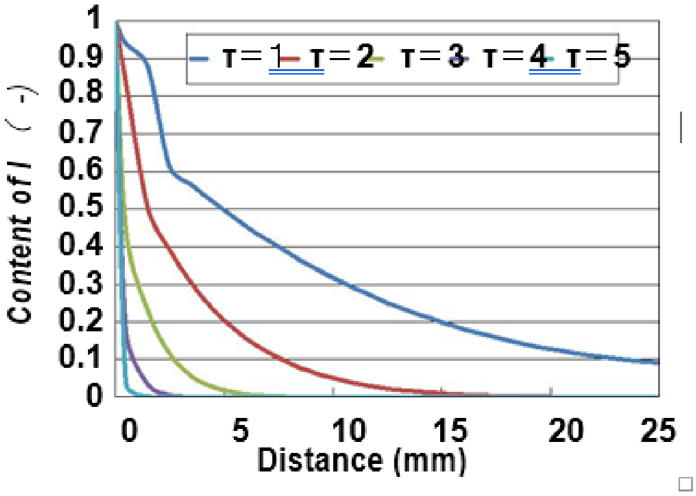


Fig. 3 Simulated results for dependence of tortuosity on total content of chloride

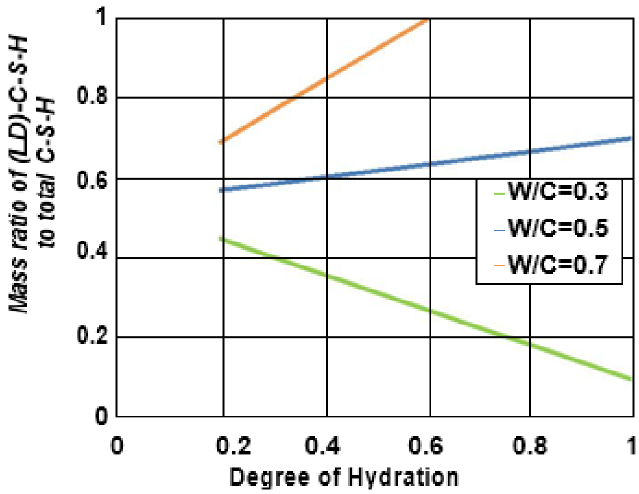
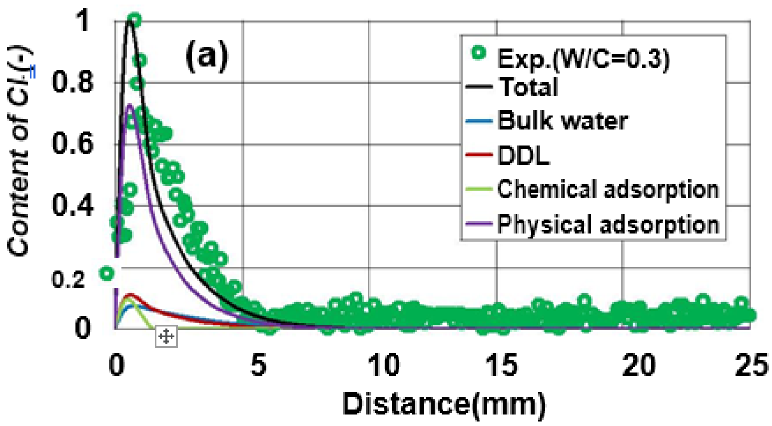


Fig. 4 LD-CSH compositions using Jennings and Tennis model [3]

4.3.2 Comparison between measured and estimated chloride ingress

The threshold pore size which controls chloride ion diffusion was specified based on the pore size distribution (shown in Figure 1) and tortuosity values determined as fractal dimension. Figure 5 compares predicted chloride profile from an integrated model and that is determined by EPMA measurement. The predicted amounts of chloride in the free water of the pore solution, diffuse double layer, chemically bound as Friedel's salt, and adsorbed on C-S-H surface are also presented. The physical adsorption of chloride dominates in the total. The simulation results show good agreement with experimental data for each W/C. The threshold pore radius is 3.95 nm, 3.51 nm and 3.43 nm respectively for W/C of 0.3, 0.5 and 0.7, and it exists in HD-CSH or inner product (Figure 1). Both simulation and experimental results show the increase of chloride penetration with W/C due to high porosity, large pore size, and small tortuosity values. The small pore significantly influence the ionic diffusion than capillary pore, which supports a previous study [2]. The agreement between simulation results and experimental data indicates that the diffusion path of 0.3 W/C specimen exists in inner product, the path in both inner and outer products for 0.5 W/C, and in outer product for W/C of 0.7. Further, inner product of each W/C controls the diffusion.



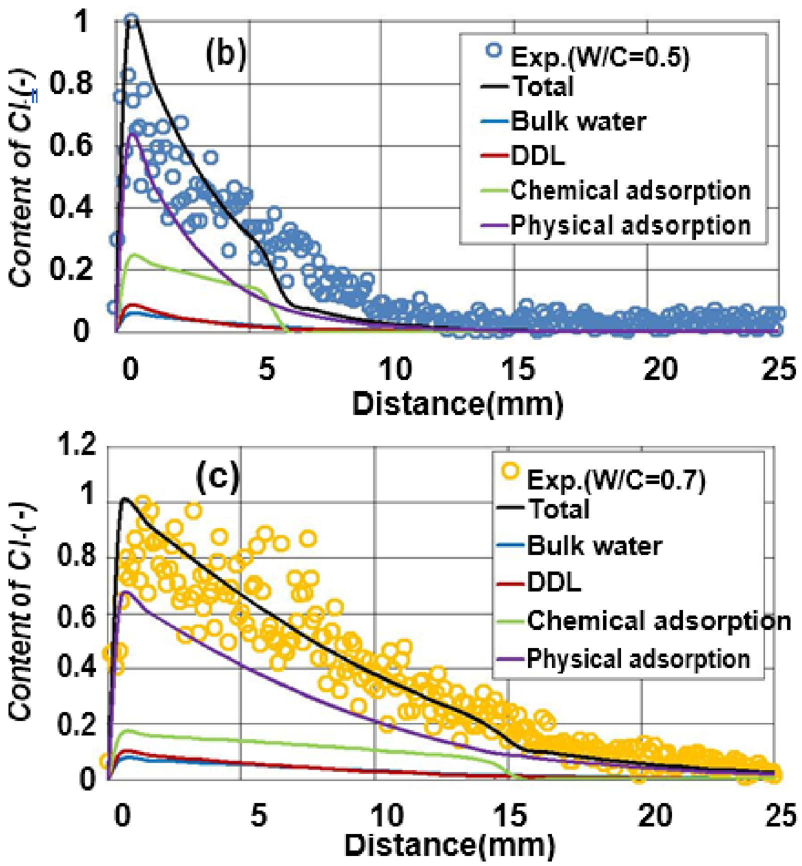


Fig. 5 Comparison between measured and simulated chloride value for HCP
(a): W/C=0.3 (b) : W/C=0.5 (c) : W/C=0.7 at 91 days

5 Conclusions

The pore structure model proposed in a previous study [5] is extended in here to determine fractal dimension for HD- and LD-CSH by fitting model results to experimental data. The threshold pore diameter for each W/C is estimated considering corresponding C-S-H and tortuosity determined from fractal dimension. The pore structure parameters are used in the prediction of chloride profiles. Comparing simulation results with experimental data suggested that diffusion path of low W/C exists in inner product whereas the path is in outer product for high W/C samples and it is in both inner and outer product for intermediate W/C. The small pore in inner product controls the diffusion in each sample.

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A Study of Cement Made From Recyled-Garbage Materials Compared With Portland Cement

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Abstract. Garbage waste is a worldwide environmental problem. Various ways have been implemented for these recycled-garbage materials to be useful in order to save the environment. One of the ways to recycle the garbage into cementitious materials is by combining organic garbage (household garbage, bagasse and rice husks) with mediteran soil. Hereinafter the recycled garbage material is called organic cement. The results of this research is aimed as a movement to save the environment. The test result of chemical compounds, through laboratory test method showed the indication of organic cement resembling the portland cement chemical compounds in the form of: CaO of 65,36%, SiO_2 18,84\\%, Al_2O_3 6,33%, Fe_2O_3 2,29%, SO_3 3,64%, MgO 1,35%, C_3S 66,72%, C_2S 3,98%, C_3A 12,9%, C4Af 6,97%. The density of organic cement was discovered trough physical examination with the amount of 3,01 g/cm^3, lower than the density of portland cement which was 3,16 g/cm^3. The fine cement grain which passes the 200 mesh sieving was as much as 59 %, more than the portland cement which was 33 %. The solidity of organic cement was 1224 kg/m^3, 3,52% lighter than the solidity of portland cement which was 1267 kg/m^3. The testing of initial and final setting time using normal consistency water content with 37 % for organic cement, more than the normal consistency of portland cement of 25 %. The initial setting time of organic cement was 105 minutes, longer than the initial setting time of portland cement which reached the 90 minutes mark. The final setting time of organic cement was on 330 minutes mark, longer than the final setting of portland cement which reached 180 minutes mark. Organic cement concrete possesses cohesive and adhesive properties as such in portland cement concrete. In the same design and age mix, the strengths of organic cement concrete were lower than portland cement concrete, caused by the slow setting time. The evaluation of recycled-garbage materials composition is needed for the faster setting time. Although the results of organic cement concrete strengths test are below than that of the portland cement concrete, organic cement concrete can still be utilized for lightweight construction and hot regions.

Key words: *organic cement, portland cement, organic garbage, bagasse garbage, rice husk garbage, setting time.*

1 Introduction

Due to the high trash volume, it is considered essential to manage it seriously (Suarna, 2008). Trash production by day increases (Umar, 2009). To decompose organic and inorganic waste, community's role is extremely important (Wompere, 2012). The high burden of trash gradually causes negative impact on the environment and population (Waryono, 2009). Makassar as part of Indonesia has produces trash as much as 4000 m^3 per day (Oktavianus, 2015). Through incineration process the organic waste will turn to ash containing SiO2 23% to 46%, AI2O3 13% to 29%, and CaO12% to 31% (Priyatna 2009). The trash in the study were collected from the final trash dump site in Antang of Makassar City. The research result orientation is the utilization of waste recycle of the materials of a little use in the community so far. Experimental study already performed in connection with such thing is a recycle a combination of organic waste (household garbage, bagasse garbage, rice husk garbage) and mediteran soil substitute to become an organic cement instead of Portland cement.

Rice husk ash, although unable to be categorized as cement matrix for not containing C3S and C2S, it can be used as partial replacement of cement to produce secondary CSH in constructing cement composite (Bakri, 2009). Bagasse ash obtained through perfect regulation of itsincineration will contain very high amorphous silicate about 88.9% to 96.7% (Wibowo. et.al. 2006). From hydration, the mixture of bagasse ash with Portland cement results in an addition setting time (Haryono et al, 2005).

The use of saturated fly ash is one of the ways to reduce high evaporation in the hydration process against the density of cement in the concrete (Victor Sampebulu, 2012). Mediteran soil is an infertile soil formed by limestone weathering and containing calcium and magnesium. This type of soil does not give a lot of benefits to agriculture but very good for building materials (Maria Sanico, 2012).

Japan has produced eco-cement made from ash of the city waste through incineration as replacement for some primary raw materials consisting of 50% ofcement made of sewage sludge (Shunsuke Hanehara, Iwata University, 2011). Hydration properties of eco-cement of sludge ash to become klinkers have obtained three kinds of hydraulic cement by developing sludge ash from primary plant waste and water distillation plant, as well as slag from steel factory (ferrate), as a replacement for some of the clay, silica alumina, and iron oxide to become raw material for cement (Kae-Long Lin, at al. 2004).

In the picture of 1A, organic cement concentrate made of organic waste (household garbage, bagasse and rice husk garbage) with mediteran soil substitute. While in the picture of B is Portland cement used as comparison in the examination of physical nature of this study.

A B

Figure 1 (A) Organic cement made from organic gerbage. (B) Portland cement

2 Outline Of Experiment

2.1 Methods Of Experiment

In examining and evaluating the chemical properties of the organic cement concentrate, a comparative study of the physical properties of the similarities and differences between portland cement and organic cement. The examination of chemical properties is first conducted to each raw material which has been processed and become the concentrate for the organic cement. Later, tests on the concentrate of the organic cement are performed. To obtain the optimal result of the tests and evaluation of the chemical and physical properties of organic cement concentrate, laboratory test based on the American Standard Testing and Material (ASTM) and Standar Nasional Indonesia (SNI).

2.2 Material and Mix Proportion

Organic cement concentrate is formed utilizing natural ingredient like mediteran soil and recycled organic garbage i.e. household garbage, bagasse garbage, and rice husk garbage. When all the raw materials are managed, it is necessary to identify the level of chemical content produced by each concentrate. Table 1 below shows the proportion of the use of the main ingredients and the chemical content produced by each concentrate.

Table 2 The presentaion of the primary materials for organic cement

No	Material Sources	The Primary (Large) Composition			Additional chemical elements. (Small)
		The Primary Chemical Component	Content/ Level (%)	Composition taken (%)	
1.	Mediteran Soil / I	CaO	60,93	61	SiO2, Al2o3, Fe2o3, Mgo,So3,Na2o,K2O
2.	Organic Garbage :				
	Household Garbage/ N	SiO2	32,56	35	Al2O3,CaO, Fe2O3, SO3, Na2O, K2O, MnO, MgO, TiO3, P2O5, HP
	Rice Husk Garbage/ A	SiO2	71,27	2	CaO, Al2o3, Fe2O3, MgO,K2O,Na2O,HP
	Bagasse/ R	SiO2	38,06	2	CaO, Al2O3, Fe2O3, MgO, K2O, TiO2, Na2O, P2O5

The empirical formula of the concentrate forming organic cement can be presented as follow:

$$\sum R_I f = \frac{\sum I + \sum N + \sum A + \sum R}{100} \qquad (1)$$

In which :

$\sum R_I f$ = Organic cement concentrate (kg)
$\sum I$ = Mediteran soil concentrate (%)
$\sum N$ = Household garbage concentrate (%)
$\sum A$ = Rice husk garbage concentrate (%)
$\sum R$ = Bagasse concentrate(%)

3 Results and Discussion

Organic waste that comes from household waste is combusted to a temperature of 700^{o}C. Meanwhile, the rice husk and bagasse wastes are combusted to a temperature of 600^{o}C. For mediteran soil, it is combusted to a temperature of 1000^{o}C. After all the materials become a concentrate, then the material combination is conducted in accordance with the percentages shown in Table 1. The combined material is then combusted in the combustion engine until it reaches the temperature of 1400ºC to remove the C2S, C3S, C3A, and C4Af compounds. The combustion results in this phase will produce clinker granules which then requeires a smoothing process so that the grinding process is possible to be conducted. The results of concentrate grinding are then examined or tested its chemical compounds where the testing that has been conducted is the testing of organic cement forming elements and several tests of physical characteristics such as its granular fineness, specific gravity, density, the initial setting time and the final setting time of the organic cement. The organic cement in this instance is the organic cement made from a combination of several recycled organic garbage (household garbage, bagasse, and rice husk garbage) with mediteran soil substitution.Table 2 indicates analysis results of chemical elements of organic cement and table 3 shows the chemical properties of portland cement based on ASTM C114.

Table 3 Chemical components of organic cement

Parameter	Percentage	Result
C_3S	%	66,72
C_2S	%	3,98
C_3A	%	12,9
C_4AF	%	6,9
LOI	%	24,5
Ash Analysis		
SiO_2	%	18,84
Al_2O_3	%	6,33
Fe_2O_3	%	2,29
CaO	%	65,36
SO_3	%	3,64
Na_2O+K_2O	%	1,01
MgO	%	1,35

Table 4 Chemical components of portland cement according to ASTM C114-07

Parameter	Percentage	Result
C_3S	%	50-70
C_2S	%	15-30
C_3A	%	5-10
C_4AF	%	5-15
LoI	%	1,58
Ash Analysis		
SiO_2	%	20,6
Al_2O_3	%	5,07

Fe_2O_3	%	2,9
CaO	%	63,9
SO_3	%	2,53
Na_2O+K_2O	%	0,88
MgO	%	1,53

3.1 Caracteristic Of Organic Cement

3.1.1 The Fineness of Cement

The fineness value of the materials for organic cement passing through strainer of 200 mesh is 59% with a solid weight of 1224 kg/m^3 while portand cement is 33% with a solid weight of 1267 kg/m^3. The picture of 2 A is the process of the examination of the fineness of the organic cement and portland cement. Meanwhile, the picture of 2 B explains the examination of the specific gravity of the organic cement. According to Kimberly Kurtis (2010), the specific gravity of portland cement is 3.15 g/cm^3 and the specific gravity of organic cement is 3.01 g/cm$^{3.}$ The specific gravity examination refers to ASTM C 188-95. The fineness of cement, the wider the surface of the granule causing its compounding with water much quicker and needing also a lot of water.

A B

Figure 2 (A) Organic cement examination process. (B) Organic cement specific gravity examination.

3.1.2 Setting Time

Setting time is the time needed for cement to harden starting from mixing with water until the cement turns into paste later become hard enough to resist a strenht as seen in Picture 3. In the study, the setting time of cement being studied is the initial setting time and final setting time.

Initial setting time of portland cement was tested with vicat needle with a diameter of 1 mm piercing through cement paste as long as 24 mm at 90 minutes after the needle has been released. The water content used for the test of setting time is water with normal consistency (25%).

The initial setting time of organic cement is also tested with similar method piercing the cement 25 mm long at 105 minutes after the needle is released. The water content used for the initial setting time is water with normal consistency (37%). According to ASTM C-191-8, the initial setting time should not be less than 45 minutes.

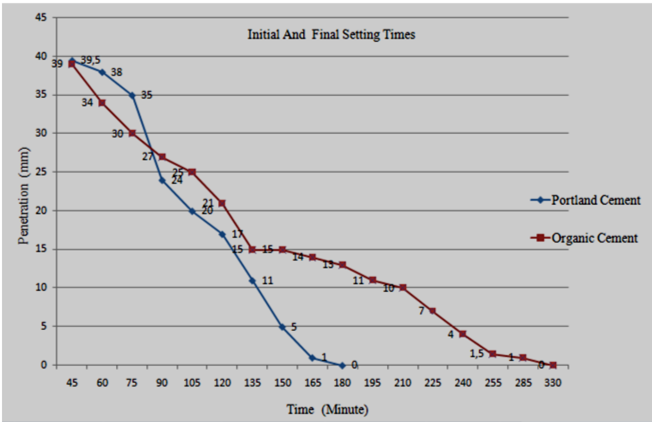

Figure 3 Initial and final setting time Graph

The final setting time of portland cement is on the 180 minutes while of the organic cement is on the 330 miutes. According to SNI standard 03-6827-2002 the final setting time should not be more than 375 minutes.

3.2 Concrete Using Organic Cement

3.2.1 Workability

Water has an influence on the workability of concrete paste, its strength, shrinkage, and durability. Normal consistence formed in organic cement is 37% and in portland cement is 25%. The following table 4 shows the result of normal consistency test. The test of normal consistency is referred to ASTM C 187-04 and SNI 03-6827-2002. To obtain good and fresh concrete, it is to be in a room temperature of about 20^0C, 30^0C, and 35^0C. The cement temperature is conditioned to 20^0C, 40^0C, and 60^0C (Sampebulu', 2012).

Table 5 Normal consistency of organic cement

Experiment	Portland Cement			Organic Cement		
	I	II	III	I	II	III
Cement (gr)		500			500	
Water (ml)	128	121	122	175	180	200
Consistency (%)	25,6	25	24,4	35	36	40

To obtain mix proportion as required by the plan, a mix design should be made as shown in Table 5.

Table 6 Mix design

Sampel	WC (%)	Tem pera ture (^{0}C)	Curing Condition and Method	Water (kgm^3)	Cement (kgm^3)	Maximum size (mm) Aggregates		Materials (kg/m^3)	
						Fine	Coarse	Fine	Coarse
Organic Cement	52	30	Water Dry,30^{0}C-60^{0}C	195	375	2,5	20	538	1232
Portland Cement	52	30	Water Dry,30^{0}C-60^{0}C	195	375	2,5	20	538	1232

3.2.2 Slump Test

To obtain good and homogenous material mix (workability), suitability is needed between water and the coarse, smooth aggregate, as well as the cement used. Slump value test is to prove the workability of fresh concrete before being applied to cast a test material of cylindrical concrete. Picture 4 shows slump test process of fresh concrete. The slump measurement in this case is closely related to planed concrete mix design. This test uses cement water (fas) 0,52%. Concrete cylinder slump test refers to ASTM C-1611 and SNI 1972-2008. The slump planned height is 12 cm and the reached height is:

- Fresh concrete using portland cement $\frac{10.7 + 14.4}{2} = 12.55$ cm

- Fresh concrete using organic cement is $\frac{9.8 + 10.9}{2} = 10.35$ cm

High ratio of water against cement in a concrete mix is one of the factors degrading the strength of the concrete. In the concrete mixture, the ratio of water against the cement is defined as water weight and cement weight shortened w/c. the ratio of w/c has a strong influence on the strength of a concrete. For certain mixture to increase the ratio of the w/c will decrease the strength of all ages and to decrease the w/c ratio will increase the strength of the concrete strength (Nicholas, 2014).

Figure 4 Slump test of fresh concrete

3.2.3 Strengths Test

3.2.3.1 Compressive Strength Test

The compressive strength test of the cylindrical concrete made from portland cement using water curing method results in 21.08 Mpa. and using dry curing method 20.22 Mpa.The compressive strength test for the cylindrical concrete made from organic cement using maintaining method of water curing, results in 5.00 Mpa. and using dry curing method 6.10 Mpa. The Picture 5, seen test process of compressive strength cylindrical concrete. And the graphs of the test results of compressive strength of cylindrical concretes of organic cement and of portland cement using dry curing and water curing methods can be seen in Picture 6. The compressive strength values produced was calculated with normative standard reference using formula according to ASTM C-39/39M-05 and SNI-03-1974-1990.

Figure 5 Test Process of Compressive Strength Cylindrical Concrete

The compressive strength test of cylindrical concrete was calculated with the following formula:

$$\sigma = \frac{P}{A} \ (\text{kg/cm}^2) \qquad (2)$$

In which:

σ σ = Concrete Compressive Strength Characteristics(kg/cm²)
P = Compressive Force (kg)
A = Cylindrical Concretesectional stress field (cm²).

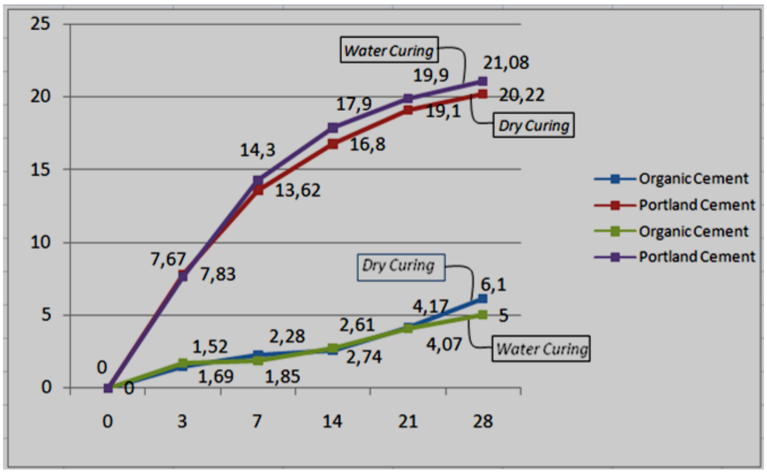

Figure 6 The Comparison graphs of compressive srength of cylindrical concretes between organic cement and portland cement

3.2.3.2 The Splitting Test

Results of spliting test indicate the measurement of the material endurance against mechanical strenght, and thermal strenght. The tensile strength of cylinder test shows tensile strength of concrete (ft) normally is around 0.05 to 0.1 compare with compressive strength value (Dicky Rezady Munaf, 2011). The tensile strength value of the tested materials can be calculated using the formula:

$$fct = \frac{2 \times P}{LD}$$

In which fct = Tensile Splitting Strength
P = Maximum Test Load (N)
L = Length of Test Item (mm)
D = Test Item Diameter

Tensile Splitting Strength of Concrete with portland cement at water curing treatment method has more strength than the concrete treated with dry curing method. Water curing method result 2,16 Mpa, while dry curing result in 2,01 Mpa. Tensile splitting strength of concrete with organic cement at water curing treatment has an ability lower than the one using dry curing method. The water curing method result 0,66 Mpa and while dry curing method result in 1,09 Mpa.

The graph of the Splitting test results is revealed in Picture 7 which is the results of tensile splitting strength test of cylindrical concrete based on the concrete age plan i.e. 28 days.

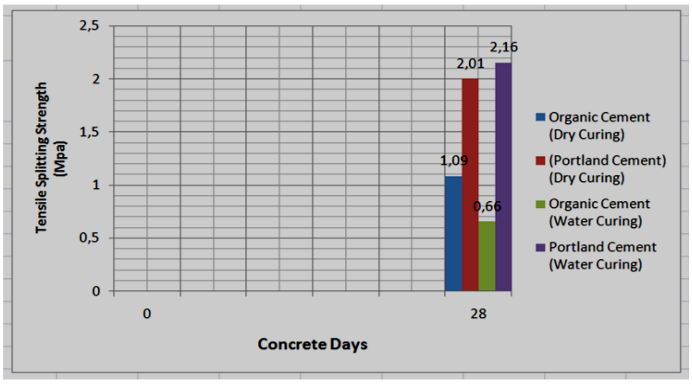

Figure 7 Comparative Graphs of Tensile Splitting Strength of Cylindrical Organic Cement Concrete and Cylindrical portland Cement Concrete.

In 8A picture, is a form of concrete cylinder using organic cement concentrate, while in 8B picture is a form of concrete cylinder using portland cement. Both pictures were taken after tensile strength test was perform.

A

B

Figure 8 Cylindrical concrete of organic cement (A). Cylindrical concrete of portland cement (B)

4 Conclusion

The chemical and physical tests of organic cement concentrate have an indication of similar compound properties of portland cement which is used as sample comparator. In the mix design of similar concrete, although the results of concrete strenghts test indicated that organic cement is still under the portland cement, the organic cement can be used for lightweight construction and in the hot regions. To increase the quality of organic cement, it is important to conduct continued advanced experimental study.

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Experimental Study of Manufacture of Lightweight Coarse Aggregate Made Of Kaolin Soil, Ball Clay, Fly Ash and Boiler Ash

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Abstract. In a concrete mixture, coarse Aggregate composition provides the most influence on the weight of concrete (about 60%). Therefore, for the purposes of lightweight concrete is required the lightweight coarse aggregates. The artificial lightweight coarse aggregate is an alternative solution to produce lightweight concrete. A laboratory test have been conducted to the material characteristics (physical and chemical) that shown the ball clay has the best physical and chemical properties as the main ingredient in the manufacture of lightweight coarse Aggregates if compared with kaolin, fly ash and boiler ash. Which lightweight coarse Aggregates that formed with 19 different variations of composition is burned at a temperature of 1000ºC, obtained uniform round shape coarse aggregates with a size ⌀10 mm - ⌀25 mm. From physical and mechanical properties testing of all the variations, it has shown that the variations that fulfill the qualification in terms weight / volume unit and wear are variations based on the rule of SNI and CEB / FIB is a mixture of 80% ball clay + 20% boiler ash, 80% ball clay + 20 % kaolin, 100% and 90% ball clay + 10% kaolin which suitable to be a lightweight coarse Aggregates to substitute stone.

Keywords: *Artificial coarse aggregate, ballclay, kaolin, boiler ash, fly ash.*

1 Introduction

For the purpose of concrete construction in soft soil such as in Pontianak and its surrounding areas , the weight of concrete plays a very important role because it will greatly affect the cost of construction , especially the construction of concrete for high buildings that require large bearing capacity and large structural cross-section caused by heavy Its own great structure . In a concrete mixture, the coarse aggregate composition has the greatest effect on the weight of concrete mortar (about 60%) [9] . Therefore for the purpose of a lightweight concrete is required mild Aggregate light. Aggregate lightly artificial aggregate is an alternative solution to producing lightweight concrete. In addition can be fabricated also indirectly to provide economy to the wider community because it is able to create new jobs. One of the coarse aggregates is clay (Kaolin), fly ash, and fly ash that has been burned as alternative material for crushed or gravel. Clay soil in Capkala district is one of the basic materials for the manufacture of similar ceramics; where later the land to be used is the land that comes from Capkala district. And also the remaining material of burning oil palm and coal. Where the material is taken as burning ash from palm oils / oiled mill and steam power plant (PLTU). With the utilization of these materials will certainly be able to help the community and government in developing the home industry and also to repeat the waste from power plants and palm oil mills [7].

2 Lightweight Aggregate Material

2.1 Ballclay

Ballclay including secondary types of clay (sediment / sludge) having particles so fine that the level of plasticity and dry strength is high, contains a lot of organic material.

Figure 1. Soil color ball clay

2.2 Kaolin Soil

Kaolin is also called clay, including the type of primary clay (residue) that serves as a major component in making porcelain blends, and used in ceramic stoneware and white earthenware. Kaolin is used to binders and ceramic body enhancer strength at high temperatures, porcelain, goods fireproof (refractory), also used as reinforcement material in the manufacture of glazes.

Figure 2. Soil color kaolin

2.3 Boiler Ash Oil Palm [5][9]

Boiler Ash is a primary of solid waste of burning boiler oil palm PT.Parna Agromas. The estimated less than 2 tons each day boiler ash is produce by PT.Parna agromas.

Figure 3. Boiler Ash

2.4 Fly Ash

Fly Ash is a part of waste of burning cole shape of particles amorf and the ash is an unorganic material which is formed from mineral material in area of burning processing.

From processing of burning cole, boiler will formed two types ash that is fly ash and bottom ash. The resulting Fly Ash composition consists of 10-20% bottom ash, while the rest are about 80-90% as fly ash.

Figure 4. Fly Ash

3 Research Preparation

3.1 Research Procedure

As for the research procedure that will be carried out as follows:

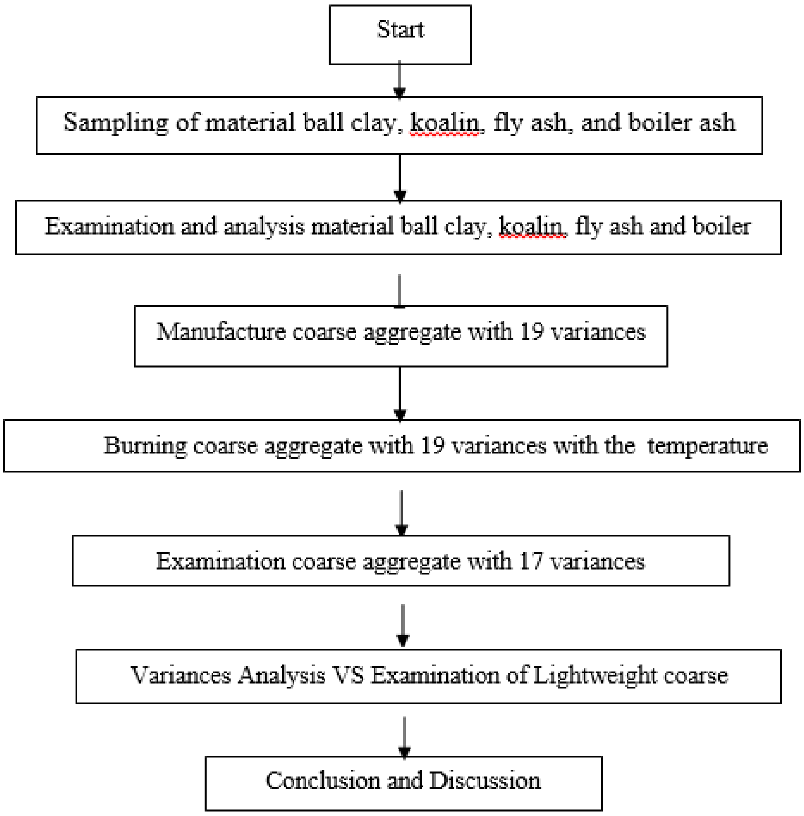

Figure 5. Research Procedure

3.2 Manufactured of Artifical Coarse Aggregate

Base material of artifical agregat is kaolin combinate with variance according weight ratio. First, the capkala soil covering the ballclay and kaolin soils is groomed for 1 day to facilitate the mixing and in the elasticity conditions achieved. This mixture is made in 19 variants as in Table 1. After the kaolin soil and boiler ash are well mixed add water so the dough is easily formed. After that the dough is ready to be rounded manually by hand with a roughly artificial aggregate measure of artificial planned Ø10 mm - Ø25 mm size.[2][4][8][12][13] Aggregates that have been formed are placed on top of the base and dried in the sun also temporarily burned to become strong and not easily broken at the time of burning later. Once dry the aggregate is put into the combustion oven and burned for 9 hours so as to reach the temperature of 1,000oC. After the temperature reaches 1,000oC, the oven is turned off and allowed to cool to facilitate the aggregate dispensing process from within the oven. Lightweight artificial aggregate is ready for the next process that is the examination of physical and mechanical properties. [8][12][13]

Tabel 1 Number of Variations of Material Mixed Samples

Varians Name	Capkala Soil		Boiler Ash	Fly Ash	Number of Samples
	Ballclay	Kaolin			
Variasi1	100%	0%	0%	0%	0.8 m3
Variasi2	90%	10%	0%	0%	0.8 m3
Variasi3	80%	20%	0%	0%	0.8 m3
Variasi4	70%	30%	0%	0%	0.8 m3
Variasi5	60%	40%	0%	0%	0.8 m3
Variasi6	50%	50%	0%	0%	0.8 m3
Variasi7	40%	60%	0%	0%	0.8 m3
Variasi8	30%	70%	0%	0%	0.8 m3
Variasi9	20%	80%	0%	0%	0.8 m3
Variasi10	10%	90%	0%	0%	0.8 m3
Variasi11	0%	100%	0%	0%	0.8 m3
Variasi12	90%	0%	10%	0%	0.8 m3
Variasi13	80%	0%	20%	0%	0.8 m3

Varians Name	Capkala Soil		Boiler Ash	Fly Ash	Number of Samples
	Ballclay	Kaolin			
Variasi14	90%	0%	0%	10%	0.8 m3
Variasi15	80%	0%	0%	20%	0.4 m3
Variasi16	0%	90%	10%	0%	0.4 m3
Variasi17	0%	80%	20%	0%	0.4 m3
Variasi18	0%	90%	0%	10%	0.4 m3
Variasi19	0%	80%	0%	20%	0.4 m3

Figure 6. Manually mixing process material

4 Result and Discusion

4.1 Examination of Base Material Lightweight Coarse Aggregates

4.1.1 Examination of Moisture Content

For the result of examination of material coarse aggregates, obtained the data for mouisture content as follows:

Tabel 2 Moisture Contents

Lightweight Coarse Aggregates Material	Moisture Contents (%)
Ballclay	10,72
Kaolin	8,41
Boiler Ash	0

From Table 2 it was found that the moisture content of the base material for the manufacture of lightweight coarse aggregates having moisture content is only the capkala soil which includes Ballclay and Kaolin soils is between 8.41% - 10.72%. This is because the soil capkala is obtained directly in the affected field there is water and soil conditions at the time of sampling. While boiler ash and fly ash do not contain water because it is obtained directly from the factory that is not touched by weather and water conditions.

4.1.2 Examination of Weight Contents

For the result of examination of material coarse aggregates, obtained the data for weight of contents as follows:

Tabel 3 Weight Contents

Lightweight Coarse Aggregates Material	Loose condition (Kg/m3)	Solid Condition (Kg/m3)	Weight Content (Kg/m3)
Ballclay	1,097	1,173	1,135
Kaolin	1,132	1,261	1,197
Boiler Ash Fly Ash	998.7	1,073	1,036
	1,150	1,280	1,215

From Table 3 it can be found that the weight of the base material volume for making the lightest lightweight aggregate is the boiler ash and the heaviest is fly ash, with the weight of the base material of lightweight Aggregate 1,036 kg/m3 – 1,215 kg / m3.

4.1.3 Examination of Specific Gravity and Absorption

For the result of examination of material coarse aggregates, obtained the data for specific gravity and absorption as follows:

Tabel 4 Specific Gravity and Absorption

Lightweight Coarse Aggregates Material	Specific Gravity (Kg/m3)	Absorption (%)
Ballclay	1,097	15.37
Kaolin	1,132	13.8
Boiler Ash	998.7	0
Fly Ash	2,150-2,600	0

From Table 4 it can be found that the spesific gravity of the base material for the manufacture of lightest lightweight aggregates is ballclay when compared to kaolin soils, with the specific gravity of lightweight Aggregate 998.7 kg/m3 - 2,150 kg / m3.

4.1.4 Examination of Plasticity Level

For the test results from rough aggregate materials obtained data for the index of plasticity as follows:

Tabel 5 Plasticity Index

Lightweight Coarse Aggregates Material	Plasticity Index	Level of Plasticity	Kohesif
Ballclay	21.5	High Plasticity	Kohesif
Kaolin	10.7	Medium Plasticity	Kohesif
Boiler Ash	4.1	Low Plasticity	Partial Kohesif
Fly Ash	5.4		Partial Kohesif

From Table 5 shows that the ballclay soil has a high plasticity level so that the soil is cohesive. The cohesive soils greatly facilitate solidification and formation so that the results obtained will be maximal for lightly coarse aggregates.

4.2 Examination of Lightweight Coarse Aggregate

4.2.1 Check Form and Texture

From All variations such as Table above is generally round with size between ∅10 mm - ∅20 mm, with surface texture Light aggregate from slick (smooth) to less slippery (slightly rough). Where the slick is Various 1 and 12, while the other surface is rather coarse. As for the colors in general are gray / ash, except variation 11 is white.

4.2.2 Specific Gravity and Absorption

For the test results of Aggregate variations, we obtain data for specific gravity and absorption of artificial aggregates as follows:

Tabel 6 Spesific Gravity and Absorption

No	Description	Spesific Gravity (Kg/m3)	Absorption (%)
1	Variasi 1	1.097	25,37
2	Variasi 2	1.101	23,96
3	Variasi 3	1.104	24,11

No	Description	Spesific Gravity (Kg/m3)	Absorption (%)
4	Variasi 4	1.108	24,27
5	Variasi 5	1.111	24,43
6	Variasi 6	1.115	24,59
7	Variasi 7	1.118	24,74
8	Variasi 8	1.122	24,90
9	Variasi 9	1.125	25,06
10	Variasi 10	1.129	25,21
11	Variasi 11	1.132	23,80
12	Variasi 12	1.087	27,69
13	Variasi 13	1.077	26,98
14	Variasi 14	1.202	27,06
15	Variasi 15	1.308	27,14
16	Variasi 16	1.119	27,21
17	Variasi 17	1.105	27,29
18	Variasi 18	1.234	27,37
19	Variasi 19	1.336	27,45

From Table 6 it was found that the lightest density was variation 13 which was 1,077 kg / m3, while the most severe was variation 19 with the density of 1,336 kg / m3 so it was obtained for all variations made for the specific gravity was 1,077 kg / m3 - 1,336 Kg / m3.

From Table 6 the smallest absorption of the smallest aggregate is 11, which is 23.80%, while the greatest is the variation of 12 with the absorption of 27.69% so that it is obtained for all variations made for absorption is 23.80% - 27.69%. In contrast to the normal aggregates, water uptake in small aggregates is greater due to the pore space in it. When aggregates are submerged, the water will seep through the surface area and occupy its porch space. The amount of water absorbed depends on the condition of the pore structure (pored structure) andthe internal pore volume. Aggregate pore space of small size separate or interconnected to form a gap in it so that the nature of absorption is high.

Water absorption is a function of the time at which the initial absorption rate but will decrease with increasing time. Generally, absorption in mild rough aggregates within 24 hours ranges from 5 to 30% of the total pore volume due to lightly tight surfaces.

Light aggregate on dry conditions (Oven Dry) after absorbed water increases weight according to prosentse uptake. Therefore the percentage of uptake above 50% is less suitable for concrete aggregates. Besides adding the weight of aggregate, the water absorption also affects the amount of concrete water requirement. The free water expected by the hydration process will be absorbed by the aggregate.

In concrete with a high w / c cement factor this absorption effect increases the compressive strength of the concrete, but at low w / c otherwise it reduces its strength.

From the research that has been done, the result of absorption is 23.80% - 27.69%. Thus all variations are suitable to be Aggregate stone replacement in the manufacture of concrete as below 50%.

4.2.3 Weight Contents

For the test results of the aggregate variation we obtained the data for the Artifical Coarse Aggregate volume as follows:

Tabel 7 Weight Contents

No	Description	Loose (Kg/m3)	Solid (Kg/m3)	Average (Kg/m3)
1	Variasi 1	962	1072	1017
2	Variasi 2	1015	853	934
3	Variasi 3	1002	800	901
4	Variasi 4	1014	859	936
5	Variasi 5	991	812	902
6	Variasi 6	1034	869	952
7	Variasi 7	908	781	845
8	Variasi 8	999	824	911
9	Variasi 9	967	801	884
10	Variasi 10	896	722	809
11	Variasi 11	988	821	904
12	Variasi 12	1.060	1.146	1.103
13	Variasi 13	998	1.073	1.036
14	Variasi 14	1.116	1.215	1.165
15	Variasi 15	1.216	1.323	1.269
16	Variasi 16	1.097	1.160	1,128
17	Variasi 17	1.082	1.151	1.116
18	Variasi 18	1.266	1,367	1.316
19	Variasi 19	1.366	1,471	1.418

From Table 7 above obtained the lightest weight of volume is the variation of 10 that is equal to 809 kg / m3, while the most severe is the variation of 19 with the specific gravity 1,419 kg / m3 so obtained for all variations made for the weight of the volume is 809 kg / m3 – 1,419 Kg / m3.

Tabel 8 Standard Weight Volume of Lightweight Coarse Aggregate dry state OD [1][3][10]

Standard	Dry Weight OD (kg/m^3)
ACI	550 – 880 (35 – 70 lb/m^3)
SNI	700 – 1100
CEB/FIB	650 – 1100 (40 – 70 lb/m^3)

According to existing standards for the lightweight coarse aggregates as in Table 8, then get for the research that has been done as follows:

Tabel 9 Appropriate Variations Standard (OD)

Standard	Appropriate Variations OD
ACI	10 and 7
SNI	10, 7, 9, 3, 5,11 ,8 ,2 ,4 ,6 ,1 , 13 and 12
CEB/FIB	10, 7, 9, 3, 5,11 ,8 ,2 ,4 ,6 ,1 , 13 and 12
OD < 1100 Kg/3	17, 16, 14, 15, 18, and 19

From Table 9 it is found for variations according to ACI only variations 10 and 7. While those eligible for SNI and CEB / FIB are variations of 10, 7, 9, 3, 5,11, 8, 2, 4, 6, 1, 13 And 12. While those which are eligible for light Aggregates are variations of 17, 16, 14, 15, 18, and 19. Thus the capkala soil base material which includes ballclay and Kaolin soils mixed with boiler ash and fly ash can be used as lightweight coarse aggregate.

4.2.4 Gradation Lightweight Coarse Aggregate

For the test results of the aggregate variation obtained the data obtained for the fineness modulus of the coarse aggregate between 5,89 - 6,00, where this result belongs to the medium coarse aggregate due to the fineness modulus of the coarse aggregate between 3 - 14. Thus the aggregate can be cavities between the grains. The coarse aggregate may be filled with fine aggregates, the gradation distribution of the mixture between the coarse and fine aggregates shall satisfy the specified standard gradation curve thereby resulting in a lightweight concrete having the strength according to plan. With gradations that are eligible to be used on concrete can have a beneficial effect on fresh concrete as well as the strength of hard concrete.

4.2.5 Moisture Content

Moisture content on lightly aggregate made for all 0% variations. This is because lightweight coarse aggregates are made in the oven for ± 9 to reach a temperature of 1000^{o}C. Because of the long burning and high temperatures resulted in the water in the aggregate for all variations no longer contained water (dry conditions of the oven).

4.2.6 Abrasion Lightweight Coarse Aggregate

Tabel 10 Destruction

No	Description	Destruction (%)
1	Variasi 1	21,5
2	Variasi 2	25,1
3	Variasi 3	35,31
4	Variasi 4	41,16
5	Variasi 5	52,12
6	Variasi 6	64,92
7	Variasi 7	72,16
8	Variasi 8	83,13
9	Variasi 9	87,98
10	Variasi 10	92,95
11	Variasi 11	99,69
12	Variasi 12	32,16
13	Variasi 13	33,19
14	Variasi 14	37,98
15	Variasi 15	39,32
16	Variasi 16	47,97
17	Variasi 17	48,92
18	Variasi 18	48,21
19	Variasi 19	48,32

Hardness, abrasi resistance and resistance to pebbles relate to the strength of the concrete to be made, so that the aggregates we make must meet the requirements of rough aggregate hardness can be seen in Table 11 below:

Tabel 11 Coarse Aggregate hardness requirements for concrete [6][11]

Concrete Strength	The vessel Rudeloff Maximum shattered parts, pierce the sieve 2 mm (%)		Los Angeles Machine Maximum shattered parts, pierce the sieve 1,7 mm (%)
	Grain Size 19 -30 mm	Grain Size 9,5 – 19 mm	
Class I Concrete and quality B0 and B1	22 - 30	24 – 32	40 - 50
Class II concrete and 12.5 MPa, 17.5 MPa, and 22.5 MPa qualities	14 - 22	16 - 24	27 - 40
Class III Concrete and quality > 22,5 MPa or Prestressed concrete	Less than 14	Less than 16	Less than 27

For the test results of Aggregate variations made obtained data for the Aggregate qualified in the manufacture of lightweight concrete with artificial aggregates as follows:

Tabel 12 Test Results Aus Los Angeles

Concrete Strength	Variations that Fulfill Tests Aus Los Angeles Machine, Maximum crushed parts, penetrate a 1.7 mm sieve (%)
Destruction> 50%	5, 6, 7 ,8, 9 10 and 11
Class I Concrete and quality B0 and B1	4, 16, 17, 18, and 19
Class II concrete and 12.5 MPa, 17.5 MPa, and 22.5 MPa qualities	12, 13, 3, 14 and 15
Class III concrete and quality > 22.5 MPa or prestressed concrete	1 and 2

From Table 12 we find Aggregate wear tested by Los Angeles for ≤ 40% for 12, 13, 3, 14, 15, 1 and 2 variations which can be used to create lightweight concrete with quality above 12.5 MPa.

5 Conclusion

The wear of the Aggregate of variation of 1 to 19 that tested with the Los Angeles machine ≤ 40% is a mixture of 90% ball clay + 10% boiler ash, a mixture of 80% ball clay + 20% boiler ash, 80% ball clay + 20% kaolin, 90% ball clay + 10% fly ash, 80% ball clay + 20% fly ash, 100% and 90% ball clay ball clay + 10% kaolin. Thus these variations can be used to make lightweight coarse Aggregates in manufacture lightweight concrete with compressive strength≥ 22.5 MPa. Aggregates is a ball clay 80% + kaolin 20% with average weight volume of 901 kg/m3. This composition is very good for coarse Aggregates used in the manufacture of lightweight concrete with a compressive strength of ≥ 22.5 MPa, with a unit weight / volume of lightweight concrete produced ≤ 901 kg/m3.

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Lock-Brick System for Environmentally Friendly Building Infrastructure

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Abstract. Infrastructure development for raw water, livable housing, and roads are very urgent. It is spearheading to the development of backward village to get to the prosperous. Programs have been launched, such as stimulant funding for unlivable housing. The community participation is expected to realize the livable housing. But the community's financial condition does not support, so that appropriate housing only could be half-constructed, which eventually jammed. Lock-brick construction system could be an alternative solution for this problem. It also could be implemented for water infrastructure such as small ponds. Lock-bricks are made from the main ingredients soil, which be added a little cement, thoroughly mixed in dry conditions, and be dampened with water to a level sufficiently moist. Then, poured to the pressing machine until 60% pressed, forming interlocked bricks when arranged to form the walls of the livable house. Columns, beams, could be constructed by this system. Lock-brick systems are used for a wide range of building infrastructure but still considering the strength of the structure, according to standards. Some examples of usability have been done for the simple building livable housing, student dormitories building, rain water ponds, runoff water-trap canals and other construction. This lock-brick system could support the development of sustainable infrastructure and built environment because of simple, easy to make, cheap and multifunction of the usability

Keywords: *lock-brick; sustainable-infrastructure; livable-housing; simple-made*

1 Introduction

Infrastructure development for raw water, livable housing, and roads are very urgent. It is spearheading to the development of backward village to get to the prosperous. Infrastructure development for raw water, such as ponds for conserving rainwater, which has been catch, or trap-canal to collect runoff water, are very important in managing rain water resource to meet the water requirement for live. It is also important to provide the livable housing, which will support the health of the people. Everything requires a building structure that is quite resistant, strong and sustainable, not easily damaged quickly. This requirement requires an expensive building material, such as reinforced concrete iron, cement, sand and splits. The community encountered many difficulties to fulfill their need independently, even by little funding from the government. Programs have been launched, such as stimulant funding of Rp. 10.000.000.- for unlivable housing. The community participation is expected to realize the livable housing, but their financial condition does not support, so that appropriate housing only could be half-constructed, which eventually jammed. It is hoped that this initial assistance can support the community to build their homes to be habitable and meet health requirements. But it is also still difficult for people to finish a half-finished house. These problems encourage being developed of an alternative building material that is lock-brick system technology, which can be used for various forms of buildings needed.

2 Lock-brick System Technology

Established in 1988, Habitech Center has conducted research and developed various building components that are environmentally friendly, energy-efficient and cost-effective. This cost-effective building system is named Habitech Building System. This system has been tested, demonstrated and disseminated through various housing projects in Thailand and in other countries throughout Asia and Pacific [1].

Literature review of the lock-brick system shows that most of these systems are used for house building construction [2, 3, 4, 5]. The recapitulation of this literature review results is shown as in table 1

Table 1 Recapitulation of articles literature review

No.	Year	Author	Title	Note
1	2014	Anis Rahmawati	Lockbrick Moduler Sebagai Inovasi Material Dinding Bangunan Rumah Tinggal	Research, funding by Ristekdikti
2	2013	M. Khasani, et.al.	Designing Preprocessed Components of Growing House	Vol 1, No 01 (2013) Jurnal Pendidikan Teknik Bangunan
3	2011	Sri Sumarni, dkk	Molding Machine Development of Sloof and Beam component for Simple Growing House Earthquake Resistant Building	Draft scientific articles
4	2009	Simion Hosea Kintingu	Design Of Interlocking Bricks For Enhanced Wall Construction Flexibility, Alignment Accuracy And Load Bearing	Dissertation

Habsya, et.al., in his article on the lock-brick system, “Lock-brick Concrete Modular for Alternative Wall Materials that Meets the Quality Standard of SNI at Low Cost”, concludes that the cost per m^2 of modular lock-brick wall is 24% cheaper than the cost of the conventional brick wall [6]. From the reviews for various patents associated with the lock-brick system are presented as in table 2. Patent development is widely available in the United States.

Table 2 Recapitulation of lock-brick patents review

No.	Year	Inventor	Title	Note
1	2013	M.A. Kashinath	Interlocking Brick	No.: 3434/MUM/2013
2	2012	Janssens et al	Building Blocks With Mating Coupling Means For Constructing Wall And Associated Method	US 2012/0102868
3	2012	Nagy, John R and Krell, Clinton C.	Modular Concrete Building	Paten US8,132,388B2.
4	2009	Steve Eugene Everett	Structural Building Block System And Method Comprising Same	Patent No.: US 7472520
5	2000	Simmons, Scott.	Modular Building Materials	US Paten Number US006,088,987
6	1999	John H	Uniform Building Construction Using Interlocking Connectors	Patent Number: 5901521
7	1997	Williams et al	Flue Walls Using Interlocking	Patent Number: 5676540
8	1981	Khoo Tian	Bricks	No. 4,299,071
9	1970	Zagray	Interlocking building block construction	Patent US 3534518
10	1939	A. J. Cilento	Interlocking Brick	Serial No. 251260
11	1934	P. Brown	Interlocking Building Brick	US 1984393
12	1908	J. Soss	Interlocking Brick	US 903906
13	1895	George J. Herth	Lock-Brick	US Patent No. 535497
14	1892	Louis A. Steiger	Interlocking Brick	Patent No. 468840

That is also registered, the “Modular Lock-brick System for Constructing Buildings”. Patent Registration Number, S00201401680, Date: March 21, 2014, Director General of Indonesian Law Ministry [7].

Habitech centre develops lock-brick base on soil material. Lock-bricks are made from the main ingredients soil, which be added a little cement, thoroughly mixed in dry conditions, and be dampened with water to a level sufficiently moist. Then, poured to the pressing machine until 60% pressed, forming interlocked bricks when arranged to form the walls of the livable house. Columns, beams, could be constructed by this system also. Lock-brick construction system could be an alternative solution for many problems, especially concerning of finance, environment and people participation. It also could be implemented for water infrastructure such as small ponds, channels and other infrastructure water buildings. Lock-brick systems are used for a wide range of building infrastructure but still considering the strength of the structure, according to standards [8].

2.1 Lock-brick System for livable, healthy and low-cost housing

This lock-brick system could support the development of sustainable infrastructure and built environment because of simple, easy to make, cheap and multifunction of the usability. A design of appropriate technology by using the soil material for lock-brick becomes the building material of the residence. The

Lock-brick system support people to build their own low cost healthy and livable house [9]. Some parts of the house construction are illustrated in Figure 1.

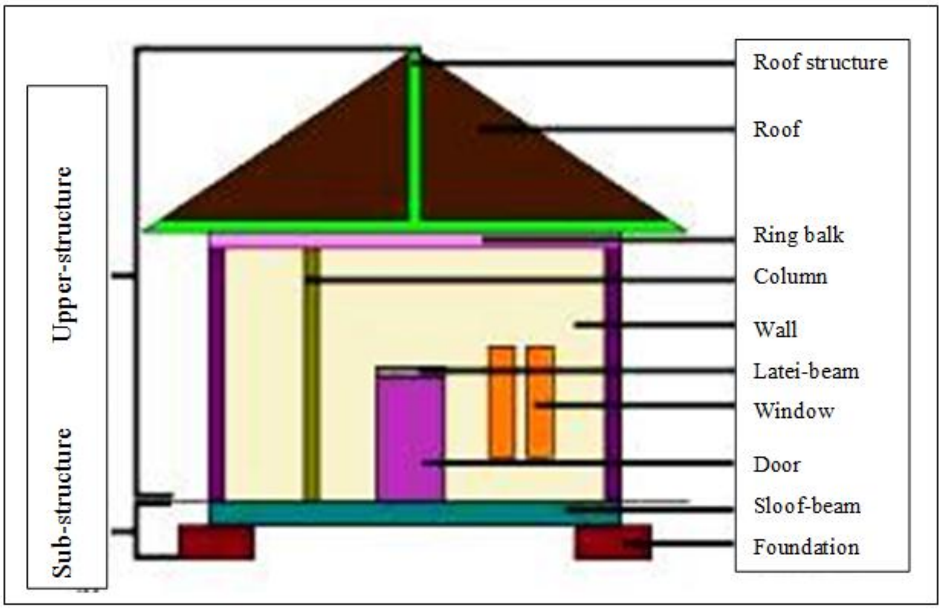

Figure 1 Parts of the simple house.

Detailed stages description of the procedure:
1. The foundation is made of stone, or could be used of this lock-brick, which is arranged, and the hole's brick is filled by mortar.
2. Sloof beams are made of lock-bricks type of U-brick, where on top of brick form U to place in an iron bar, then casted as a concrete sloof.

Figure 2 Foundation and installing iron on the sloof beam.

3. Practical columns structures are made by inserting an iron bar into the vertical hole of the lock-brick, then casted as concrete columns.

Figure 3 Arrange the walls of the building and prepare the iron for the column

4. Walls are constructed using lock-bricks, which are arranged in accordance to the shape of the building, without adding mortar, but only arranged interconnected each other.

Figure 4 Installation of lock-brick wall, door and window holes

5. Concrete beam wall hole, is a concrete latei-beam to hold the wall brick above the wall hole.

Figure 5 Construct concrete reinforcement for latei-beam

6. Ring balk made as well as making sloof beam, as wall coverings and pedestal of the roof construction.

7. Roof structure is constructed from wood, and for the finishing by lock-brick also.

Figure 6 Implementation of roof installation work

8. Building a simple house that has been completed

Figure 7 The completed simple house lock-brick

2.2 Lock-brick System for Various Building Infrastructure

Lock-brick system is also suitable for various building structures, such as water structure, such as pond conservation, rain catcher channel, etc.

2.2.1 Lock-brick System for Water Ponds

To create a rain-water pond is required stages of work as follows:

1. Soil excavation
2. Lock-brick arrangement for the base of water pond
3. Lock-brick arrangement for the wall
4. Concrete slab for the top of water pond

The work stages are described as follow:

1. Soil excavation for the water pond. Excavation is done for the construction of existing tubs in the soil. For the construction of the container tub that does not require excavation, then directly arranged the retaining wall structure as a pond wall.
2. Lock-brick arrangement for the base of water pond. This arrangement is intended to stabilize the base of the pond, which can be directly casted, thereby reducing the volume of casting concrete that requires high cost.

Figure 8 Installation of sloof beam reinforcement floors of pond..

3. Lock-brick arrangement for the wall. This lock-brick system intended to reduce the required concrete wall volume. The arrangement of this wall each brick hole given a rod iron as reinforcement of concrete.

Figure 9 Installation of pond wall

4. Concrete slab for the top of water pond. The concrete slab structure is constructed for cover the water pond, and conventionally such as concrete slab construction.

2.2.2 Lock-brick System for Other Building Infrastructure

Lock-brick system could be used for runoff water-trap channels (Fig.10).

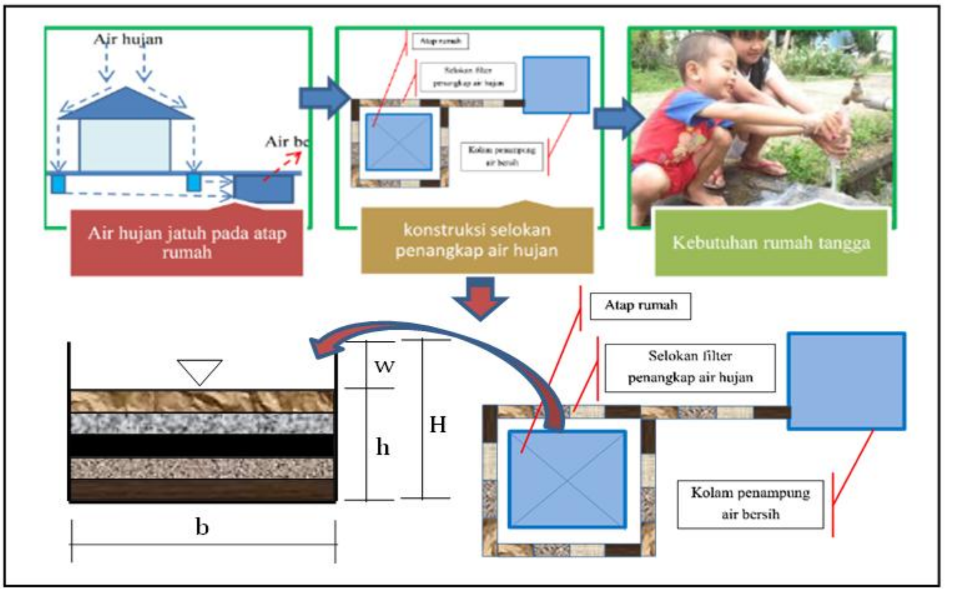

Figure 10 Runoff water-trap channels concept

The rainwater runoff catcher channel is created to capture runoff flowing rainwater, and then flowed into a rainwater catchment pond, through this channel. Water runoff flowing through this channel is expected to experience of mineralization process, so that the quality of rainwater harvested is quite feasible for raw water.

3 How the Lock-Brick System Can Be Environmentally, Friendly and Sustainable

The question of how this lock-brick system is environmentally sound and suitable as a material that supports various building structures is a concern in this research. Several reasons that support this statement include:

1. Lock-brick made from soil material added with very little cement, the ratio between soil and cement is about 1: 8-10. This indicates that most of the main

materials used to form lock-brick are natural materials with no chemical processing or engineering.
2. The lock-brick system used to build various structures is based on community participation system. Meaning that to make the lock-brick can be done by the community itself because it is simple and easy, as well as in arranging it into a building structure. More significant impact is the need for the required cost becomes very low. This provides an opportunity to build more people's needs for development to become more prosperous.
3. Through various experiments performed and mention before, that can be said that this lock-brick system is environmentally sound, friendly and suitable as a material that supports various building structures

4 Lesson Learned

Some examples of usability have been done for the simple building livable housing (Fig.7), student dormitories building (Fig.11), rain water ponds (Fig.9), runoff water-trap canals and other construction. This lock-brick system could support the development of sustainable infrastructure and built environment because of simple, easy to make, cheap and multifunction of the usability.

Figure 11 Student dormitory building using lock-brick system

5 Conclusion and Recommendation

From various studies conducted so far, and also the application of research results that have been done for various types of structural buildings using a lock-brick system, it can be concluded that lock-brick system is environmentally friendly and suitable as a material that supports various building structures.

This lock-brick system is recommended to be applied to other building structures such as retaining wall structures, village road structures by adding plastic waste materials to increase its strength as filler fibers in lock-bricks, and other innovations.

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Verification on Seismic Rapid Evaluation Using the Building Data of the 2016 Meinong Taiwan Earthquake

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Abstract. A feasible strategy on evaluating the seismic capacity for a huge volume of existing buildings is to carry out a rapid screening at beginning. Then, those buildings labeled with safety concern by rapid evaluation can be further examined by a detailed evaluation to confirm the seismic resistance. The existing seismic rapid screen methods, such as Hassan and Sozen (1997), adopted the column and wall indexes to represent the seismic vulnerability of the existing buildings. In this study, an alternative seismic rapid evaluation method proposed by National Center for Research on Earthquake Engineering (NCREE) is presented. NCREE adopted the seismic detailed evaluation data bank of the school buildings in Taiwan to establish an empirical formula of the performance ground acceleration and the column-to-floor area ratio of the existing low-rise RC buildings. In the other words, the performance ground acceleration of a low-rise RC building can be rapidly accessed by the column-to-floor area ratio of the building. The seismic rapid evaluation method had been verified by the data bank of damaged buildings from the 2016 Meinong Taiwan Earthquake. Comparison shows that the predictions of the rapid evaluation correlates well with the damaged status of buildings caused by earthquake. However, the rapid evaluation method is conservative but without losing the capability on screening seismic capacity of the existing low-rise RC buildings. In this paper, the proposed rapid evaluation, the data bank of damaged buildings and the verification results are reported.

Keywords: *seismic rapid evaluation, bulding*.

1 Introduction

A major earthquake with ML6.6, Meinong earthquake, attacked the south region of Taiwan on 06 February 2016. It caused 117 death and several collapsed and severely damaged buildings. After the Meinong earthquake, a reconnaissance team composed of Purdue university and National Center for Research on Earthquake Engineering (NCREE) collected 113 buildings data in the strong ground motion area. Data collected included hand sketches of floor plans, dimensions of columns and walls, location and level of damage in the buildings, photographs, and structural and architectural blueprints (if available). This data can be used to verify the existing seismic evaluation methods, such as seismic vulnerable index [[1]] and seismic rapid evaluation proposed by NCREE [[2]]. Hassan and Sozen [[1]] proposed column index and wall index to evaluate seismic vulnerability of buildings under a strong ground motion. NCREE [[2]] proposed an seismic rapid evaluation index by an empirical formula of safe column-to-floor area ratio of buildings. The aim of this paper is to introduce NCREE's seismic rapid evaluation method and its verification using the building data of the 2016 Meinong Taiwan earthquake.

2 Building data of the 2016 Meinong Taiwan earthquake

The reconnaissance team of Purdue university and NCREE collected 113 buildings data in Tainan city after the 2016 Meinong Taiwan earthquake. Data collected included hand sketches of floor plans, dimensions of columns and walls, location and level of damage of structural elements, photographs, and structural and/or architectural blueprints. All data collected from the field surveys can be found at https://datacenterhub.org/resources/14098. [[3]]

Total number of samplings are 113 buildings (Figure 1), including residential buildings, school buildings, district office, public buildings, public market, etc. All buildings located in the area affected by a strong ground motion with peak ground acceleration (PGA) larger than 150 gal during the 2016 Meinong Taiwan earthquake. The proportion of 2-story and 3-story buildings accounts for 78% (Figure 2). Majority of equivalent peak ground acceleration (EPA) of design basis earthquake (DBE) for these buildings in Tainan City are 0.28g and 0.32g.

In this paper, the damage classifications of structural elements are defined by NCREE. Damage classifications of reinforced concrete (RC) column/beam, RC wall and brick wall are listed in Table 1 to Table 3, respectively.

Damage level of buildings were labeled by in-situ observations in accordance with Table1 to Table 3. There were 73 buildings (65% of total buildings) with damage level I, 19 buildings (65% of that) with damage level II, 6 buildings (5.3% of that) with damage level III, 6 buildings (5.3% of that) with damage level IV, and 9 buildings (8% of that) with damage level V. To be noted, the damage classifications are marked as light, moderate, severe, and collapse on the data center hub, which are defined by Purdue [[3]]. NCREE's damage classifications are mapping to Purdue's as shown in Table 4.

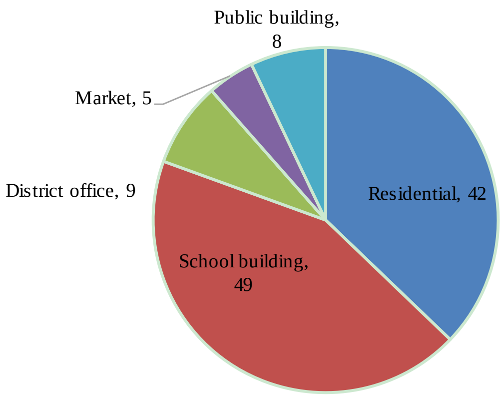

Figure 1 Building Category.

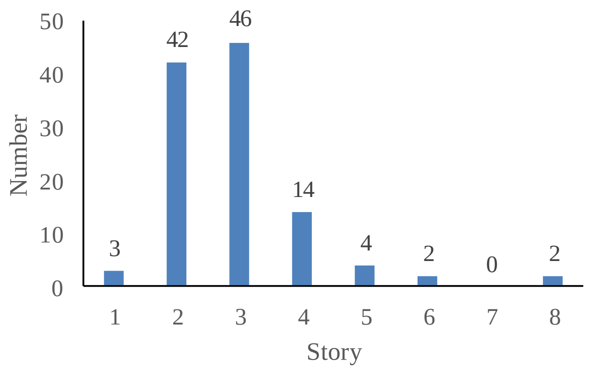

Figure 2 Distribution of Building Story.

Table 1 Damage classification of RC frame by NCREE.

Level	Status	Remark
I	None or slight cracks	
II	Shear cracks with 0.3 mm width. Spall of painting layer.	
III	Partial spall of concrete cover, but no bar buckling, no hoop opening or fracture.	Number of columns with level III more than 20% of total columns of a building shall shift to level IV
IV	Large area of cover spall, few hoop opening or fracture, may have bar buckling	Number of columns with level IV more than 20% of total columns of a building shall shift to level V
V	hoop opening or fracture, bar obviously buckling, core concrete spall, floor subsidence.	

Table 2 Damage classification of RC wall by NCREE.

Level	Status	Remark
I	Slight horizontal cracks with less 0.3mm width.	
II	Obviously horizontal cracks propagating to columns. Incline cracks with 0.3~0.5mm width.	
III	Incline cracks, partial spall of concrete cover, but no wall rebar exposed.	
IV	Lots of incline cracks, wall rebar exposed without fracture. Concrete cover spall of boundary columns.	
V	Severe incline cracks, wall rebar fracture, boundary column buckling, concrete crashed, floor subsidence.	

Table 3 Damage classification of brick wall by NCREE.

Level	Status	Remark
I	Slight cracks in bed joints or cross joints. Crack width ≦1mm.	
II	1mm＜crack width ≦10mm. Splitting cracks in solid brick.	
III	Crack width ＞10mm. Perforation on the masonry and brick crashed.	
IV	Lots of brick crashed. Boundary columns with severe shear failure.	
V	Partial masonry collapsed	

Table 4 Mapping NCREE's damage classification to Purdue's.

<table>
<tr><th>NCREE's damage level</th><th>Purdue's damage level [[3]]</th></tr>
<tr><td>I</td><td>Light</td></tr>
<tr><td>II</td><td>Moderate</td></tr>
<tr><td>III</td><td rowspan="2">Severe</td></tr>
<tr><td>IV</td></tr>
<tr><td>V</td><td>Collapse</td></tr>
</table>

3 Seismic rapid assessment method for low-rise RC building

The principle of rapid evaluation of seismic capacity for low-rise RC buildings is to estimate the seismic capacity based on the amount of columns and walls on the ground floor of the buildings. NCREE [[4]] adopted 1,187 school buildings with bare frames in the longitudinal direction from the school building seismic database set up by NCREE to perform statistical analysis. The database contains information on the total floor area, column area and the performance ground acceleration derived from the pushover analysis. From this information, a relationship between the column to floor ratio and the associated seismic performance, A_p, can be derived through regression analysis. Therefore, NCREE [[2]] proposed an empirical equation to rapid evaluating seismic performance capacity of low-rise RC buildings by equivalent column to floor area ratio of the buildings. The rapid evaluating equation is as shown in Equation (1).

$$\begin{cases} A_{\mathrm{p}} = \dfrac{100CFR_{\mathrm{eq}} - 0.4 + 0.05N_{\mathrm{f}}}{1.62 - 0.24N_{\mathrm{f}}}, CFR_{\mathrm{eq}} \geq (0.4 - 0.05N_{\mathrm{f}})\% \\ A_{\mathrm{p}} = 0, CFR_{\mathrm{eq}} < (0.4 - 0.05N_{\mathrm{f}})\% \end{cases} \tag{1}$$

in which A_p is the performance ground acceleration of a building; N_f is the number of levels in the building and no larger than four (e.g., N_f shall be taken as 4 for a five-level or six-level building); CFR_{eq} is the equivalent columns to floor area ratio, which can be calculated from Equation (2) as

$$CFR_{\mathrm{eq}} = \frac{\sum A_{\mathrm{C}}}{\sum A_{\mathrm{f}}} + \frac{0.36\sum A_{\mathrm{bw3}} + 0.45\sum A_{\mathrm{bw4}}}{\sum A_{\mathrm{f}}} + \frac{1.36\sum A_{\mathrm{rcw3}} + 2.38\sum A_{\mathrm{rcw4}}}{\sum A_{\mathrm{f}}} \tag{2}$$

where $\sum A_{\mathrm{C}}$ is the total column area on the ground floor; $\sum A_{\mathrm{bw3}}$ is the sum of the cross-sectional area of brick walls confined on three sides on the ground floor; $\sum A_{\mathrm{bw4}}$ is the sum of the cross-sectional area of brick walls confined on four sides on the ground floor; $\sum A_{\mathrm{rcw3}}$ is the sum of the cross-sectional area of brick walls confined on three sides on the ground floor; $\sum A_{\mathrm{rcw4}}$ is the sum of the cross-sectional area of the ground floor's RC walls that are confined on four sides; and $\sum A_{\mathrm{f}}$ is the total floor area on and above the second floor. If there is an additional penthouse with RC and brick material on the top floor of buildings, the entire additional floor area is accounted for the calculation of total floor area; if the additional penthouse is lightweight material such as steel and wood, half of its area is included in the calculation of the total floor area. In equation (2), the equivalent conversion coefficients for different types of walls were proposed by Chiou et al. [[2]].

Substituting the equivalent column to floor area ratio for the directions parallel and perpendicular to the street, CFR_{eqx} and CFR_{eqy}, in Equation (1), the performance ground acceleration in the two directions, A_{px} and A_{py}, can be obtained. The seismic capacity of a building is the lesser of the two, i.e. $A_p = \min(A_{px}, A_{py})$.

Seismic demand on the site of the buildings shall be determined as the equivalent peak ground acceleration (EPA) of design basis earthquake (DBE) in accordance with Seismic Design Specifications and Commentary of Buildings in Taiwan. Therefore, the seismic demand shall be determined by $0.4S_{DS}$, which S_{DS} is short-term design horizontal acceleration coefficient.

Basic seismic coefficient, E, of buildings shall be defined as the ratio of seismic capacity to seismic demand as shown in equation (3)

$$E = \frac{A_p}{0.4S_{DS}} \tag{3}$$

Consequently, the seismic vulnerable index, Is, shall be determined as equation (4)

$$I_s = E \times q_1 \times q_2 \times q_3 \times q_4 \tag{4}$$

where q_1, a modification factor of construction year, will be 0.9 for the buildings constructed before 1974, 0.95 for that between 1975 and 1983, 1.0 for that between 1983 and 1999, and 1.05 for that after 2000; q_2, a modification factor of eccentricity effect, will be 0.9 for buildings with corridors on both sides, and 1.0 for those with a corridor on only one side; q_3, a modification factor of weak story effect, will be 0.9 if any wall in the building frame is removed, otherwise, q_3 will be 1.0.; q_4 is a modification factor of short column effect which is shall be calculated according to the following equation and it no less than 0.5.

$$\text{q4} = (1 - \text{ratio of number of short columns to the total number of columns}) \geq 0.5 \tag{5}$$

If the rapid evaluation result is $I_s < 1.0$, the building will be tagged as more seismic vulnerable. On the other hand, $I_s \geqq 1.0$ represents the building will be with less seismic vulnerability.

4 Verification and discussion

Applying the rapid assessment method to the 113 buildings of the 2016 Meinong Taiwan earthquake, the performance ground acceleration in east-west and north-south directions for each building, A_{px} and A_{py}, can be rapidly evaluated by substituting number of story and the equivalent column to floor area ratio for the two directions, CFR_{eqx} and CFR_{eqy}, in Equation (1). The peak ground accelerations of the 2016 Meinong Taiwan earthquake for each building in east-west and north-south directions, $A_{rec,x}$ and $A_{rec,y}$, are estimated by Jean et al.[[5]] in the database. Assessment results versus the damaged level of the buildings experienced in the 2016 Meinong Taiwan earthquake are illustrated in Figure 3, where the ordinate indicates the minimum of $A_{px}/A_{rec,x}$ and $A_{py}/A_{rec,y}$ and the abscissa indicates damage level of the buildings. If the seismic performance of buildings, A_p, is greater than the recorded peak ground acceleration of the earthquake, A_{rec}, (i.e. $A_p/A_{rec} > 1.0$) seismic damage of the buildings should be light or moderate. On the other hand, if the ratio of A_p divided by A_{rec} is less than 1, seismic damage of the buildings is expected to be severe or collapse. The red solid circle on Figure 3 represents average of the ratio corresponding to its damaged level.

Figure 3 shows that the results of rapid assessment are less than 1 for majority of buildings with severe and collapse damage. The rapid assessment results are greater than 1 for most buildings with light or moderate damage. This indicates that the assessment results are in agreement with the actual level of seismic damage. However, some of the buildings with light or moderate damage are still evaluated as seismic insufficiency, demonstrating that the results of the rapid assessment are conservative.

As a seismic assessment method, the seismic resistance criteria of buildings shall base on DBE. The proposed seismic vulnerable index, I_s, represents a ratio of seismic capacity to demand based on DBE. Figure 4 shows that seismic vulnerable index of the buildings corresponds to actual seismic damage level. The average of seismic vulnerable index for the buildings with damage level I is 1.69, 1.49 for damage level II, 0.51 for damage level III, 0.38 for damage level IV, and 0.58 for damage level V. This matches with the trend that the lower seismic vulnerable index, the greater damage level.

In the buildings data of the 2016 Meinong Taiwan earthquake, there are 21 buildings with severe and collapse damage. Only two buildings of that are evaluated as $I_s > 1.0$ as shown in Figure 4. Moreover, assessment results indicate that number of buildings with seismic vulnerable index less than 1.0 is 50 buildings (i.e. 44% of total buildings). It means that flagging and retrofitting 44%

of the building inventory would have averted 90% of buildings with severe and collapse damage. The proposed rapid assessment showed a high economic effect in the seismic screening stage as shown in Figure 5.

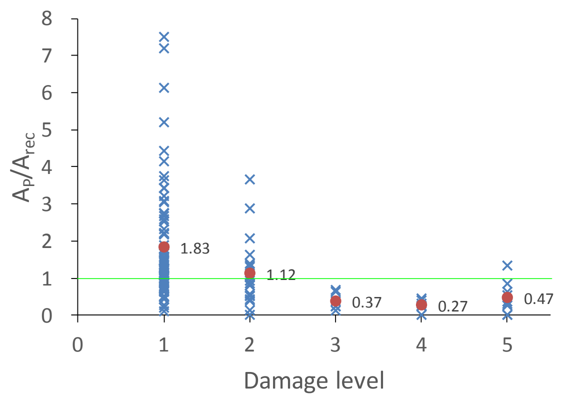

Figure 3 Ratio of Rapid Assessment Performance to Recorded Acceleration versus Actual Seismic Damage Level.

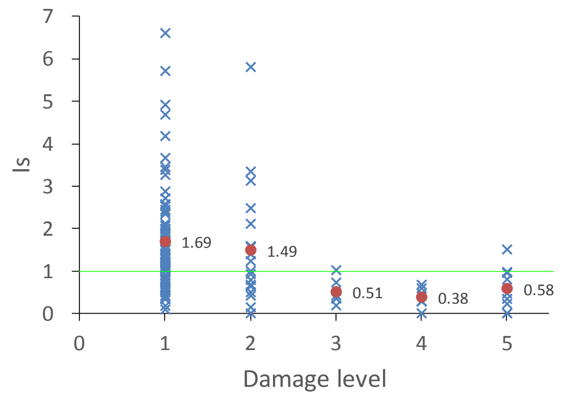

Figure 4 Seismic Vulnerable Index versus Actual Seismic Damage Level.

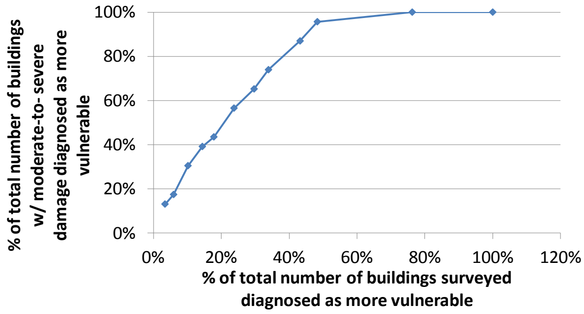

Figure 5 Economical Effect of the Proposed Rapid Assessment

5 Conclusion

Buildings data of the 2016 Meinong Taiwan earthquake is presented in this paper. The data can be used to check the applicability of the existing seismic assessment methods. The proposed method is applicable to RC or brick infill buildings up to six stories with rigid floor panels. Through validation using the buildings data of the 2016 Meinong Taiwan earthquake, this method is justified to be conservative and able to serve as a screening tool. It can be used in the seismic rapid screening for a large number of low-rise RC buildings for earthquake safety.

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An Autogenous Shrinkage Behaviour of Internally Cured High Strength Mortar Developed From Local Artificial Lightweight Aggregate (Lalwa)

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Abstract. This research provided an overview of an alternative techniques for curing concrete in Indonesia especially preventing for shrinkage. Internally curing requires some of water storage that can supply water to cement mortar during hydration and cementitious reactions caused by increased of fly ash and silica fume. The use of lalwa as internal curing agent on High Strength Mortar (HSM) due to obstacle of autogenous shrinkage expected workings properly compare with shrinkage prediction of CEB-MC 90-99 model. The test was conducted on HSM mixture with water to cementicious materials ratios of 0.27, 0.30 and 0.35 to investigated the effect of using lalwa which made from pure expanded shale as a partially replacement of fines aggregate. We found that the lower the w/cm paste, the more effectively the use of alwa towards autogenous shrinkage reduction.

Keywords: *HSM, Mortar, lalwa, internal curing, autogenous, shrinkage*

1 Introduction

The interest of high strength concrete has been increased in the last two decades and followed by the development of concrete technology and the development of appropriate methods. However, the use of low cement water ratio and the addition of silica fume and fly ash in high strength concrete will decreasing relative humidity in concrete and increasing the potential for early age shrinkage. This fact occurs in concrete with constant temperature conditions with insulated humidity, which means there is no exchange of temperature and humidity with the outer environment.

Moreover shrinkage affected by the hydration of the cementicious particles which continue and leads to water depletion in capillary pore. The pores have smaller diameter decreased in total volume of pores, as shown in Figure 1 (Young 1974).

Furthermore it leads to decreasing of permeability and increasing strength and durability of the cement paste, but also decreasing the humidity of the paste and leads to autogenous shrinkage, particularly at early age concrete.

Thus required some treatment to reduce the occurrence of humidity degradation in high strength concrete by adding additional water into the concrete to keep the concrete moist and prevent the potential for shrinkage. Conventionally, some of this additional water has been provided by external curing techniques such as immersion, fogging, spraying, and wet jute applications use. However under high strength concrete, the capillary porosity becomes disconnected during the first few days of hydration (Powers, Copeland, & Mann, 1959). The external water penetrated water only a few mm into concrete and external curing is no longer effective for early hardening concrete.

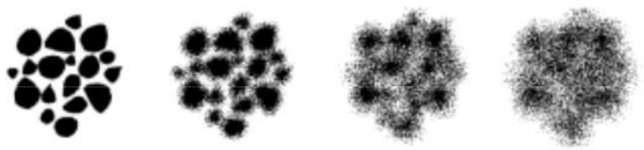

Figure 1 Typical advancement of cement paste hydration with time (left to right), resulting in decreased porosity. [Kronlöf 1999]

Accordingly, it is imperative to investigate lalwa use as internal curing agent for high strength concrete to know its effectiveness in reducing autogenous shrinkage compared with a shrinkage prediction model of CEB-MC 90-99 where using new approach for shrinkage by subdivides the total shrinkage into the components of autogenous shrinkage and drying shrinkage which calculated from equation :

$$\varepsilon_{sh}(t,t_c) = \varepsilon_{cas}(t) + \varepsilon_{cds}(t,t_c) \tag{1}$$

$\varepsilon_{sh}(t,t_c)$	=	total shrinkage,
$\varepsilon_{cas}(t)$	=	the autogenous shrinkage,
$\varepsilon_{cds}(t,t_c)$	=	drying shrinkage at concrete age t (days) after the beginning of drying at t_c (days)

2 Research Method

2.1 Materials

The present study used portland cement OPC ex. Indocement with specific gravity 3.15 and performed on mortar. As fine aggregate used quartz sand material with 1.85% absorption while the internal curing material used lalwa sand with 16.74% absorption and desorption of 0.032%. Admixture using fly ash (FA), (Silica fume SF) and Superplastisizer N 3115 as water reducer.

2.2 Mix Proportion

Determination of mixed proportions using ACI 211 4R-08 (design mix for high quality concrete) using fine aggregate and the use of lalwa refers to ASTM C1761/1761M-12 standard specification for lightweight aggregate as internal curing concrete. The calculation of the need of lalwa used this equation :

$$M_{LWA} = \frac{C_f * CS * \alpha_{max}}{S.W_{LWA}} \tag{2}$$

M_{LWA}	=	mass of lightweight aggregate per unit volume kg/m3 (OD),
C_f	=	cementitious materials content for concrete mixture, kg/m3,
CS	=	chemical shrinkage of cementitious materials
α_{max}	=	maximum potential degree of hydration of cementitious materials (0 to 1.0),
S	=	degree of saturation of pre-wetted aggregate relative to the wetted surface-dry (WSD) condition (0 to 1.0),
W_{LWA}	=	mass of water released by from WSD condition at a RH of 94 %.

The calculation results show the need of the lalwa by using expected maximum degree of hydration to be 1 for water-to-cement mass ratio (w/c) of 0.36 or greater and to be approximated by (w/c)/0.36 for a lower w/c (Bentz, Lura, & Roberts, 2005) and the degree of saturation of free wetted aggregate relative to the wetted surface dry condition of 88%. So the following table present a mixture proportion for high strenth mortar.

Table 5 HSM mixture proportion

Material	Unit	Rasio w/c		
		w/c = 0.27	w/c = 0.3	w/c = 0.35
Cement	kg.m-3	577.89	520.10	445.75
FA	kg.m-3	115.58	104.02	89.15
SF	kg.m-3	77.05	69.35	59.43
Fine Aggregate	kg.m-3	776.02	895.99	1050.34
Alwa	kg.m-3	330.64	297.57	255.03
Water	kg.m-3	208.44	208.46	208.48
Berat Beton	kg.m-3	**2085.62**	**2095.50**	**2108.20**
HRWRA 0.5-1 % dari jumlah material yg bersifat semen	kg.m-3	5.78	5.20	4.46
w/c real		0.36	0.40	0.47
w/cm		0.27	0.30	0.35

2.3 Experimental method

2.3.1 Compressive strength

Specimens of high quality mortar using w / c 0.27 with mortar size 5 x 5 x 5 cm as many as 3 specimens to be tested at ages 3, 7, 28 and 56

2.3.2 Chemical shrinkage

Chemical shrinkage used cement paste with w/c 0.27 by weight and specimens used as + 150 grams. The chemical shrinkage test perform with 3 specimens using FA and SF.

2.3.3 Autogenous shrinkage

The fresh mortar cast into free shrinkage molds equipment of 1 m length and 50 x 50 mm square and placed in a thermostatically controlled room at 23-240 with RH between 60-80% and checked using hygrometer tools.

2.4 Instruments

2.4.1 Universal Testing Machine (UTM)

In this research, UTM will be used for concrete compressive test for cement mortar cube of 5 x 5 x 5 cm3.

2.4.2 Dial Gauge

Dial Gauge serves to measure horizontal displacement in autogenous shrinkage specimens with high accuracy of 1/1000 mm which cause of high sensitivity, so the test area should be free of any obstacles

2.4.3 Instrumen chemical shrinkage

As per ASTM C1608-12 (Standard Test Method for Chemical Shrinkage of hydraulic Cement Paste) chemical shrinkage measurement instrument using a pyrex glass with a capillary tube that hold up by rubber block as the following illustration.

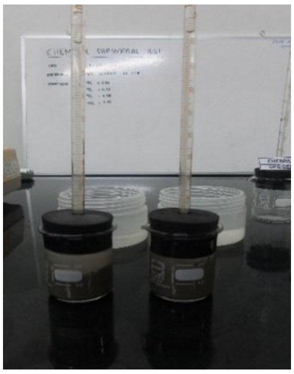

Figure 2 Chemical Shrinkage assembly

2.4.4 Autogenous shrinkage

Instrument is a modification of ASTM C1698-09 (Standard Test Method for Autogenous Strain of Cement Paste and Mortar) by using free autogenous shrinkage type which allows for the data of horizontal direction of shrinkage specimen.

Figure 3 Autogenous Shrinkage instruments

2.5 CEB MC90-99 Model

Determination of shrinkage prediction using CEB-MC 90-99 calculated using relative humidity as decimal expression and without external curing. Therefore the drying start immediately after placing. This prediction also depend on type of cement and concrete mean compressive strength at zero (f_{cm0}) and 28 days (f_{cm28}) as time function. Thus used value of RH= 0.7, f_{cm0} = 10 MPa and f_{cm28} adjusted to w/c variations.

3 Results and discussion

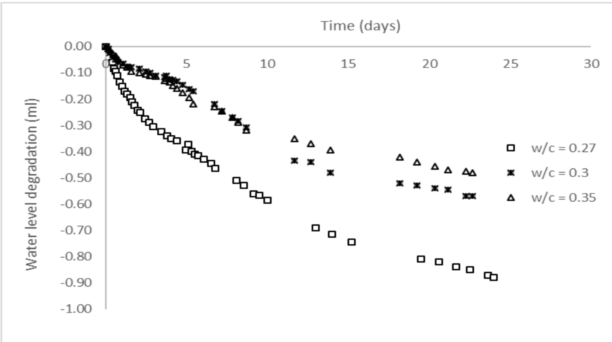

Figure 4 Time vs Water level degradation CS instrument

As seen on figure 4 the change of water level on the chemicals shrinkage instrument increases further along with the decreasing ratio of w/c. This resulted in reduced pastes and generate a chemical shrinkage (CS). Its occur when cement and water mixture reacts and formed into crystalline and gel hydration products and the water incorporated into these hydration products which is continued by pozzolanic reaction. Both products are occupied hydration has less space than the reactants.

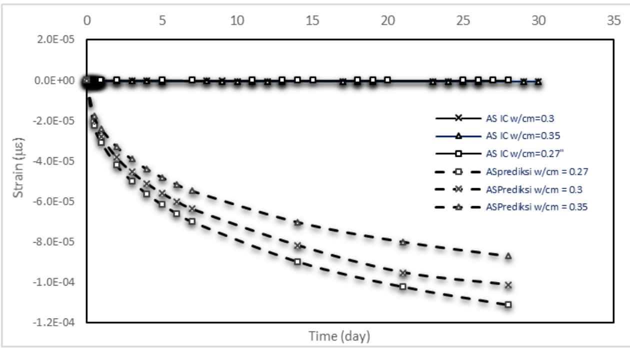

Figure 5 Autogenous deformation of HSM for w/c 0.27, 0.3 and 0.35

The above figure is a plot of the free autogenous shrinkage of HSM mixtures measured from 1 h after mixing as a function of age up to 28 days. Each point in figure 5 represents the average free autogenous shrinkage measurements of three specimens compared with shrinkage prediction model. In detail, the experimental results show that most of the curve fitting are effective in decreasing an autogenous shrinkage and mostly caused by internal self-desiccation developed within the first week of hydration. This effect starts appears to decrease after the hydration process and slows down with time. Therefore, the prevention of an excessive self desiccation and autogenous shrinkage cracking in HSM structures should involve an effective techniques that are effective for at least one week after mixing.

This can be due to the use of silica fume and fly ash which cause early age hardening and its confirmed by the results of a compressive strength test that shows hardening at an early age and then increases at the later ages as seen on figure 6 below.

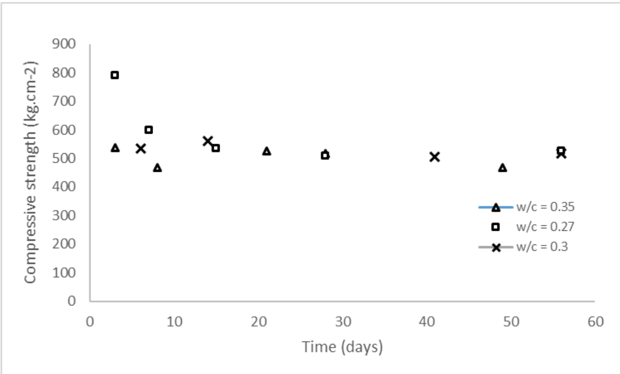

Figure 6 Compressive strength of HSM specimen

4 Conclusion

- The use of low water cement ratio increasing the use of cementitious materials such FA and SF. This materials accelerating early hardening and early age shrinkage but decreases immediately slowly due to the presence of lalwa reservoir. Which mean the agents starts working.

- The lower the w/cm paste is, the more effectively the use of alwa towards autogenous shrinkage compared with CEB prediction.

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Fire Behavior on the Burning Structure

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Abstract. Property destruction is an impact of uncontrolled fire. A strategy to tackle this situation is by using passive fire protection system. This system is embedded in building materials to save and protect people from fire. It is built in a building system and does not need special operation on fire. This system will be conducted by making a new fire resistance material. The purpose of this description is to tackle the deficiency of current fire resistant materials. At the moment, fire resistant materials are gypsum, brick, stucco, concrete, and intumescent paint. Geopolymer, which is a new fire resistance material, is based on making it as brick. This study consists literature regarding fire triangle, development process of fire, heat transfer, heat flow, fire protection systems, method to make a new fire resistance material, and passive fire protection mechanism. The purpose of this study is to analyse the behaviour of fire in each four periods. The main results and the finding of this study are the solidification into a thick multicellular char as the impact of fire on the fire resistant material. This char is a product of cross link formation in passive fire protection material.

Keywords: *passive, fire, protection, resistance, behaviour, structure, material, geopolymer.*

1 Introduction

Fire is a chemical reaction. This reaction is a substance combines with oxygen and heat. Usually, fire occurs when a source of heat comes into contact with a combustible material. If a combustible liquid or solid is heated, it evolves into vapor and if the concentration of vapor is high enough, it forms a flammable mixture with oxygen in the air. If this flammable mixture is then heated further to its ignition point, combustion starts. Similarly, a combustible gas or vapor mixture burns if it is heated to a sufficiently high temperature.

There are three conditions essential for a fire [1]: (1) fuel, (2) oxygen, and (3) heat. These three conditions are often represented as the fire triangle as shown in Figure 1. If one of the conditions is missing, fire does not occur; if one of them is removed, fire is extinguished.

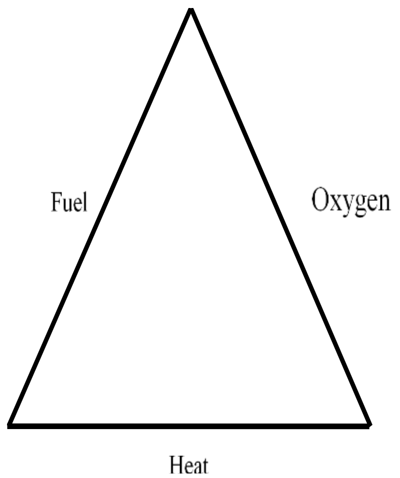

Figure 1 The fire triangle [1].

Normally, the heat required is initially supplied by an external source and then provided by the combustion process itself. The amount of heat needed to cause ignition depends on the form of the substance. A gas or vapor may be ignited by a spark or small flame, while a solid may require a more intense heat source.

Ignition of a combustible gas or vapor mixture may occur in two ways. In the first, the energy for ignition is supplied by a local source such as spark or small flame at a point within the mixture. In the second, the bulk gas mixture is heated up to its ignition temperature.

The three conditions of the fire triangle in Figure 1 also provide clues on how fires may be fought. The first method is to cut off the fuel. The second method is to remove heat. Putting water on the fire usually does this. The third method is to stop the supply of oxygen. Examples on the third method are the use of foam or inert gas. Explaination regarding three conditions that are essential for a fire in this section will be further expanded at the next section by the development process of fire. The next section consists of fire development process in a room.

2 Process of Fire Development

The typical development of a fire in a room is described in Figure 2.

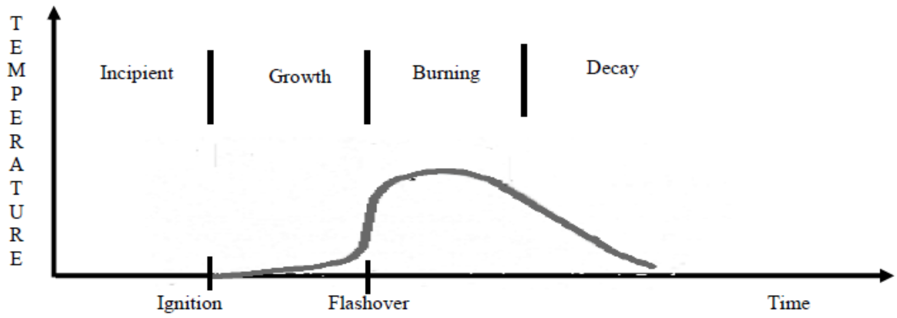

Figure 2 Time-temperature curve for full process of fire development [2].

Figure 2 shows a typical time-temperature curve for the complete process of fire development inside a typical room, assuming no fire suppression by sprinklers or fire-fighters. The next paragraph consists of the description of fire behaviour.

In Figure 2, fire behavior is divided into four periods: incipient, growth, burning, and decay period. In the *incipient* period of fire development, heating of potential fuel is taking place. *Ignition* is the start of flaming combustion, marking the transition to the *growth* period. In the growth period, most fires spread slowly at first on combustible surfaces, then more rapidly as the fire grows, providing radiant feedback from flames and hot gases to other fuel items. If upper layer temperatures in [2] reach about 600°C, the burning rate increases rapidly, leading to *flashover* which is the transition to the *burning* period. The rate of burning in the growth period is generally controlled by the nature of the burning fuel surfaces, whereas in the burning period the temperatures and radiant heat flux within the room are so large that all exposed surfaces are burning and the rate of heat release is usually governed by the available ventilation. It is the burning period of the fire which impacts on structural elements and compartment boundaries. If the fire is left to burn, eventually the fuel burns out and temperatures drop in the *decay* period, where the rate of burning again becomes a function of the fuel itself rather than the ventilation.

Fire normally grows and spreads by direct burning, which results from impingement of the flame on combustible materials, by heat transfer or by travel of the burning material (heat flow). Heat transfer consists of three main modes based on [1],[3],[4]: conduction, convection, and radiation. Meanwhile, heat flow in materials [3] are basically concerned with the flow of heat to, from or within substances. Heat transfer and heat flow will be explained in the next two sub-sections, respectively.

2.1 Heat Transfer

All thermal problems are concerned with the transfer of heat between or within bodies. There are three ways in which heat may be transferred, namely by conduction, by convection, and by radiation. All of these ways of heat transferred are significant in heat transfer from fires. Definition and its function of each type of heat transfer will be presented in the next paragraph.

Conduction, convection, and radiation have its definition and its function in heat transfer. Conduction is the transfer of heat from one part of a body to another part at a lower temperature with negligible movement of the particles or molecules of the body. Heat is transferred from molecule to molecule. Conduction based on [3] may occur in solids, liquids, or gases. Most practical conduction problem [3] involve solid materials. It is because conduction occurs most efficiently in the solid materials,. Conduction is important because it allows heat to pass through a solid barrier and ignite material on the other side. Meanwhile, convection is the transfer of heat from place to place due to movement of a fluid such as a liquid or a gas. In the case of convection, the heat being carried with the moving fluid. The convection arise when some unstable condition arises, as, for example, when cold air is in contact with a hot surface. Most of heat transfer from fires based on [1] is by convection and radiation. In addition, radiation is the transfer of energy through space by means of electromagnetic waves and it does not need a medium for the transfer. The difference of radiation from conduction and convection is radiation does not need medium for the transfer and conduction and convection require medium for the transfer. Radiation is important because radiated heat is transferred directly to nearby objects, does not go preferentially upward, and crosses open spaces. Heat flow as one of effect of fire spread will be presented in the next section.

2.2 Heat Flow

Problems regarding thermal are associated with material and its fabrics of which they form part, with or without air spaces. Materials are basically concerned with the flow of heat to, from or within substances. The nature of this flow, its rate, direction and effects on changes in temperature are dependent primarily on the basic heat transfer processes of conduction, convection, and radiation.

The nature of heat flow starts with temperature difference. Temperature difference is the potential that drives heat from hotter to colder zones. The rate of heat flow is influenced by temperature difference. The greater the temperature difference the faster the flow of heat. In addition, direction of heat flow due to different temperature gradient profiles in a homogeneous material is steady state and unsteady state. Materials from the heat flow point of view are divided to be homogeneous or composite. Homogeneous materials are those without air spaces and the flow of heat along them is entirely by means of conduction. On the other hand, composite materials include air spaces and the flow of heat. In composite materials, there are all type of heat transfer: mainly conduction and radiation, and a lesser extent convection. Heat flow has three component parts [3]. First, the heat reaching and entering one surface. Second, the passage of heat through materials. Third, the eventual loss of heat at the other surface. The next section presents fire protection system for material.

3 Fire Protection System

Problems regarding thermal are associated with material and its fabrics of which they form part, with or without air spaces. Materials are basically concerned with the flow of heat to, from or within substances. The nature of this flow, its rate, direction and effects on changes in temperature are dependent primarily on the basic heat transfer processes of conduction, convection, and radiation. Burning materials is experiencing reduction of yield stress and elastic modulus. In order to tackle this reduction in materials, it needs a fire protection. In the next paragraph, fire protection systems are categorized based on each functional.

Based on each functional by [5], [6] and [7], fire protection system as a whole can be categorized into three major systems namely active fire protection system, passive fire protection system, and fire safety management. This three major fire protection system is named the triangle of fire protection, as shown in Figure 3, where means of escape is included in passive system. All figures and tables should be centered and numbered consecutively. Active fire protection, passive fire protection, and fire safety management are presented in the next three chapters, respectively.

Active fire protection in [5], [6], and [7] is an energized system for installed fire protection. It is commonly require electrical energy to start and keeping it operated. This type of fire protection comprises fire detection and alarm systems, water-based fire protection systems (such as automatic sprinkler systems, standpipe & hose, and hose reel), and chemical-based fire protection system. In the next paragraph, passive fire protection is presented.

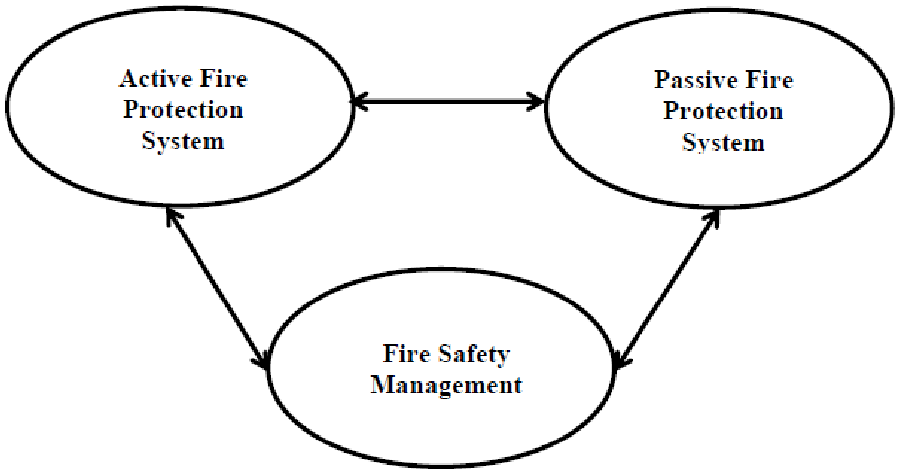

Figure 3 The Triangle of Fire Protection

Passive fire protection in [5], [6], and [7] is regarded as built-in systems. It also include as passive fire protection several methods and systems for smoke control, smoke exhaust, and smoke ventilation. Examples of passive fire protection are the selection and uses of non combustible materials and other recommended building materials in view of their properties that do not support the intensity of fire, the application of compartmentation having appropriate fire resistance, fire barrier and separation, protection of the openings, utilizing fire stopping materials, fire or smoke dampers installed in air conditioning ducting systems and shafts. After brief explanation regarding active fire protection and passive fire protection, a brief explanation regarding fire safety management is in the next paragraph.

Fire safety management in [5], [6], and [7] implies all types of managerial activities aims at preventing and extinguishing fires through manning systems, materials, machine, methods, budget allocation, and information. Fire safety management is commonly regarded as human systems.

As a conclusion, passive fire protection works in the growth period, burning period, and decay period of fire development. In growth period of fire development, it works by selecting materials with resistance to flame spread. Meanwhile, in the burning and decay period of fire development, it works by providing fire resistance, contain fire, and preventing collapse.

4 Method to make a new fire resistance material

New fire resistance material will be made by method in making brick. Conventional methods in making brick are by burning and cementing. Two drawbacks of these conventional methods are high energy consumption (approximately 2 kWh/ brick in [8] and 0,30 kWh/kg in [9]), and high impact pollution that caused by CO_2 (±0,41 kg CO_2 in [8]). In order to tackle the shortcoming from conventional methods, a new method called geopolymerization emerge. Geopolymerization and its product named geopolymer are briefly presented in the next paragraph.

According to [10], geopolymerization is a technology that relies on the chemical reaction of amorphous silica and alumina rich solid materials with a high alkaline solution at ambient or slightly elevated temperatures to develop a new form of inorganic polymer or geopolymer which considered as amorphous to a semi-crystalline aluminosilicate material. Definition and components of geopolymer have beeen studied by [11], [12], and [13]. Geopolymer is a lightweight inorganic aluminosilicate polymer in which the alkaline liquid reacts with the source material which is rich in silicon and aluminium. Geopolymer has two main constituents such as a source material and an alkaline liquid. The source materials and an alkaline liquid are presented in the next paragraph.

The source materials of geopolymer may be of natural minerals such as clay, kaolinite or by-product minerals such as fly ash, slag, silica fume, RHA, Red mud. The source material should be rich in silica and alumina which is helpful for binding action. It can be selected based on its availability, cost, and type of application and demand of end users. Meanwhile, the alkaline liquid preferably used for geopolymer may be sodium or potassium (sodium/ potassium hydroxyde and sodium/ potassium silicate).

5 Protection Mechanism by Passive Fire Protection

In Section 3, it has been presented passive fire protection works in the growth period, burning period, and decay period of fire development . In this section, protection mechanism by geopolymer as a passive fire protection will be conducted. Based on a study by [14], fire resistant coatings in the event of a fire will inflate to be a thick charcoal. The development of this fire-resistant coating will protect the coated material.

Fire-resistant coating used is an intumescent material. According to [15], intumescent materials provide a thermal and physical barrier to the underlying substrate and thus block the high temperatures and rapid flame spread of fires. During exposure to a fire, the temperature within these materials rises, causing melting of the thermoplastic matrix. When the temperature corresponds to an appropriate value for the viscosity of the melt, an endothermic gas-producing chemical reaction is triggered. The gas collects in small bubles, causing the material to foam. Solidification into a thick multicellular char by the process which cross-link production, provides an insulating layer that slows down the transport of heat and reduces the amount of material that becomes involved in the fire. The formation of a thick multicellular char as a result of cross-link production is the same result which is found by [16]. Study conducted by [16] found that material with good heat stability is material which has *cross-link*. The same cross-link is found in geopolymer. The next paragraph consists of geopolymer fire protection mechanism.

According to [17], the fire protection mechanism by geopolymer is formed through the formation of cross-link within the geopolymer. Figure 4 shows fire protection mechanism by formation of cross-link beneath geopolymer. Dissolution of the solid aluminosilicate source by alkaline hydrolysis (consuming water) produces aluminate and silicate species in the initial step of Figure 4. This is followed by the formation of a supersaturated alumino silica solution due to result of disolution amorf alumino silicate. Thick alumino silicate solution will form a gel. The formation of supersaturated aluminasilika solution will release the water consumed during the early stages of the geopolymer formation process. The remaining water in the supersaturated aluminasilika solution will fill the pores of the solution. This type of gel is known as b-phasic where the supersaturated aluminosilica and water solution form two stages. After both stages, the supersaturated solution will form the gel by releasing the water in the solution. Stages after the process of gel formation is the arrangement of the relationship between one gel with another gel. This is followed by the formation of three-dimensional aluminasilica through polymerization and hardening processes which are characteristic of geopolymers. Cross-link exist in the final stages of geopolymer formation. Once a cross-link is established within the geopolymer, the geopolymer can be used as a fireproof coating material. Where the geopolymer fire retardant coating will expand in the form of thick coal in the event of a fire. The development of this geopolymer refractory coating will protect the coated material.

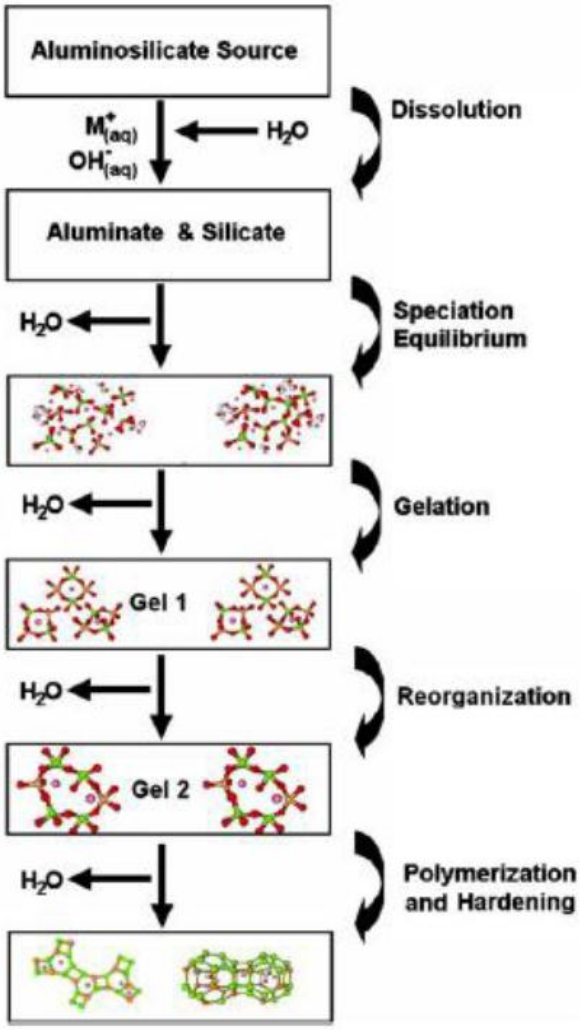

Figure 4 Geopolymer formation process [17]

6 Conclusion

As a conclusion, five points are presented :

1. Three conditions essential for a fire are fuel, oxygen, and heat.
2. Fire behavior is divided into four periods: incipient, growth, burning, and decay period.

3. Fire protection system as a whole can be categorized into three major systems namely active fire protection system, passive fire protection system, and fire safety management.

4. Passive fire protection works in the growth period, burning period, and decay period of fire development. In growth period of fire development, it works by selecting materials with resistance to flame spread. Meanwhile, in the burning and decay period of fire development, it works by providing fire resistance, contain fire, and preventing collapse. Impact of fire on the material fire resistant coatings is the formation to be a thick charcoal. Solidification into a thick multicellular char by the process which cross-link production, provides an insulating layer that slows down the transport of heat and reduces the amount of material that becomes involved in the fire.

5. In addition, impact of fire on the structure is reduction of yield stress and elastic modulus.

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Structural Integrity Management System for Fixed Offshore Platform

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Abstract. The main objective of Structural Integrity Management System (SIMS) is to ensure that structure is fit for purpose and maintain the integrity of facility throughout its life cycle. SIMS is a part of PHE WMO Asset Integrity Management Framework. The structural component covered in SIMS for fixed offshore platform including substructure (jacket, including vertical, horizontal, and diagonal bracing) and upper structure/topside (deck girder, deck leg, trusses, and other personnel safety structure). SIMS managed in a centralized online database management system to make sure that the assets are registered and program including inspection, assessment, maintenance and repair activities are monitored and completed on schedule.

SIMS fundamental process as per API RP2SIM consists of 4 primary elements: data, evaluation, strategy, and program. This process is developed into integrity management cycle: Plan, Do, Check, Action (PDCA) cycle as basis to establish structure integrity program. The Plan cycle include Inspection, Maintenance, and Repair (IMR) Strategy and Program Plan, Risk-Based Underwater Inspection. The Do cycle consist of procedure and execution of Above Water and Under Water Inspection, structural identification and component numbering. The Check cycle contains anomaly assessment report, produce recommendation for anomaly findings, integrity status methodology and determination for each platform. The Action cycle covered further detailed inspection, execution of maintenance and repair. All of the cycle monitored, maintained, and recorded in database management system.

In conclusion, SIMS is a continuous process to ensure that structural asset is fit to operate safely, reliably, and effectively from FEED until decommissioning. Further development and improvement shall be done along the implementation of SIMS to escalate integrity performance.

Keywords: *asset integrity management system, fixed offshore platform, structural integrity management system*

1 Introduction

PHE WMO is one of local production sharing contract that manages oil and gas resources at West Madura area. PHE WMO strives to commit of performing safe operations and improving production efficiency. Currently PHE WMO operates 16 (sixteen) active fixed offshore platforms with steel jacket template type with various numbers of legs. Common platform type used at platform is braced-monopod (especially at wellhead platform). With the asset contains of number of offshore facilities, it requires the strategy that cover the systematic program in inspection, maintenance, and repair which can assure the fitness of serviceability of the assets. A system is required as a tool to manage all assets covering 5 (five) major aspect; structural, pressure system, pipeline, corrosion and floating system, called Asset Integrity Management System (AIMS).

Structural Integrity Management System (SIMS) is a part of PHE WMO Asset Integrity Management Framework as one of Process Safety Management (PSM) element. Gap analysis, AIMS policy and standard, and strategy have been developed since 2015 which become basis for AIMS program development. AIMS policy and strategy covers all aspect of asset management to operate asset by stakeholder including inspection, maintenance, evaluation, and review. The main objective of SIMS as part of AIMS is to ensure that structure is fit for purpose and maintain the integrity of facility throughout its life cycle.

2 Structural Asset Management

SIMS fundamental process as per API RP2SIM consists of 4 primary elements: data, evaluation, strategy, and program.

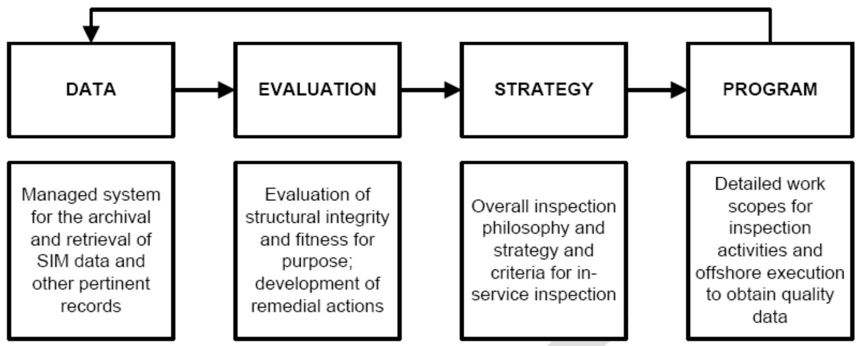

Figure 1 SIMS Fundamental Process[1]

2.1 SIMS Cycle and Implementation

SIMS provide framework for inspection planning, maintenance, and repair for group of platforms. This process is developed into integrity management cycle: Plan, Do, Check, Action (PDCA) cycle as basis to establish structure integrity program. PHE WMO SIMS Guideline has been developed as basic guidance to implement the system and to provide role and responsibilities for each parties involved in the process.

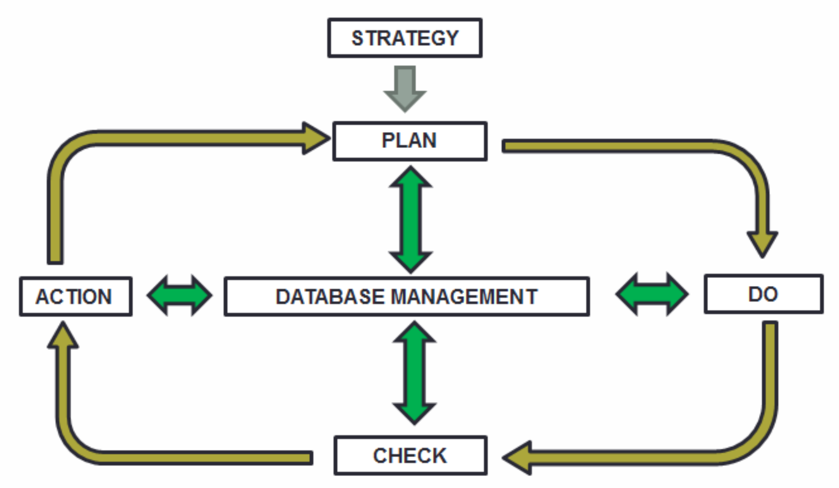

Figure 2 SIMS Operational Process

The structural component covered in SIMS for fixed offshore platform divided into 2 (two) main parts; substructure (jacket, including vertical, horizontal, and diagonal bracing) and upper structure/topside (deck girder, deck leg, trusses, and other personnel safety structure). Each of structural components is labeled with a sequence of unique number and registered in the database. Inspection, Maintenance, and Repair (IMR) program will be arranged and recorded based on this system.

The Plan cycle include IMR Strategy and Program Plan. Inspection scope of work will be produced by structural integrity engineer. Structural inspection program divided into above water (AWPI) and under water (UWPI). AWPI is conducted time-based while UWPI is carried out based on Risk-Based Underwater Inspection (RBUI) with fixed schedule until year 2030. Inspection Program also has been determined (Level I, II, or III) in RBUI schedule and methodology.

The Do cycle consist of the execution of Above Water and Under Water Inspection. Procedure for both inspections have been developed to make sure that the execution is in accordance with regulations and company requirements and also to make sure that the latest condition of the platform is well captured.

The Check cycle contains anomaly assessment and produce recommendation for anomaly findings. After data from inspection is obtained, it is need to be assessed by structural integrity engineer to produce recommendation for the structural component, is it fit for service, need to be monitored in the next planned inspection, or need to be repaired. A guideline has been produced to determine anomaly limit for each type of inspection. When major repair is needed, it is necessary to conduct structural engineering assessment based on applicable code (API RP2A WSD [2]) before execution to check platform structural capacity.

The Action cycle covered the follow up action for the recommendation produced in anomaly assessment. It could be further detailed inspection such as MPI, detailed engineering assessment, or corrective action/repair. Repair scope of work/work package will be send to execution team with applicable due date to measure performance (scope vs actual).

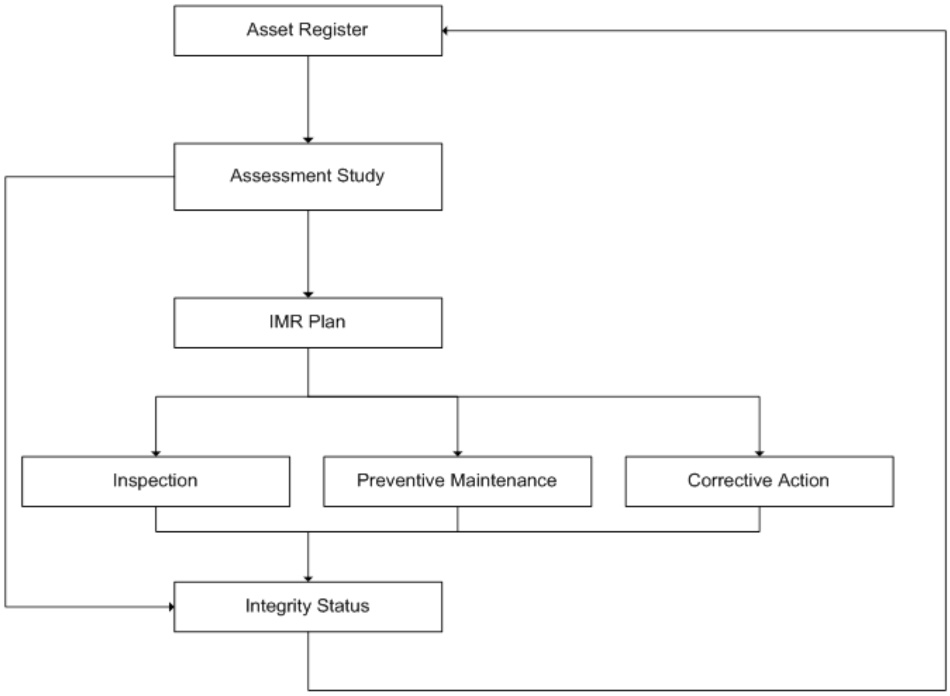

Figure 3 SIMS Work Flow

The product of this system is structural integrity status of the asset. Different from piping/pipeline which have an integrity status for each line number, structure element of a platform is a unity of various structural major and minor components that worked simultaneously to withstand given load, including equipment, environmental, and live load as per design basis. A method has been developed to determine structural integrity status of a platform with scoring system combining platform condition based on latest condition of the platform based on inspection result and platform structural design analysis. A single dimensional mathematical approach is used to combine all parameter into a single process of analysis by using weighting score for each parameter based on professional judgment by structure integrity specialist. There will be 4 (four) general condition of a platform; Good, Fair, Poor, or Bad based on previous scoring system mentioned. Integrity statements for each platform will be produced annually consist of platform general information, integrity status, and recommendation related to platform critical anomalies.

2.2 SIMS Web Database Management System

All of SIMS cycle mentioned above is monitored, maintained, and recorded in centralized online database management system. The objectives are to make sure that the assets are registered and program including inspection, assessment, maintenance and repair activities are monitored and completed on schedule. All parties involved in SIMS cycle will have their own role and responsibilities based on organization chart and all function from top management level to engineer level could take advantage from this web database system to support their role to maintain asset integrity.

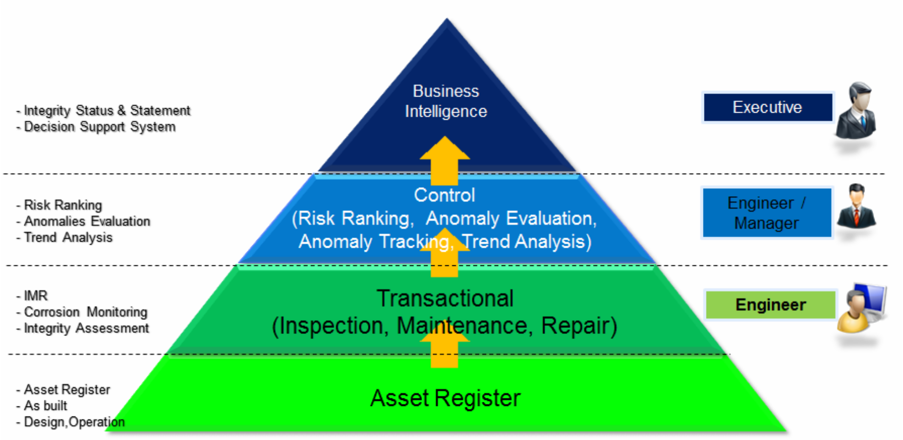

Figure 4 AIMS Database Management System Data Hierarchy and Target User

AIMS database for structure generally divided into 5 (five) section as per follows:

a. Asset Register (platform data from original design and modification record including drawing, analysis, and design basis; and also environmental data required for analysis)

b. Inspection (Plan, Do, and Performance Measurement; consist of inspection scope of work, inspection result and history, and summary of inspection execution for both above and under water)

c. Assessment (Integrity Assessment consist of inspection result analysis to provide recommendation; and Engineering Assessment which provide structural analysis result)

d. Corrective Action (Plan, Do, and Performance Measurement; consist of corrective action scope/package and execution program monitoring)

e. Executive Summary (summary of assets information and integrity status mentioned in integrity statement for each platform).

AIMS Database also contains certification modules (SKKP) document and validity for each platform and also RBUI schedule and methodology.

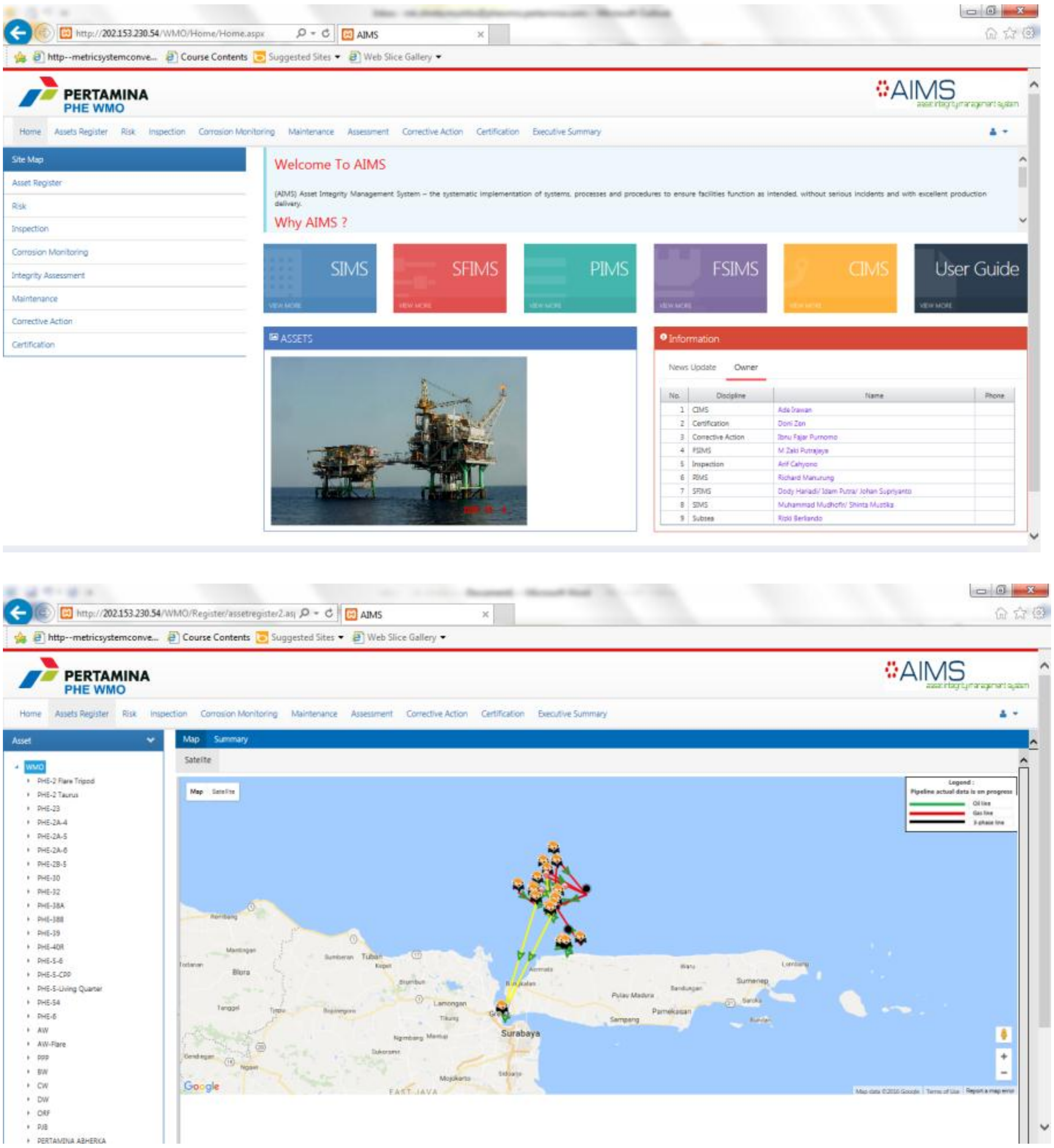

Figure 5 AIMS Database Management System Data Hierarchy and Target User

3 Conclusion

In conclusion, SIMS is a continuous process to ensure that structural asset is fit to operate safely, reliably, and effectively from FEED until decommissioning.

PDCA cycle shall be implemented and recorded in the database to maintain structural integrity of the platform. Since gap analysis has been developed in 2015, SIMS implementation at PHE WMO already achieved in 2017. Implementation of SIMS at PHE WMO has brought advantages both for time and cost efficiencies in managing assets. Therefore further development and improvement shall be done along the enforcement of SIMS to escalate integrity performance.

4 Nomenclature

AIMS : Asset Integrity Management System

FEED : Front-End Engineering Design

IMR : Inspection, Maintenance, and Repair

PDCA : Plan, Do, Check, Action

PSM : Process Safety Management

RBUI : Risk-Based Underwater Inspection

SIMS : Structural Integrity Management System

SKKP : Sertifikat Kelayakan Konstruksi Platform

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TRANSPORTATION SYSTEM AND ENGINEERING

Regression Analysis of Trip Attraction and Parking Evaluation with Tariff on Office Building in Samarinda, East Kalimantan

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Abstract. The purpose of this research is to determine of causative factors and how strong these influence trip attraction at Samarinda Province Government Center and to analysis the charactheristics of parking and tariff that would be applied. The results showed that the model of trip attraction that occurs after the regression analysis is $Y = 0.451 + 0.503\ X_1 + 0.395\ X_5$ with the most influential factors of car users and revenues of 50.1%, which is considered to have a fairly strong relationship. When an increase in the intensity of activity, then the office building with an area of 1 ha able to attract 240 motorcycles and 390 cars / day. With the accumulation of parking at peak hours of 86 cars and 200 motorcycles with the highest parking duration 120-180 minutes (2-3 hours), with the number of vehicles 103 vehicles cars and 176 motorcycles parked vehicles. Applied rates are the rates that may be progressive with the rate of Rp 2000, - for the first two hours and a maximum rate of Rp 4000, - for the automobile. And Rp 1500, - for the first two hours and a maximum rate of Rp 3500,- to a maximum tariff for motorcycle.

Keywords: *trip attraction; parking; parking rates, regression analysis.*

1 Introduction

The high intensity of activity in the office BAPPEDA, causing the region has a high traffic attraction. People who come to the office BAPPEDA which generally have a goal to work. The movement of employees and visitors / guests who come to the office BAPPEDA Province East Kalimantan has a high impact in an increased need for parking and this is a problem that needs solving, especially relating to issues associated with the variables into factors affecting the trip attraction of the journey to BAPPEDA office of East Kalimantan Province.

1.1 Problems

The problem of this research are:

1. Are the factors car users, users motors, public transport users, the user pick, the amount of income and other variables used in this study had a positive impact on the attraction of the trip?

2. Whether the dominant factor affecting the trip attraction model of the trip that might happen?

3. How much parking space requirements are needed?

4. What is the optimal parking fees that may be applicable?

1.2 Research Purposes:

The purpose of this study are:

1. Know the factors that influence the magnitude of the trip attraction,

2. Trip attraction model that may occur, as a result of the intensity change / increment of the independent variables,

3. Know the needs of parking spaces required,

4. Know the optimal parking fees that may be applied

2 Literature Review

2.1 Trip Attraction

Trip attraction is the stage of modeling that estimates the number of moves that led to a zone or land use.

2.2 Parking

Parking is defined as the state does not move a vehicle which is temporary (PP No.43 of 2005), including in terms of parking is any vehicle that stops at certain places either by signs or otherwise for the purpose of raising or lowering persons and goods.

2.3 Parking Rate

Parking fees are a method used to control the parking facilities. For the determination of tariffs in a downtown parking can be determined based on the number of vehicles parking, type of vehicle parking, spacious parking, parking capacity and traffic volume.

$$Pi = \sum_{i=1}^{n} f\ (Vp, Duration\ of\ vehicle\ parking) \qquad (1)$$

With Pi is a function of parking rates in a zone I is affected by the stated volume Vp vehicles parked in the zone I, and long vehicle parking is an independent variable.

2.4 Regression Analysis

Regression Analysis Method approach produces an equation for predicting the total number of trip attraction that can be used as a means of forecasting the upcoming trip. The general form of a simple linear regression is:

$$Y=a+bx \qquad (2)$$

where :

Y	=	dependent variable
x	=	independent variable
a	=	regression of constant
b	=	regression of coefficient

Method of least squares regression is used in a simple process where the line of least squares obtained so that the amount produced. Multiple linear regression analysis is used to estimate the magnitude of the coefficients generated by a linear equation, involving two independent variables to be used as a tool of great predictive value of the dependent variable. The usefulness of this model is to calculate the magnitude of the influence from two independent variables to predict a dependent variable and the dependent variable using independent variable.

3 Research Method

3.1 Respondent

To be able to determine the number of samples that can present the actual state, then the number of samples to visitors / guests in getting BAPPEDA office based on data obtained from the office BAPPEDA for the number of visitors / guests office per day.

Based on existing data, the number of visitors / guests per day at the office building BAPPEDA is ± 300 people / day. So that the number of samples for respondents visitors / guests that need to present the actual state table based on 169 respondents krijcie is ≈ 170 respondents.

To determine how the large number of samples for office workers BAPPEDA East Kalimantan Province is also using the Krijcie table, for the amount of the employee population 123 people with 95% confidence level, then the minimum sample size needed as many as 92 people, and in this study will be rounded up to 100 people an employee. In total number of respondents to 270 respondents.

4 Trip Attraction and Parking Demand Analysis

4.1 Parking Accumulate

Further accumulation of vehicle seen parked in BAPPEDA Office Building East Kalimantan province, both for vehicle wheel 4 (four) or two-wheeled vehicle (two), as shown in the picture below:

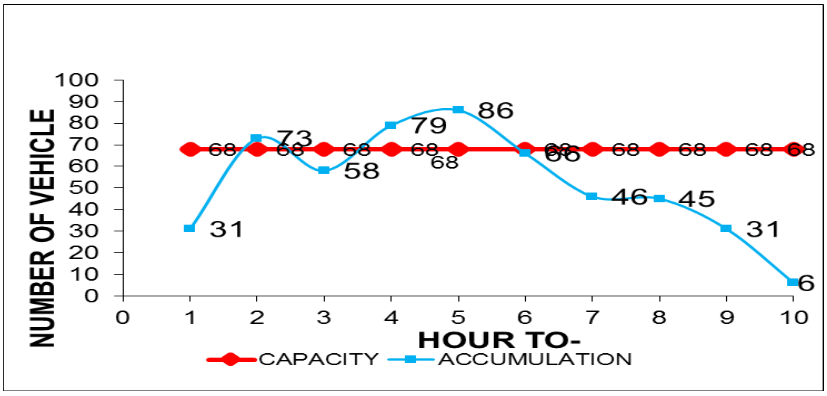

Figure 1 The Acummulated Parking Chart of Four-Wheeled Vehicles

Based on the above image data, it appears that the accumulation of the vehicle is stationary / parking was highest at 10.00 until 11.00, ie 86 vehicles in line with the meeting in the office building BAPPEDA East Kalimantan Province. While the capacity of formal parking spaces are available only 68 SRP. Result has been exceeding the available parking capacity, then most of the guests who come only vehicle stopped for a moment to lose passengers and then exit back from the region of East Kalimantan Province BAPPEDA office. While the advantages of existing vehicles parked in the circulation area that it interferes with the movement of traffic movements will enter and exit.

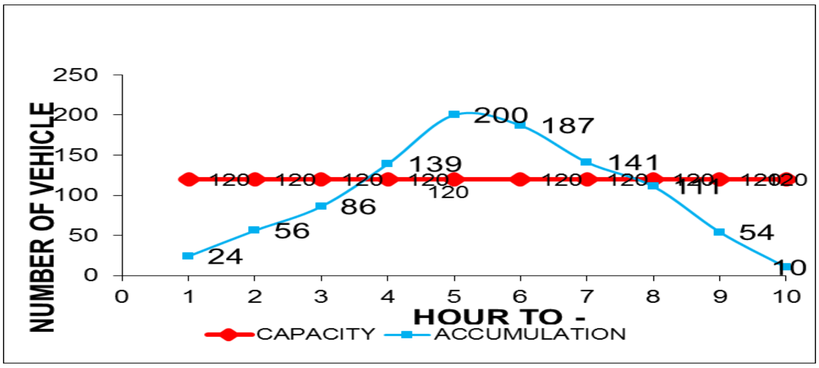

Figure 2 The Acummulated Parking Chart of Two-Wheeled Vehicles

Similarly, the vehicle wheel 4 (four), for vehicle wheels 2 (two) based on the data table and graph above shows that the accumulation of the vehicle is stationary / parking was highest at 09.00 to 13.00, which is 200 vehicles at the fifth (10.00 - 11.00 WITA), along with the meeting in the office building BAPPEDA East Kalimantan Province. While the capacity of formal parking spaces are available only 120 SRP. As a result most of the guests arriving vehicles parked in the circulation area that it interferes with the movement of traffic movements will enter and exit.

4.2 Parking Duration

Based on the results of traffic surveys counting every 15 minutes that has been done for two-wheeled vehicles and four-wheeled, can be known a long time (duration) in an office building parking kendaaan BAPPEDA East Kalimantan Province. More results can be seen in the following diagram:

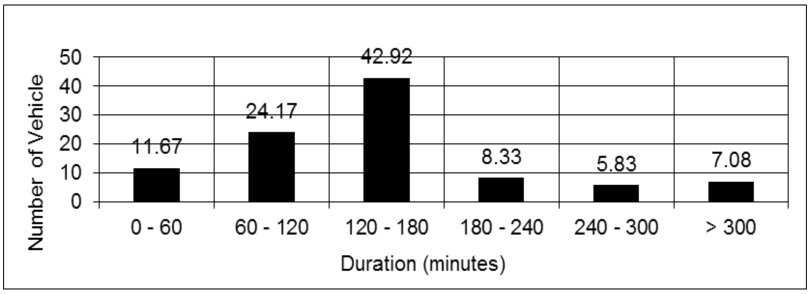

Figure 3 Car Parking Duration

For cars, the largest parking duration is 120-180 minutes (2-3 hours), with the number of vehicles 103 vehicles (42.92%). This is related to the duration of the meeting which took place in an office building BAPPEDA East Kalimantan Province. After the meeting guests gradually left the office BAPPEDA vehicles to get to the respective agencies.

While for two-wheeled vehicle (two), long duration of parking can be seen in the following diagram:

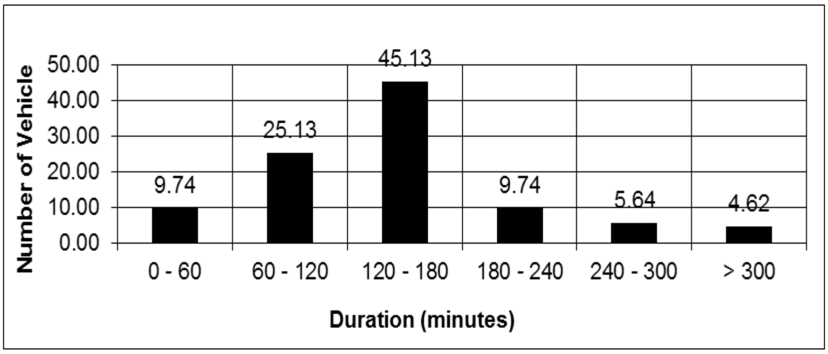

Figure 4 Motorcycle Parking Duration

For two-wheeled vehicle (two), the largest number of vehicles is 176 vehicles (45.13%) by the number of parking duration 120-180 minutes (2-3 hours). This corresponds well with the length of the meeting regarding the 2012 budget briefing RKA conducted in an office building BAPPEDA.

4.3 Turn Over

From the results of calculations using Microsoft Excel, it can result in parking turnover to indicate the level of use of parking space that is 3.53 times and 5.74 times respectively for cars and motorcycles.

4.4 Parking index

Parking Index of the calculation results in getting a value of 1.265% for four-wheeled vehicles (cars) and 2.941% for two-wheeled vehicles (motorcycles).

4.5 Trip Attraction Analysis

4.5.1 Stepwise Analysis

a. $\hat{Y} = 0{,}648 + 0{,}837\, X_1$

b. $\hat{Y} = 0{,}451 + 0{,}503\, X_1 + 0{,}395\, X_5$

With the X1 is the user's car and the X5 is the amount of revenue. In the analysis for the model b shows the R value of 0.708 which can be interpreted that the relationship between car users and powerful enough income that is equal to 70.8%, then to the value of R square of 0.501 indicates that the amount of travel is determined by the trip attraction of car users and revenue by 50,1%.

4.5.2 Parking Rate Analysis Cars

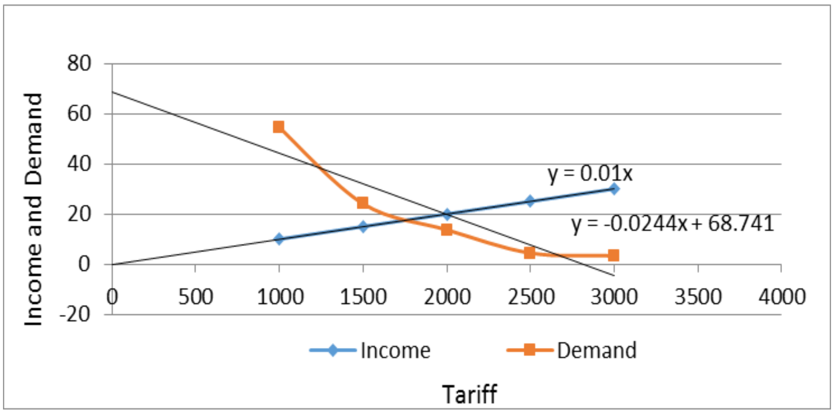

Figure 5 Optimalisation of Car Parking Tariff

a. Relationships with Income Car Parking Rates
b. Based on the results of data analysis that connects between the rates given by the value of the Rupiah and income are expressed in relative value (%), obtained by an equation, as follows:

$Y = 0{,}000000000000001528 + 0{,}010\, X_1$ = If Y = R :

$$MR = \frac{\Delta Y}{\Delta X} = 0{,}010 \text{ where MR} = \text{Marginal Revenue}$$

Marginal Revenue (MR) by 0.010 gives the sense that any increase in tariff of Rp 1000, - would raise revenue by 10%.

c. Relationships with demand and parking rates

Based on the results of data analysis that connects between the rates given by the value of the Rupiah and income are expressed in relative value (%), obtained by an equation, as follows:

Y = 68,736 – 0,024 x ; if Y = D , thus:

$$MD = \frac{\Delta Y}{\Delta X} = 0{,}024$$

Where MD = changes in car parking demand

Changes in car parking demand for the change of car parking rates for 0.024 gives the sense that any rise in parking fees of Rp 1000, - will reduce demand for parking as much as 24%.

4.5.3 Parking Rate Analysis for Motorcycle

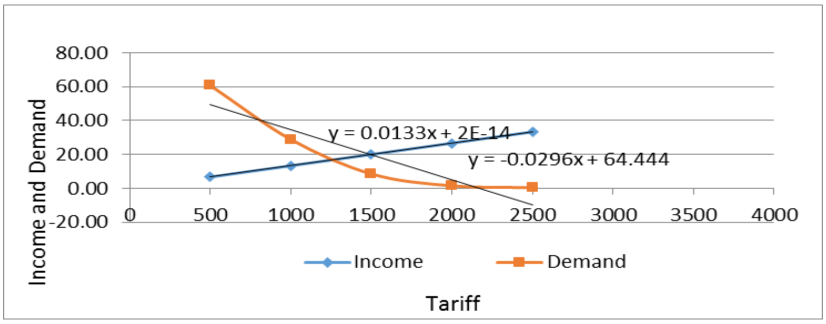

Figure 6 Optimalisation of Motorcycle Parking Tariff

5 Conclusions and Suggest

5.1 Conclusions

By considering the objectives and problems and the results of the analysis, we then can put forward the conclusions, as follows:

1. Factors - factors that influence the magnitude of trip attraction in East Kalimantan Province BAPPEDA are:

a. Car users with a linkage of 46.6%
b. Car users and revenues by 50.1% linkage

Both are considered to have a fairly strong relationship.

2. Trip attraction models that are found are the result of analysis performed by the stepwise analysis, are:
   a. Y = 0.648 + 0.837 X1, which gives the sense that any one person car user growth will lead to increase intake of 0.837 trips per person per day, or per person on average 1.195 times carry out tug trip.
   b. Y = 0.451 + 0.503 + 0.395 X1 X5 shows that the increase in car users as much as a people, will increase the trip attraction of 0.503 trips per day, and increase income of $ 1, - will increase the attraction of 0.395 trips per person per day. Or total effect = 0.503 + 0.395 = 0.898 so that the average of trip attraction = 1.114 times per person per day.

3. From the survey results revealed the largest parking accumulation occurred at 10:00 to 11:00 pm, ie 86 vehicles and 200 cars vehicles motorcycles.

4. Motorcycle and car parking in East Kalimantan Province BAPPEDA current tariffs are not imposed, it is common in all the institutions that exist in the province of East Kalimantan. However, it offered the option to withdrawal rates for vehicle parking in BAPPEDA, namely the application of progressive parking rates with the value rate of $ 2000, - for the first two hours and a maximum rate of $ 4000, - for the automobile. And Rp 1500, - for the first two hours and a maximum rate of $ 3500, - to a maximum tariff.

5.2 Suggest

1. Associated with the analysis of parking rates in East Kalimantan Province BAPPEDA suggested to be a consideration of the trial, because this will also support efforts to increase revenue. And of course this should be supported by such regulations decree governor of East Kalimantan Province which may range can be extended to all offices Office / Agency / and institutions - institutions that are under the control of the Provincial Government of East Kalimantan.

2. To facilitate the implementation of parking fees can be done through several policies, among others:

   a. Charges are made, through cooperation with existing cooperatives in each SKPD which will submit to the cooperative in charge of local revenue stream, and of course in this case the cooperative shall be entitled to pay service charges for the purposes of the cooperative members.

b. Charges are implemented through incentives to improve the income deductions are carried out periodically (once a month), so the shape becomes a subscription parking, and parking apply to all parking areas in East Kalimantan SKPD the provisions in the regulations set by the Governor.

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Is It Possible the Traditional Mode to be Use as a Sustainable Urban Transportation Option in Indonesia? A Review

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Abstract. Traditional modes are widely used in Indonesia such as bicycles, tricycles and horse carts. Some parts of Indonesia, the existence of traditional modes become a tourist icon and unique than to other areas. However, in facts of facilities and infrastructure not supported yet. Some examples of the problems are not lane of the availability if there is used motorized parking. The purpose of the paper is to review the possible users of the traditional modes an urban area by the study of literature. The methods are used literature review on view of regulatory and users need. The regulatory review is related to the rules of the provision of facilities and infrastructure of traditional modes. While the user needs are related to the implementation of traditional modes and accessibility. The results of the regulatory review obtained the difference in regulations that have not prioritized the needs of infrastructure. Review of user requirements is the availability of infrastructure for easy accessibility related to safety convenience and security. Understanding user needs and regulatory support from the Government allows the continued sustainability of traditional transport by the community.

Keywords: *Traditional mode; sustainable; urban transportation; regulation; user need.*

1 Introduction

Non-motorized vehicles are human-powered vehicles referring to use by walking, cycling and other variants such as the use of carts, wheelchairs, and scooters. (Litman, 2011). In Indonesia, non-motorized vehicles are defined as vehicles driven by people or animals. The types of non-motorized vehicles are bicycles, tricycles, horse-carts, and strollers. The development of the use of non-motorized vehicles has been modified by the driving force using motorized engines such as motor tricycles. Motorized tricycles have been used, but traditional tricycles are still widely used. Vehicles do not use motor vehicle technology categorized as traditional vehicles (Soegijoko, 1982). Non-motorized vehicles are not machines called traditional modes in the paper. Traditional modes are used for daily activities such as to markets, schools and recreation around the square or enjoying the atmosphere of the city by use horse-carts and tricycles. In addition, travel by traditional modes (walking and bikes) converges to reduce travel by car. (Ewing & Hamidi, 2014). Transportation activities in Indonesia contribute 23% CO2 emissions with the largest energy consumption on the road by 90.7%. Indonesia, Transport sector emissions will increase in 2030 to 443 MtCO2e with rapid population growth (206 million in 2000 to 238 million in 2010) and strong urbanization trend (50% in 2010 and estimated to be 66.6% in 2035), So cities are under pressure from increasing demand for transport capacity. (Kemenhub dan GIZ, 2014). The use of traditional modes is used to reduce emissions, pollution and to improve public health. (Wey & Chiu, 2013). The benefit of switching to non-motorized vehicle use in off-peak condition is obtained financially if it occurs from 1 mile for $143,300 (Litman, 2011), or if the current exchange rate is Rp. 190, 132, 800, 00 presented in Table 1.

Table 1 Benefits of using traditional modes

Benefits	Per mile ($)	Total ($)	Exchange (Rp)	Total (Rp)
Decrease in congestion	0.02	200	13,296	2.659.200
Road wide cost savings	0.05	500	13,296	6.648.000
Vehicle cost savings	0.20	2,000	13,296	26.592.000
Parking fee (Assumed 1 mile average travel length)	1.00	10,000	13,296	132.960.000
Decrease in air pollution	0.05	500	13,296	6.648.000
Decreased noise	0.03	300	13,296	3.988.800
Energy conservation	0.04	400	13,296	5.318.400
Traffic safety benefits	0.04	400	13,296	5.318.400
Total	1.43	14,300	13,296	190.132.800

Based on the table, the benefits of using traditional modes are very large. It is necessary to encourage people to use non-motorized vehicles. There is a need to study the possibility of using traditional vehicles to overcome the dependence of citizens on the use of motor vehicles. This is done for the sustainability of traditional transportation. Sustainability is needed to be enjoyed and perceived by future generations. A sustainable transport system is defined as the access and development of the basic needs of individuals and communities that are safe, consistent in human health and ecosystems. Offers are an affordable and efficient mode choice in support of the competitive economy and regional development balance. Minimizing impacts are land use, low emissions, waste, and noise. (Rastogi, 2011). The aims of the research review the possible use of the traditional mode in an urban area by the study of literature. The possibility of using traditional modes in urban transport sustainability in the paper is assessed by regulation and user needs.

2 Definition of Traditional Mode

Judging from the driving force, the vehicle is divided into two, namely motor vehicles and non-motorized vehicles. Non-motorized vehicles defined as human-powered vehicles refer to their use with walking, cycling, and other variants such as wheelchairs, scooters and cart usage (Litman, 2011). Government Regulation of the Republic of Indonesia number 74 the year 2014 Concerning Road Transport Chapter I, article 1, paragraph 4 states that non-motorized vehicles as vehicles driven by human and/or animal power. (Presiden Republik Indonesia, 2014). Indonesia's Road Capacity Manual defines vehicles with wheels driven by people or animals (bicycles, tricycles, horse-drawn carriages and strollers).(Dirjen Bina Marga, 1997). Non-motorized vehicles and collectively interpreted include walking, cycling that is more sustainable and environmentally friendly than individual motorized modes. (Tolley, 2003; Bertolini et al, 2005; Tiboni & Rossetti, 2011) dalam (Bonotti, Rossetti, Tiboni, & Tira, 2015). Reviewed the use of technology because it is not motorized then categorized into a traditional mode. (Soegijoko, 1982). The development of non-motorized vehicles in Indonesia are reviewed by a shift driving force of human power into the motor as an example of a motorized rickshaw or often called bentor. Bentor is already used in some parts of Indonesia, and distribution is uneven. The use of bentor begins with community innovation and is not a typical local transport. Its existence is controversial in terms of safety and licensing. This paper is a category of traditional vehicles that have been modified engines are not included in the category of traditional modes.

3 Regulation related to traditional mode in Indonesia

The Government passed laws and regulations on the implementation of traditional modes to ensure safety and security in traffic. Regulation studies are grouped into 5 aspects: traffic procedures, special lanes, stop and park, vehicle requirements, and implementation.

3.1 Traffic procedure

Government Regulation No. 43 of 1993 on road infrastructure and traffic has regulated traffic procedures for non-motorized vehicles. The government guarantees the safety and security of traditional vehicles, in article 53. The article states when there is a traditional vehicle then the driver must slow the vehicle if it will pass. Article 55 explains if there is a traditional vehicle the driver must provide opportunities for vehicles to a cross. (Presiden Republik Indonesia, 1993). In addition, it is also explained in article 116 of Constitution of the Republic Indonesia Number 22 in 2009 on Traffic and Road Transportation. For security reasons, in article 76 section 1 traditional vehicle users are required to use the left lane. While Article 77 section 1 the traditional mode driver shall not use a lane for motor vehicles if a special lane is provided. (Presiden Republik Indonesia, 2009).

3.2 Special Lane

Indonesian Highway Capacity Manual 1997, in the planning of urban roads, rural roads, and intersection signalized and not signalized, the traditional modes (non-motorized vehicles) are not considered in the traffic element but included in the category of the side frictions. So the planning width of road lanes, the need for space or road width for traditional vehicles are not taken into account. (Dirjen Bina Marga, 1997). Constitution of the Republic of Indonesia Number 22 in 2009 stated traffic and road transport, article 45 lane bicycles as supporting facility, not as the main facility. Article 62 section 2, the cyclists are entitled to facilities supporting security, safety, order, and fluency in traffic. (Presiden Republik Indonesia, 2009). But specific lanes for traditional vehicles are described in Instruction of Director General of Highways No.2 in 2012. Traditional modes (cyclists and others) require three elements to be safe and efficient. (Dirjend Bina Marga, 2012).

1. Space - Lateral spaces free of greater and faster motor vehicle interference

2. Connectivity - a continuous path without bulge

3. Flat surfaces - free of holes, uncovered drains, sand, mud, and gravel

Special lines should be provided for bicycles and other slow vehicles on the primary arterial road (sub 5.1.a), recommended for a primary collector road (sub 5.2.a), and secondary arterial road (sub 5.4.a). (Departemen Permukiman dan Prasarana Wilayah, 2004). The arrangement of circulation of cyclists, tricycles and horse-carts vehicles is mapped to the hierarchy/class of roads in the planning area. The physical arrangement includes aesthetics, image, and character of the region. The way of doing is the first a circulation system planning that reflects the local characteristic. The second, circulation system planning is simultaneous with local public informal vehicle arrangements such as tricycle, horse-charts, taxi-bike, minibus, and urban transportation as the optimization of the utilization of local movement characters with different types of transportation modes. (Peraturan Menteri Pekerjaan Umum, 2007).

3.3 Stop and Park

Article 66 sections 1 of Government Regulation No. 43 of 1993 has arranged a stop or parking place in particular places. The particular place is described in section 2 around a pedestrian crossing, or specified bicycle crossings. (Presiden Republik Indonesia, 1993). In fact, the special lane is widely used for parking vehicles and selling street vendors.

3.4 Vehicle

Article 61 section (1) of the Constitution of the Republic of Indonesia Number 22 of 2009, every non-motorized vehicle (traditional mode) should meet safety requirements when operated on the road. The requirements are technical and procedures for loading goods. Section (2) states that the technical requirements to be met include: 1) construction; 2) Steering system; 3) Wheel system; 4) Brake system; 5) Lights and light reflectors; and 6) warning device with sound. The intended dimension is the size of the load based on the length, width, and height of the vehicle tub that meets the safety requirements vehicle, Driver, and other Road User. (Presiden Republik Indonesia, 2009).

The safety requirements of traditional vehicle sizes consisting of bicycles, tricycles, and horse-carts (one-carriage cart) are described in Government Regulation No. 5 of 2012. These are presented in Table 2.

Table 2 Type and requirements traditional mode

The type of vehicle	Requirements	GR No 5 of 2012
Bicycle	Dimension : Maximum width: 550 mm Maximum length: 2100 mm	Article 115 section 1
	Eligibility requirements : Sparkboard; brake	Article 115 section 2
Tricycle	Dimension : Maximum width: 1500 mm Maximum length: 2800 mm Maximum height: 1800 mm	Article 116 section 1
	Technical completeness the suspension system to withstand the load, vibration, and shock to ensure safety	Article 116 section 2
	Eligibility requirements : Sparkboard; brake	Article 116 section 3
Horse carts (one-carriage cart)	Dimension : Maximum width: 1700 mm Maximum length: 2250 mm Maximum height: 5250 mm	Article 118 section 1
	Eligibility requirements : The tools serve to slow down the speed of vehicles as a replacement brake.	Article 119 section 1

3.5 Implementation

Article 120 states the type and use of Non-Motorized Vehicles regulated by a Regional Regulation. (Presiden Republik Indonesia, 2012). As well as the Constitution of the Republic Indonesia number 22 the year 2009 Article 63 section 1 states the Regional Government can determine the type and use of Non-Motorized Vehicles in the region according to the characteristics and needs of the region. The section 2 states the types and usage are set to the regulations of the district/city. While section 3 states if it is cross-district / city is regulated by provincial regulation. (Presiden Republik Indonesia, 2009). It is also regulated in the Government Regulation of the Republic of Indonesia Number 74 the year 2014, Article 12, Article 13 section 1, and Article 13 section 2. Article 13 section 3 stated if its operation area exceeds the provincial boundary is regulated by agreement between the Provincial Government which is adjacent to the agreement. (Presiden Republik Indonesia, 2014).

4 Sustainable Urban Transportation

Definition of sustainable transportation of the Council of Ministers of Transportation of the European Union in (Rastogi, 2011) namely: 1) Enable access and development of the basic needs, companies, and communities and in a manner consistent with human health and ecosystems, and promote equity within and between successive generations. 2) Affordable, operating adequately and efficiently, offering a choice of modes of transportation, and supporting a competitive economy, as well as balanced regional development. Social equality and transport behavior should involve a fair consideration of the benefits to all those who are accountable for the needs of the weaker group. (Wey, Zhang, & Chang, 2016). The society's view of sustainable urban mobility is oriented towards reducing private transportation costs, air pollution, and traffic accidents; Stakeholders are more supportive of increasing car-free accessibility and reducing the consumption of land and public space generated by urban mobility. Accessibility in facilitating non-motor mobility is done with cyclability. (Marletto & Mameli, 2012). The common options considered for sustainable urban transport in medium-sized cities located in developing countries are one way of support for non-motorized travel modes. Key strategies to consider in developing cities are exclusive bike paths, which are adequately protected from car traffic. (Pojani & Stead, 2015). Improve cycling zones to improve non-motor travel and reduce motor vehicle travel. The use of non-motorized transport is cycling benefit to reduce carbon, but also healthy lifestyle and physical activity. (Mat Yazid, Ismail, & Atiq, 2011). Promoting non-motorized modes of transportation needs to understand the needs of users, as an environmentally friendly feeder mode for public transport and as an optional mode for short-distance travel. (Salleh, Rahmat, & Ismail, 2014).

Traditional mode widely used for daily activities. Furthermore, the traditional use of developmental modes are used for tourism/recreation (Soegijoko, 1982), (Murti, 2007), (Wulandari, 2014), (Risdiyanto et al., 2015), (Aquarita, Rosyidie, & Pratiwi, 2016), and environmentally friendly transportation.(Pramono, 2008).

5 User Needs

Traditional non-motorized vehicles spread in developing countries, including cycle-rickshaw (Bangladesh, India), becak (Indonesia), cyclos (Vietnam, Cambodia), samlor (Thailand), Saika (Myanmar), bicitaxi (Columbia, Cuba) and Ecologico (Mexico). It is estimated more than 10 million pedicab operators in Asia and Latin America (Rahman et al. 2010) in (Rahman et al. 2010) in (M. M. Rahman, Este, & Bunker, 2010). There are 600,000 rickshaws in Dhaka (Rahman, 2007, STP, 2005), 7,800 in Bandung (Joewono and Kubota, 2005), 106,000 in Kolkata (Gupta and Agarwal, 2008), and 456,000 in Delhi (Kurosaki et al., 2012). According to a National Household Travel Survey in 2009, 10.9% of individuals travel by walking and 1.0% by bicycle, an increase of 25% since 2001. In Dhaka City, rickshaws can be used for feeder service to BRT if done: rickshaw queue arrangement at BRT station. Transfer of mode from becak to BRT station is no more than 3 minutes walk, with better road and environmental facilities.(M. S. Rahman et al., 2013).

In Indonesia, the use of traditional modes such as bicycles, pedicabs, and horse-carts spread throughout the country although the percentage of users is not known for sure. Bicycle users in Semarang about 1.5% Tembalang, 0.5% Banyumanik. (Hermawan, Riyanto, & Basuki, 2009), while is a user of bicycles 4% - 7% on the road in Tegal. (Rusmandani, Arifin, & Wicaksono, 2015). In Indonesia, the existence of becak is beginning 1930s. However, there are some restrictions on the use of becak in some areas. In Jakarta, the Local Government of DKI issued Regional Regulation No. 11 of 1988 and 1994 was not operational. Impact of restriction is illegal pedicab operation in Jelambar, Teluk Gong, Kapuk, Pluit, Tanjung Priok, Cilincing and surrounding areas. (Wulandari, 2014). In Surabaya, restrictions on the number and operation of rickshaws have a socio-economic impact on a pedicab driver. (Indari, 2016). However, in some areas such as Kudus, Bandung, Medan, Solo and Yogyakarta rickshaws operate 24 hours. Users are mostly housewives and housemaids. Used and liked by the middle to high income. (Soegijoko, 1982). In Yogyakarta, becak drivers can speak foreign languages 27%. (Risdiyanto, Koenti, & Hasanah, 2015). Another traditional vehicle is a horse-cart. Its existence has since the early 19th century as a marker of social status. In Yogyakarta, the number is about 358 units since the 2006 earthquake. The driver can speak foreign languages as much as 36%. (Risdiyanto et al., 2015). Use of horse-cart can decrease CO2 from close transport activity

4,792 ton per year CO_2. In Mataram, the use of horse-cart for citizens' activity is about 3.25%. (Pramono, 2008).

The sustainability of the use of traditional transport has required an understanding of user needs. Consideration of important user groups in the region is required. Travelers classified into 2 groups, namely choice, and captive user. The choice group has 2 modes of travel to choose non-motorized transport or motorized service (bicycle or motor), while the captive group has one travel option that is using non-motorized transport. Therefore a safe environment is required. (Mat Yazid et al., 2011). The use of traditional vehicles such as pedicabs, bicycles, and carriages for commuting and tourism activities require safety and comfort. The thing to be aware of is the space free from motor vehicle interference, continuous connectivity, and a flat surface. (Dirjend Bina Marga, 2012). The goal of urban mobility policy is to facilitate non-motorized mobility through cyclability. (Marletto & Mameli, 2012). Urban transport projects in developing countries reflect local issues relevant to sustainability, carried out the provision of safe and efficient cycling roads. (Jones, Tefe, & Appiah-opoku, 2013). The priority of the slow special lane vehicle is the safety and comfort factor. (Amudi, Wicaksono, & Agustin, 2015). Provision of a separate line needed for traditional vehicles in all arterial roads. (Mohan & Tiwari, 2000).

The main requirements for a cyclists network are: 1) Direction: the shortest or the straightest route; 2) Cohesion: infrastructure forms an interconnected network; 3) Attractiveness: the infrastructure is designed and accordance with the environment, in such a way, cyclists view it as interesting; 4) Traffic safety: an infrastructure ensures the safety of cyclists and other road users by avoiding conflicts at high speeds at the crossings and on the road itself; 5) Security: route cycle runs through environments that ensure user safety (e.g. illuminated well, visible to the population, etc.); 6) Convenience: delays and jams caused by congestion or additional physical effort should be prevented (Mkhize, Mouws, & Linders, 2009). Based on research in the Netherlands, there are 5 key requirements representing all users' wishes about non-motorized transport infrastructure, namely: coherence, directness, comfort, attractiveness and safety, coherence. (Servaas, 2000).

Evaluation of the impact of urban development on non-motorized traffic needs attention to the indicators of the level of service (V / C), level of safety (conflict point), level of convenience (detour time), level of independence (mixed level), level of comfort (Environment-friendly). (Wang, Li, Zhu, Wu, & Li, 2015).

Bicycle trips with access to the station are influenced by urban use and urban design. Urban use factors are density (1. population density, the 2. density of housing); Diversity (1. number of shops around the area, 2. different types of shops); while the urban design is: 1. facilities for cyclists, namely: a. the lane bike, b. the effective width of bicycle lanes, c. rules of pavement lanes, d. the presence of trees, e. Street lighting. (Monteiro & Campos, 2013).

6 Conclusion

The implementation of traditional modes requires regulatory support in favor of the user's interest and consistent with the use of the special lane provided shall not be for parking activities and used by motor vehicles. Security and comfort are absolutely necessary to protect traditional mode users. Traditional modes can be used as a sustainable urban transportation mode by understanding the needs of users.

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3D Mobile Mapping Surveying For Road Condition Monitoring

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Abstract. Road is one of main infrastructures in transportation sector having important supporting role in realization of development acceleration and overcoming traffic problem in a region. In Indonesia, there are several types of roads such as national, provincial, residential/municipal. Since the significance role of those roads, the government should collect each road condition data periodically. Given road condition data, expected can be used to facilitate the road monitoring and to be analyzed if there are broken roads, it may have be repaired immediately by local government. However, many of roads are not yet put in up-to-date data collection. One cause of the problems is the long and time consuming process of road data inventory.

Based on the issues, an effective surveying method is necessary as a solution to accelerate the implementation of road condition inventory with the accuracy meet the specified standards. One of methods for object of investigation in this study is carrying out road condition inventory survey using MMS (Mobile Mapping Syatem) method. MMS is one of scanning laser instruments that can record an object on a three-dimension scale by using mobile vehicle. Using mobile, the inventory of roads may be recorded indirectly in short time.

Beside the advantage of MMS, there is still a question about how to get data immediately with the accuracy meet specified standards both for road conditions information and the position. This research aimed to formulate surveying design in order to acquire road condition data as well as information on the accuracy of road condition and geometric.

Keywords: *mobile mapping system, road condition, scanning laser instruments*

1 Introduction

1.1 Backgrounds

Road is one of the most important main infrastructure to support the implementation of development acceleration. Thus, it is important for government to collect the road condition data. With road condition data, government can monitor and fix damaged road. But currently, road condition data has not been updated, because inventory of road data is time consuming and take a long time.

Based on that problem, it needs method for collect road condition data faster and meet the specified accuracy standard. One of the method for road condition data problem is Mobile Mapping System (MMS). MMS is one surveying method that use laser scanning that is attached in top of car. As the car moves, laser scanning scans the road and its surroundings [4].

1.2 Component of MMS

MMS uses Topcon IP-S3 HD1 as research instrument and consist of two main components, hardware component and software component. Hardware component consists of Global Navigation Satellite System (GNSS), Inertial Measurement Unit (IMU), laser scanner, wheel encoder, digital camera, timing box, indicator box and IP-S3 Cube [6]. Software component consists of mobile master field and mobile master office. Those two components is shown in Figure 1.

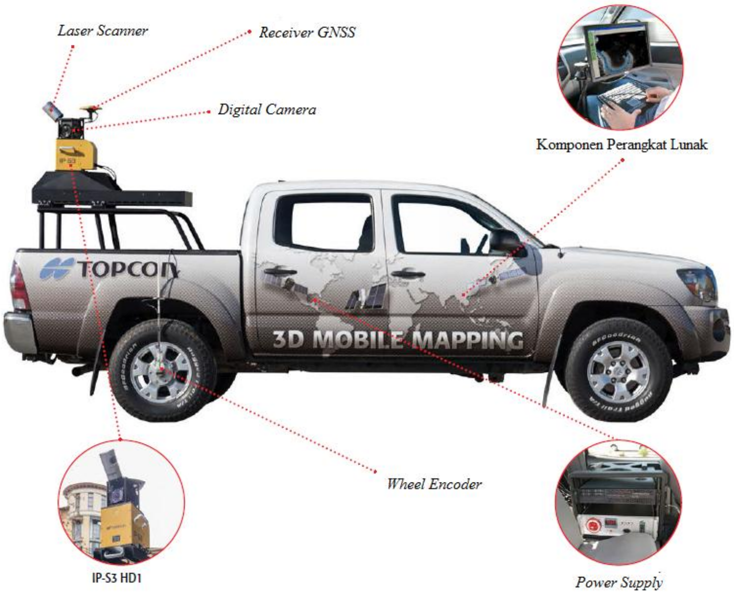

Figure 1 Component of MMS [Topcon X]

1.2.1 Hardware Component

Hardware component is whole part of physically form of Topcon IP-S3 HD1. Each part of the component has its function. Topcon IP-S3 HD1 is shown in Figure 2.

Figure 2 Topcon IP-S3 HD1 [6]

Topcon IP-S3 HD1 consists of seven parts that integrated to obtain point clouds [6]. Those seven parts are:

1) Global Navigation Satellite System (GNSS)

   GNSS is a positioning technology and Topcon IP-S3 HD1 uses Global Positioning System (GPS) from United States and Globalnaya Navigatsionnaya Sputni Kovaya Sistema (GLONASS) from Russia. The principle of GNSS measurement of MMS is that the position of the vehicle (rover) is determined relative to the base station so that the configuration can produce corrections for some error sources that occur during the GNSS measurement so that the resulting position data is more accurate [Abidin X].

2) Inertial Measurement Unit (IMU)

   IMU is integrated system of accelerometers, gyroscopes, and a set of computers that can calculate speed transformations and several other mechanisms for determining position information, attitudes and speed. The function of accelerometer is to detect vehicle speed and gravity acceleration. Gyroscope is used to detect angular change [4].

3) Laser scanner

   Laser scanner has two types measurements. First is distance and second is angle. Distance measurements on MMS uses pulse-based or time of flying (TOF). TOF records the travel time of laser waves when emitted until received back by the laser receiver which then travel time will be used to calculate the distance between the laser scanner with the object [3]. In angular measurements, MMS uses angular encoders that serve to measure the vertical angles and horizontal angles of the incident light on the laser scanner against the point of the object. Topcon IP-S3 HD1 has density point at 700.000 dots per second, vertical viewing angle at 30°, horizontal viewing angle at 360°, and can reach object maximum at 100 m [6]. Laser scanners on MMS utilize laser light technology that is used to scan objects on the surface of the earth. The results obtained using a laser scanner are a set of points (points clouds) that have three-dimensional coordinates with a particular coordinate system with additional information in the form of reflectivity value of the scanned object [3].

4) Wheel encoder

   Wheel encoder is used to determinate vehicle speed with calculate wheel rotation and duration for one wheel rotating. In MMS, wheel encoder is attached on the car rim. The calculation of speed is used to correct instrument position [4].

5) Digital camera

   To get color of point clouds, MMS uses spherical digital camera with panoramic mode [9]. There are six camera sensors to capture photo of object at the same time. This camera has 30 megapixels' resolution and 10 fps in shutter speed.

6) Timing box

   Timing box is a part that used to connect laser scanner, camera, GNSS, and IMU with wheel encder and indicator box [4].

7) Indicator box

   Indicator box is used to know condition of MMS hardaware components also to know signal of GPS and GLONASS [4].

1.2.2 Software Component

There are two softwares that used in MMS. There are Mobile Master Field (MMF) and Mobile Master Office (MMO).

1) Mobile Master Field (MMF)

   MMF is used when collecting data with TOPCON IP-S3 HD1. It is important to put laptop with MMF installed in the vehicle. MMF can plan route of data collecting and also monitor all the hardware components sensor. In MMF, there is playback function to see the result of data that has been collected. The result of MMF is position data, point cloud, and panoramic image [4].

2) Mobile Master Office (MMO)

   MMO is used after collecting data with TOPCON IP-S3 HD1. In MMO, it is needed rinex data from base station. Rinex data is obtained from Continuously Operating Reference Stations (CORS) in the area of data collecting. MMO can integrate the measurement of IMU, GNSS receiver, and wheel encode. It also can show post processing data from base station, adjustment trajectory, generating cloud, panoramic images and trajectory. The result of MMO is trajectory data, 3D point cloud data and panoramic image data [4].

2 Methodology

2.1 Principle of MMS

Topcon IP-S3 HD1 obtains three data which is processed at the same time. First is point cloud. Point cloud is occurred from laser scanner sensor that scatters wave pulse and scans objects around the area which the car goes through. The principle of laser scanner is shown at Figure 3 [3].

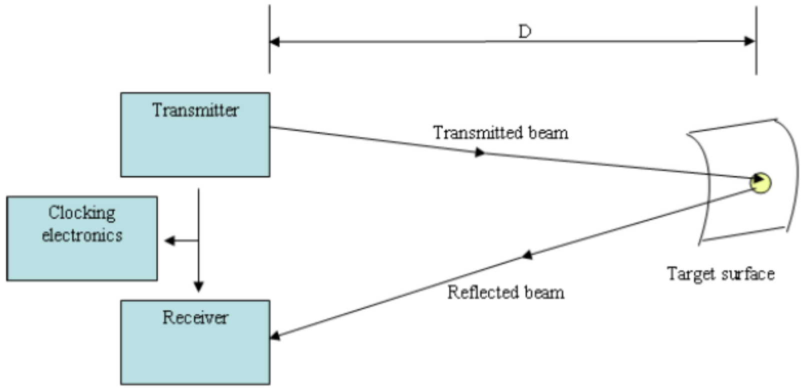

Figure 3 Distance measurement by laser scanner [3]

The equation [3] based on Figure 3 is:

$$D = (C \times \Delta T) \div 2 \tag{1}$$

Second, MMS collects panoramic image from spherical digital camera. Third is object position that is obtained from sensor in GNSS, IMU, and DMI [5]. All of the three sensors are integrated by timing box and the result is three dimensional object spatial data in the form of point clouds. To integrate the sensors, it is needed the equation below [2],

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_G^l = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{GPS}^l + R_b^l\,(\omega\ \varphi\ \kappa)\ \times (R_s^b\ (d\omega\ d\varphi\ d\kappa) \times r^s(\alpha\ d) - \begin{bmatrix} l_x \\ l_y \\ l_z \end{bmatrix}^b \tag{2}$$

2.2 Method

To get the result of MMS, there are two main steps, data collecting and data processing.

2.2.1 Data collecting

First, it is needed CORS. CORS is geodetic framework, that each point has receiver. The receiver can receive signal from GNSS satellites continuously for 24 hours a day, 7 days a week. Thus, user can get CORS data as post processing data or real time data. In this research, it uses CORS that belongs to Geospatiol Information Agency (BIG – Badan Informasi Geospasial), in Lembang, Bandung.

Beside CORS, there are point cloud, trajectory, and image data that is collected by MMF. It takes W.R. Supratman Street, Bengawan Street, and Pasupati Fly Over. Data are taken in night because the traffic is not busy as noon. The installment is shown in Figure 4.

Figure 4 Installment of Topcon IP-S3 HD1

After the installment, MMS needs to do static alignment. Static alignment is calibrating the direction and position of IMU when the vehicle stops. Static alignment must be done in open area, thus signal of GNSS can be received. After that, it must be done kinematic alignment. Kinematic alignment is done when vehicle moves. It must be turn right and left then go forward straightly in 30 km/ hour [7]. After calibrating, TOPCON IP-S3 HD1 is ready to collect data. Those data are shown in Figure 5.

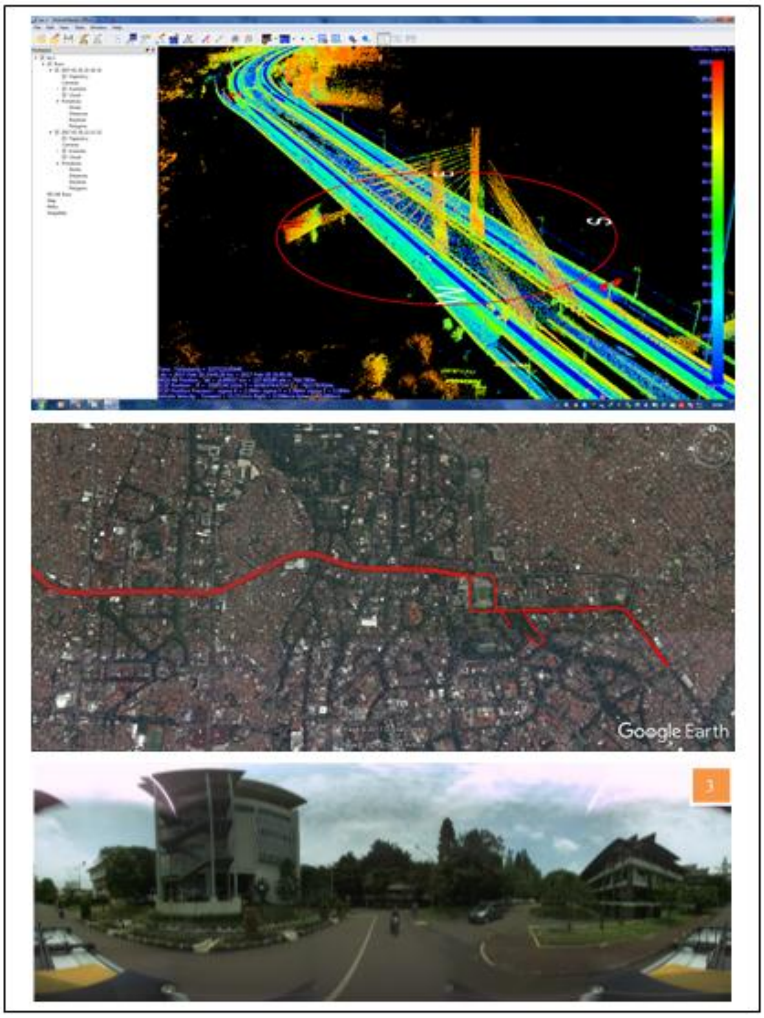

Figure 5 Point cloud data (top), trajectory data (middle), and panoramic image (bottom) [4]

The large amount of point cloud looks like three dimensional shape. Trajectory data is route of data collecting and the last is panoramic image from camera. After using Topcon IP-S3 HD1, this research uses real time kinematic (RTK) GPS to know position of road mark up. The method is called stop and go, it means point which is determined is static, but receiver will be move and stop in point of road mark up [1].

2.2.2 Data processing

All the data are processed in MMO. Base station data from CORS is added to MMO and its format is RINEX. There are six parameters to estimate trajectory in instrument. There are elevation mask for selected satellites, code standard deviation to calculate the position accuracy, ionosphere correction is given when delay of code signal propagation or GPS phase propagation acceleration, wheel encoder, GLONASS signal, and quality factor to fix result from IMU that is represented accuracy of GNSS kinematic. This research use parameters of urban area. The table of parameters is shown in Table 1.

Table 1 Parameters of data processing [8]

Observation area / Parameter	*Urban area*	*Suburban area*	*Open area*
Elevation mask	10^o	10^o	5^o or greater
Code standard deviation	10,0 m	7,0 m	3,0 m
Ionospheric correction	*Auto*	*Auto*	*Auto*
GLONASS	*Select*	*Select*	*Select*
Quality factor	3 or 4	3	2 or 3

The mode of trajectory is loosely coupled, it means trajectory is estimated with integrated the result from post kinematic with base station from GNSS, IMU, and wheel encoder separately [4].

Then there is align multiple passes, this process is used to integrate laser scanner data with trajectory data and panoramic image. Align multiple passes consists of pose scan to result laser scanner data which needs trajectory data and colorize scan from panoramic image to give color in laser scanner data [4]. After that, panoramic images must be stitched, then match with trajectory data and given color to enhance the image. The last is laser scanner data generates point cloud and it must be filtered to eliminate error from process of generate point cloud. All of those processes is used MMO. MMO is shown in Figure 6.

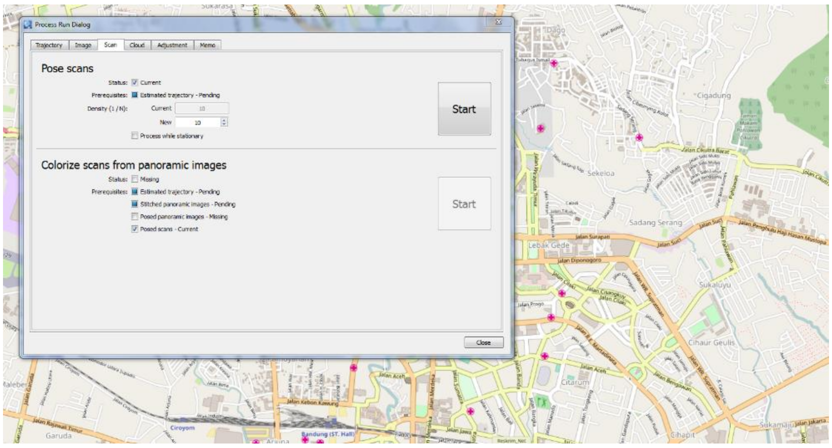

Figure 6 MMO for data processing

After using MMO, the next step is filtering with MAPTEK I-Site Studio 6.0. Filtering is manually done with identification of unused object, such as tree, sideway, or vehicle. The process is done by eliminate the point clouds of those objects. Filtering is shown in Figure 7.

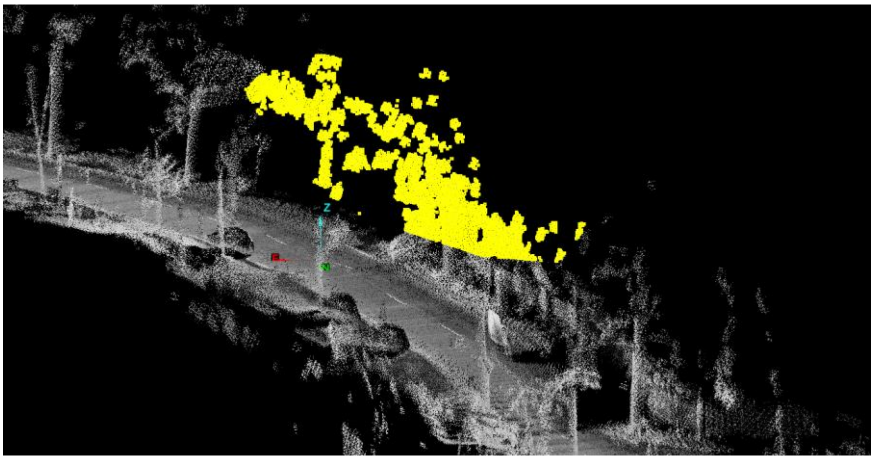

Figure 7 Filtering in MAPTEK I-Site Studio 6.0

The filtered point clouds will be made as three dimensional model using MAPTEK I-Site Studio 6.0 as the software. Three dimensional model will give the viewer shape of road more clearly.

3 Result and Discussion

The result of data processing of road surface point clouds that has color from image and coordinate with global coordinate system using MAPTEK I-Site Studio 6.0 is a three dimensional form that is shown in Figure 8.

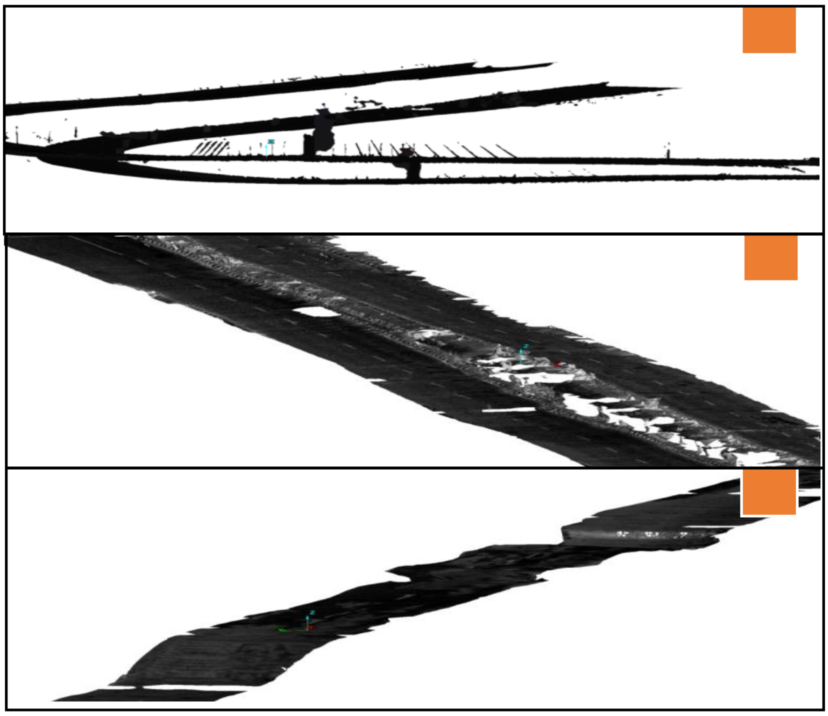

Figure 8 Pasupati Fly Over (1), W.R. Supratman Street (2), and Bengawan Street (3)

To know the accuracy of MMS, point clouds must be compares with measurement of stop and go method from RTK. As previously stated, RTK only takes place in Bengawan Street, thus the comparison is between point clouds and GNSS points from RTK in Bengawan Street. Comparison of MMS with RTK is shown in Figure 9 and Table 2.

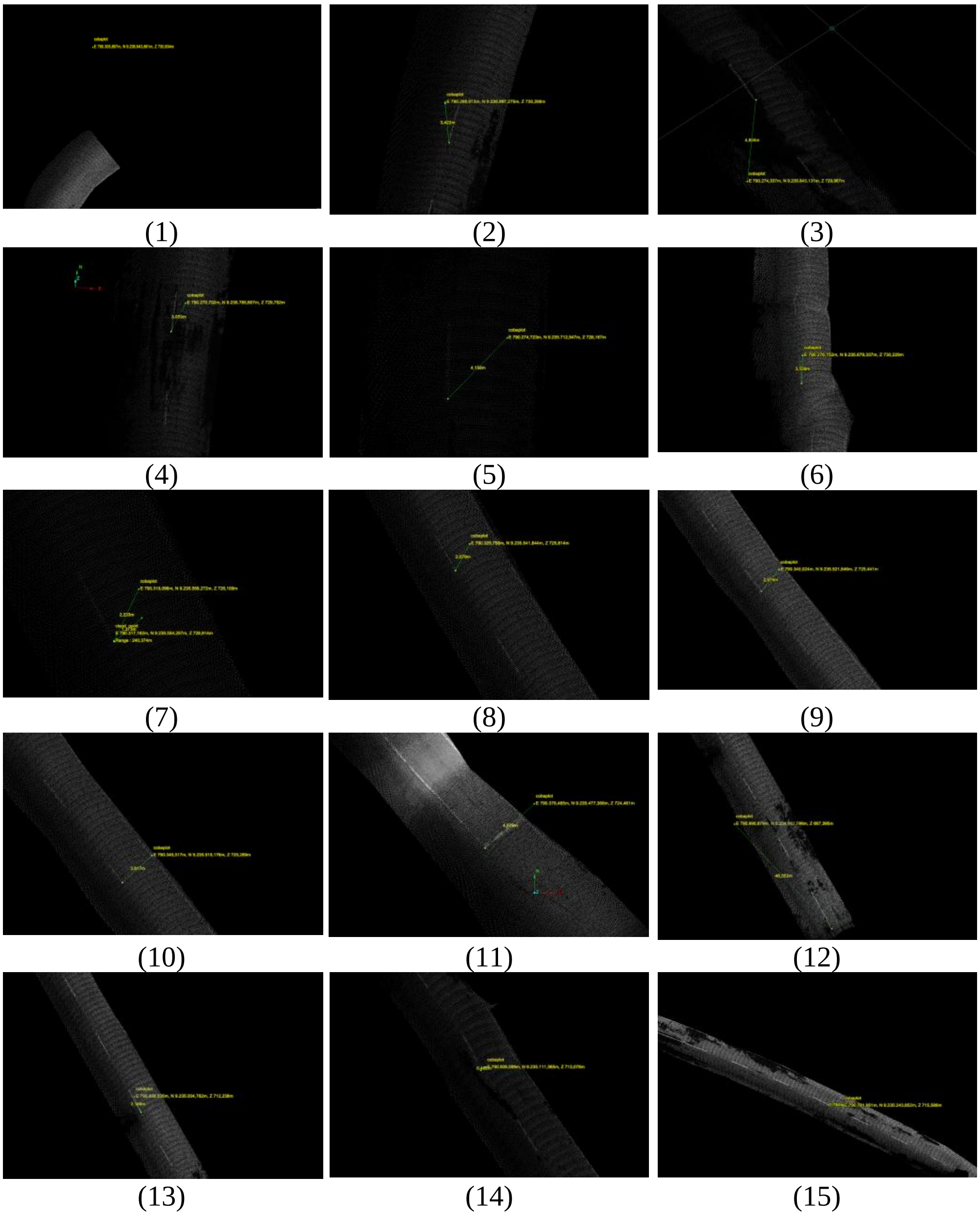

Figure 9 Comparison of point clouds and RTK points of road mark up

Table 7 Difference of coordinate between MMS and RTK

Points	Difference of coordinate E (m)	Difference of coordinate N (m)	Difference of coordinate Z (m)	Quality
1	0	0	0	Fixed
2	0,304	3,501	2,295	Fixed
3	3,033	2,799	2,474	Float
4	0,697	3,136	2,474	Float
5	1,910	3,370	2,120	Float
6	0,145	2,337	2,934	Float
7	0,029	1,967	2,850	Fixed
8	0,934	2,015	2,855	Fixed
9	0,962	1,856	2,575	Fixed
10	2,489	2,416	1,640	Fixed
11	3,347	3,129	0,617	Fixed
12	12,128	13,389	45,389	Float
13	0,827	2,022	0,511	Float
14	0,400	0,253	0,963	Float
15	2,659	0,225	0,885	Fixed

The yellow mark on Table 2 shows the quality of points. Point 1 isn't added in calculating accuracy, because point cloud in point 1 has been identified as unused object and eliminated in filtering process. Thus, there are seven points, 2, 7, 8, 9, 10, 11, and 15. Those points is averaged and the result is shown in Table 3.

Table 8 Difference of coordinate between MMS and RTK mean

	Difference of coordinate E (m)	Difference of coordinate N (m)	Difference of coordinate Z (m)
Mean	1,532	2,158	1,960

The mean result of point cloud accuracy of MMS is quite big because of some factors. First, Bengawan Street has many trees, it will be caused the GNSS can't work properly. Second, there is an error in MMF software when retrieving field data. Third, trajectory method is less precisely, thus it can't reach the maximum accuracy. Fourth, when using MMO, processing parameters uses low and medium level.

4 Conclusion

The accuracy of the Topcon IP-S3 HD1 for measuring roads using the MMS method is 1,532 meters for Easting coordinates; 2,158 meters for Northing coordinate; and 1,960 for height value. It is because some technical factors in field and data processing. In duration, MMS takes two hours to scan the road condition with length of road is ± 9,12 km. It means MMS quite fast to inventory road condition.

5 Acknowledgment

This research is supported by PT. Exsol Innovindo for lending Mobile Mapping System Instrument and financially supported by LPPM ITB.

6 Nomenclature

$\alpha\ d$	=	angle and distance of object to the laser scanner sensor
C	=	laser ray wave velocity (3 x 10^8 m/s)
D	=	the distance of the laser scanner to the point of the object
ΔT	=	the amount of time the signal goes back and forth.
$d\omega$,,	=	angle of rotation between the laser scanner sensor against the IMU sensor
lx,,	=	the spatial distance (lever arm) between the laser scanner sensor against the IMU system.
X, Y, Z (GPS)	=	coordinate GPS in global coordinate system (e-frame)
ω,,	=	rotation of the sensor to the local coordinate system (l frame), shown by roll value, pitch, heading

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WATER RESOURCES ENGINEERING AND MANAGEMENT

Groundwater Study in Boja District, Kendal, Central Java Province Based on Hidrogeology for Residential Development

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Abstract. Clean water availability is a crucial case for the sustainability and development of human life. Regional District of Boja is a highland area with rapid settlement growth. Currently this day, PDAM has not been able to supply clean water to the area. So the current water needs can only be fulfilled from groundwater resources in the form of a wellbore. The research purpose is to analyze the condition of groundwater based on hydrogeology.

In this study, measured the depth of groundwater level and took groundwater samples from wells inhabitants that spread over 15 villages in the district of Boja. After samples were taken, physically observed to see its color and odor as well as laboratory test to measure the hardness value, the value of TDS, SAR, DHL, and WQI.

Based on result, water discharge is 0,038417032 m^3/s. Result of geolectrical measurement showed subsurface lithology are tuff, lapili ,breccia, and andesite. Based on contour map depth of groundwater level showed flow accumulation of groundwater from south to north and southwest to northeast. Result of laboratory test showed value of hardness, TDS, SAR, WQI can be concluded that groundwater quality in that area are commonly good for consumption and for daily purposes.

Keywords: *Aquifer, Flow Accumulation, Geoelectrical, Groundwater, Groundwater Quality, Hidrogeology, Lithology.*

1 Introduction

Water is a chemical compound that composed of two Hydrogen elements (H) and one Oxygen element (O). In Residential area development, clean water supplies factor is one of important aspect for sustainable human life. Groundwater as one of the water resources is a water that comes from rainfall into the soil and seeps into the layer beneath it [10]. It has some advantages that generally more resistant to chemical or biological pollution compared with surface water because the contaminant passes prior filtration in the vados zone before reaches groundwater [8].

This research was located in District of Boja which is a highland area and has a rapid settlement growth (Figure 1).

Figure 1 Map of District Administration Boja, Kendal Regency

Currently this day, PDAM has not been able to supply clean water to the area. So water needs can only be met from groundwater resources, in the form of dug wells and drilled wells. Besides that, groundwater exploration and exploitation will cause a problem in urban area if not kept in balance. Groundwater formation processes will greatly affect water contents in physical or chemical properties. Groundwater content was anylized in order to know the condition of ground water in the research area whether good or not used for daily needs.

The purpose of this research is to study the condition of groundwater based on hydrogeology to know geological condition, hydrogeology, distribution and utilization, and quality of ground water in research area.

2 Literature Review

2.1 Regional Hydrogeology

Kendal regency divide into two land area, highland and lowland. North Kendal dominated by the lowlands and adjacent to the Java Sea, while the southern is a mountainous area and highlands.

Boja belongs to the Clandestine Basin of Semarang (CAS). The groundwater basin is supplied by the Bodri SubWatershed, the Large Dali Pemali Sub - Comal - Jratunseluna. Most of the upstream rivers flow located in the scope of South Kendal. In general, the southern part of Kendal Regency is a rainwater catchment area which is expected to fill a useful aquifer as a source of water. The watershed area traversed by 10 rivers, including Aji River (Kedung Pengilon), Bodri, Blukar, Bulawan, Damar, Kuto, Blorong, Waridin, Buntu and Kendal which are mostly used for technical irrigation system of fields and plantations (Table 1).

Tabel 1 Wathersed Area (DAS) in the Region of Kendal Regency [2]

No	Watershed Name	Area (Km^2)	Flow (m^3/dt)	Length (Km)
1	Aji	53.65	0-10	
2	Waridin	21.15	2-10	
3	Damar	90.50	0-5	
4	Blorong	128.3	4-19	51
5	Kendal	372	0.5-8	9.5
6	Buntu	29.35	0.5-7	10
7	Bodri	552.45	3-33	87
8	Blukar	143.05	1-10	57
9	Bulawan/Pening	29.05	0.2-4	48
10	Kuto	390.05	1-3.5	52

Rain becomes an important role in the hydrological cycle. The amount of rainfall depends on the geographical location. Highland will have a higher humidity so the value of rainfall will also be greater. Therefore, Boja District located in the highland have a large enough rainfall so it is good to supply the groundwater (recharge zone). The Boja District rainfall data is shown in (Table 2).

Tabel 2 Rainfall Boja District Data 2013-2015 [2]

Month	Rainfall (mm)		
	Boja		
	2013	2014	2015
January	526	646	505
February	428	323	580
March	633	409	379
April	663	448	383

AdvanceTable 2 Rainfall Boja District Data 2013-2015 [2]

Month	Rainfall (mm)		
	Boja		
	2013	2014	2015
May	208	107	183
June	465	214	5
July	160	205	3
August	65	97	0
September	53	0	0
October	214	82	25
November	312	314	201
December	377	289	300

2.2 Regional Geology

Based on the location of physiographic according to Van Bemmelen [9], the research area is included into the depression zone and the Serayu Utara mountain row (Figure 2). In addition, the research area also gets the influence of volcanic activity from Mount Ungaran.

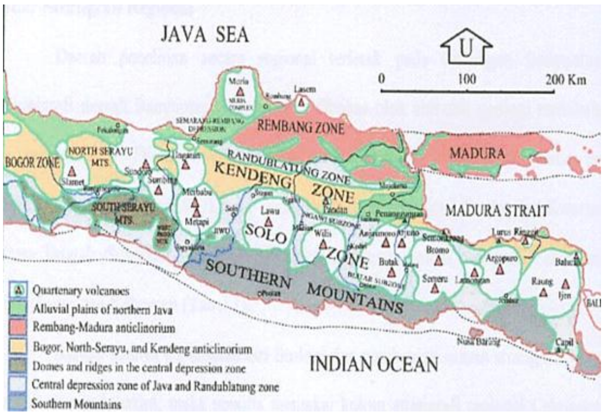

Figure 2 Physiography of Central Java

Based on the Geology Map of Magelang and Semarang Sheets compiled by Thanden et al.[7], the research area is dominated by volcanic rocks. The following rock groups are found in the research area:

1. Andesite Intrusion
   Andesite hornblenda augit is found in G. Down and G. Kendalisodo. This rock age shows the Middle Miocene.

2. Kaligetas Formation (Qpkg)
   This formation consists of volcanic breccias such as lava, tuff and claystone. Generally suffered from extensive intensive weathering resulting in a reddish-

brown soil material, exposed in Kali Putih, G. Sambi, G. Cerme, Sukorejo and Singorojo.

3. Kaligesik Volcano Rock (Qpk)
   This rock is the result of volcanic activity in the form of basal flow of olivine augit, exposed on the northern slope of Mount Ungaran.

4. Gunungapi Gadjah Mungkur Rock (Qhg)
   Consisting of andesite hornblende augit which is generally a lava flows and unfolded at the top of Mount Ungaran as well as surrounding the distribution of volcanic rock Kemalon and Sangku.

The geological structure found is a fault that acts as a tectonic boundary, between the Damar Formation and the Kerek Formation. The faults are illustrated in the east-west direction and bypass the Shingle Formation, the Damar Formation, and the Getas River Formation. The fault is a Quaternary fault that is younger than the age of the formation cut by the fault, the Damar Formation (Plio-Plistocene).

According to Thanden et al [7], tectonic activity in this area is characterized by the emergence of basal and andesite intrusions in the Early Tertiary. This activity is then followed by the removal and erosion process. The erosion then settles and forms the turbidite sediment precipitated by the Shingle Formation in the neritic environment, which is then topped by Kalibeng Formation in the deep ocean environment, and the Damar Formation in the transitional environment - abisal. In Plio-Pliostosen, tectonic activity develops asymmetrical folds and followed by a relatively west-east trending fault, a north-east and south-south-east, and a normal cesarean section.

2.3 Standariztion Water Quality

Water is one of resource for living human, because used for drinking water, living everyday, irigation, and industrial. Human uses water having must suitable standarization that created by Medical Minister regulation or world health Organization (WHO). That's Regulation can be seen at (Table 3).

Tabel 3 Minimum Standarization Drinking Water [4] and [11]

Parameter	Maximum Allowed		Unit
	Permenkes No.492/MENKES/PER/ IV/2010	WHO 2011	
Physics			
1. Colour	Colorless	Colorless	-

Tabel 4 Standarization Drinking Water [4] and [11]

Parameter	Maximum Allowed		Unit
	Permenkes No.492/MENKES/PER/ IV/2010	WHO 2011	
2. Flavor	No Flavor	No Flavor	-
3. Smell	No Smell	No Smell	-
4. Electric Conductivity	-	-	µS/cm
5. Turbidity	5	5	NTU scale
6. Dissolved Solids	500	1.000	mg/L
Chemical			
1. Acidity (pH)	6,5-8,5	6,5-8,5	Unit pH
2. Bicarbonate (HCO_3^-)	-	-	mg/L
3. Calcium (Ca^{2+})	-	-	mg/L
4. Sulphate (SO_4^{2-})	250	250	mg/L
5. Chlorida (Cl^-)	250	250	mg/L
6. Amonium (NH_4^+)	1,5	1,5	mg/L
7. Natrium (Na^+)	-	-	mg/L
8. Nitrate (NO_3^-)	50	50	mg/L
9. Magnesium (Mg^{2+})	-	-	mg/L
10. Mangan ($Mn^{2+)}$	0,4	0,4	mg/L
11. Kalium (K^+)	-	-	mg/L
12. Iron (Fe^{3+})	0,3	0,3	mg/L
13. Nitrite (NO_2^-)	3	3	mg/L
14. Hardness	500	500	mg/L

3 Methods

There are 2 (two) methods; Qualitative and quantitative. Qualitative method in this research is by conducting a survey to the field directly to obtain data such as the types of lithology, geomorphological conditions and hydrogeological conditions. Quantitative methods in this study include measurements of surface water flow, shallow groundwater measurements, geoelectric, and groundwater quality laboratory tests. Measurements of groundwater depth and groundwater sampling from wells of residents in 15 sub-districts in Boja sub-district. Samples taken at the physical observation to see the color and odor and conducted laboratory test to measure hardness value, TDS value, SAR value, DHL value, and WQI value. Laboratory test results are processed with hydrogeological formulas, then made in kurlov table, stiff and piper diagram. Geoelectric measurements were performed at 4 different points of measurement locations and the results were used to create subsurface lithologic maps. Surface water flow rate measurements were carried out in rivers spread over 15 sub-districts in Boja where the results were used to map contours of groundwater flow.

4 Result and discussion

4.1 Geology of Research Area

Based on geological mapping, it can be seen that the lithology found in Boja District are Tuff and Lapili, andesitic lava, alloclastic breccia and autoclastic breccia and andesite intrusion (Figure 3)

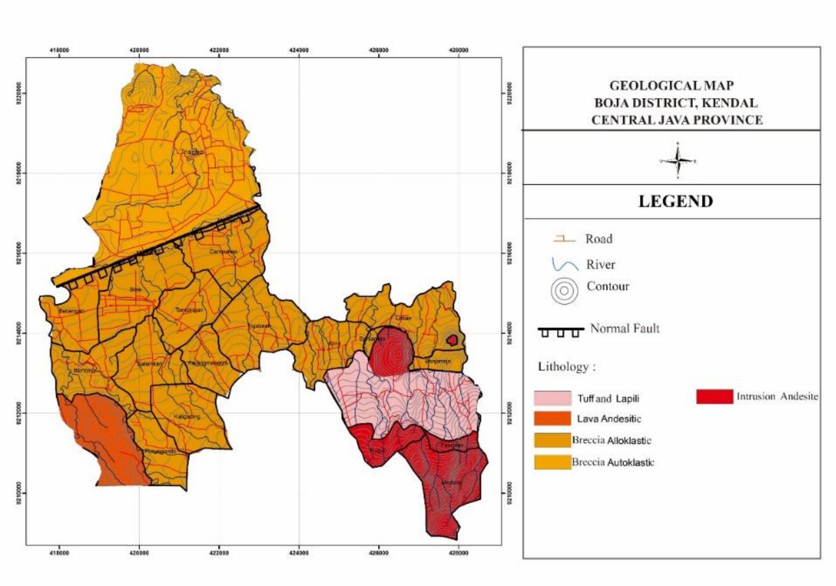

Figure 3 Geological Maps of Research Areas

The lithology has different capabilities in storing and flowing water. The lithology can be described as follows:

A. Tuff and Lapili

Tuff and lapili are explosive eruptions of volcanoes with lithologic characteristics that resemble clastic sedimentary rocks (Figure 4). Tuff and lapili are composed of dust grains that not cementation but undergo a process of consolidation so they can become rocks. The grain contact in the lithology enables the free space to form porosity and permeability. Thus, in the presence of porosity and permeability in tuff and lapillary, fluids may be stored and channeled to this lithology. This causes the lithology of tuffs and lapillas to be delineated as aquifers.

Figure 4 Tuff and Lapili

B. Breccia autoclastic and alloclastic
An autoclastic breccia and an alloclastic breccia are rocks that have relatively tapered fragment sizes (Figure 5). An autoclastic breccia has the same kind of lithology between the fragment and its matrix. The upper edge of the lava that is in direct contact with air is cooling and compacting. The compacted lava is then enclosed into lava that is still liquid and becomes a tapered fragment. Whereas alloclastic breccias are characterized by differences in lithologic type between fragments and matrices. In the field it was found that the fragments of the alloclastic breccia are andesite and the matrix is tuff. Both types of this breccia can act as aquarium on hydrogeology system because this lithology has a pore space between fragments and matrix. However, due to its poor sorting and various types of fragments, this lithology has an inadequate ability to store and drain fluids. Fluids can flow and store in these rocks, but at low discharges and volumes. So both types of breccia is delineated as a aquitart.

Figure 5 Breccia Autoclastic and Alloclastic

C. Andesite and andesite lava intrusion

Both types of lithology are delineated as aquiqlud because lithology is formed by interlocking minerals between each other. Interlocking these minerals causes the porosity and permeability values of these rocks to be very small, so they can not store and drain water properly (Figure 6 and 7).

Figure 6 Andesite

Figure 7 Andesite Lava Intrusion

4.2 Hydrogeology of Research Area

Based on the results of the hydrogeological mapping in the research area, observation of groundwater depth or soil water level to some shallow wells and wellbore. Several wells point as a whole both on shallow well and deep well that can be seen in (Figure 8).

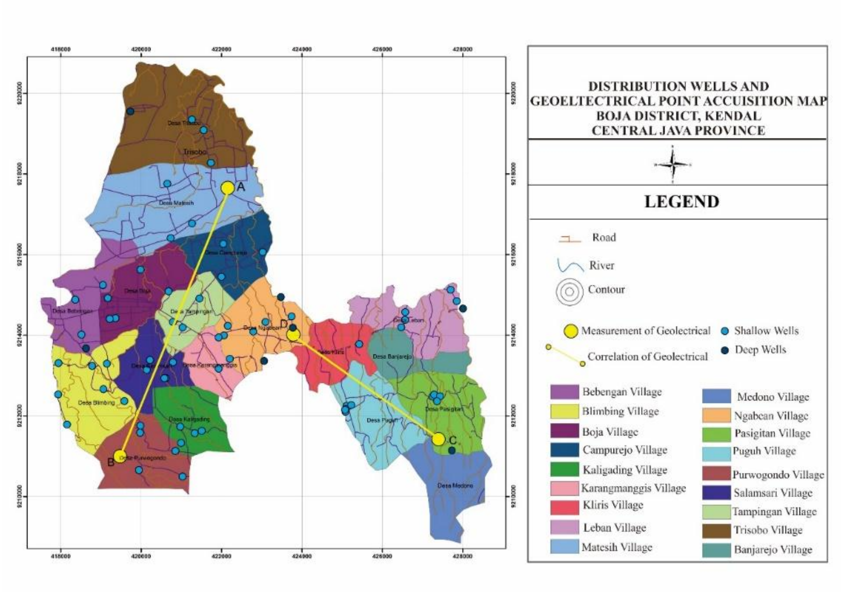

Figure 8 Map Distribution Wells And Geoelectric Acquisition Points

Based on the shallow well and deep well maps, it can be seen that the deep wells in these areas are located at several points of location, such as Trisobo, Babengan, Ngabean and Pasigitan where the map is marked with dark blue dots. Furthermore, superficial shallow deployments may be observed in almost all regions of the area. From the presence of shallow wells and deep wells it can be seen that shallow wells tend have higher groundwater values than in deep wells which tend to have lower groundwater values.

To know the subsurface condition of Boja area, geophysical survey was conducted using geoelectric method in four different regions. Retrieval of resistivity data was conducted in Medono area with a stretch of 400 m. Purwogondo with a stretch of 100 m, Ngabean with a stretch of 300 m, and Tulang Bawang with a stretch of 400 m. The rock resistivity data obtained were then analyzed and the determination of the rocks based on the Telford classification [6]. Here are the progress of the four lines:

A. The area of Medono

1. The first layer with a depth of 0 - 0.46 m thickness of 0.46 m resistivity 3764.01 ohm, is igneous rock.
2. The second layer with a depth of 0.46 - 1.04 m thickness of 0.58 m resistivity 15183.42 ohm, is igneous rock.
3. The third layer with a depth of 1.04 - 1.8 m thickness of 0.76 m resistivity 5104.66 ohm, is igneous rock.
4. The fourth layer with a depth of 1.8 - 4.37 m thickness of 2.57 m resistivity 7994.14 ohm, is igneous rock.
5. The fifth layer with a depth of 4.37 - 84.48 m thickness of 80.11 m resistivity 9148.78 ohm, is igneous rock.
6. The sixth layer of depth 84.48 - 85.20 m with a thickness of 0.72 m with resistivity 5738.63 ohm is igneous rock.
7. The seventh layer with a depth of 85.20 - 88.01 m thickness 2.81 m resistivity 2668.63 ohm, is igneous rock
8. Eighth layer with depth 88.01 - 106.68 m thickness 18.67 m resistivity 484.48 ohm, is tuff and lapilli rock.
9. The ninth layer with depth 106.8 - 142.10 m thickness 35.3 m resistivity 671.11 ohm, is igneous rock.
10. The tenth layer with a depth of 142.1 m thickness of unknown resistivity 1578.98 ohm, is igneous rock.

B. Purwogondo area

1. The first layer with a depth of 0 - 1.2 m thickness 1.2 mm resistivity 814.36 ohm, is igneous rock.
2. The second layer with a depth of 1.2 - 1.6 m thickness of 0.4 mm resistivity 2077.24 ohm, is igneous rock.
3. The third layer with depth 1.6 - 4.93 m thickness 3.63 m resistivity 699.12 ohm, is igneous rock.
4. The fourth layer with a depth of 4.93 - 38.94 m thickness 34.01 m resistivity 141.09 ohm, is tuffan-lapilli rock.
5. The fifth layer with depth 38.94 - 46.41 m thickness 7.47 m resistivity 79.66 ohm, is tuffan-lapilli rock.
6. The sixth layer of depth 46.41 with unknown thickness with 452.96 ohm resistivity is tuffan-lapilli.

C. Ngabean Region

1. The first layer with a depth of 0 - 3.21 m thickness of 3.21 m resistivity 52.31 ohm, is soil.
2. The second layer with a depth of 3.21 - 6.18 m thickness 2.97 m resistivity 139.73 ohm, is tuffan lapilli.
3. The third layer with a depth of 6.18 - 36.72 m thickness of 30.54 m resistivity 3.52 ohm, is softland soil or fresh water.

4. The fourth layer with a depth of 36.72 - 40.53 m thickness 3.81 m resistivity 100.92 ohm, is tuffan-lapilli rock.
5. The fifth layer with a depth of 40.53 - 41.37 m thickness 0.84 m resistivity 113.46 ohm, is igneous rock.
6. The sixth layer of depth 41.37 - 45.92 4.55 m thickness known with 33.96 ohm resistivity is tuffan-lapilli.
7. The sixth layer of depth 45.92 - 48.26 m thickness of 2.34 m with a resistivity of 176.67 ohms is tuffan-lapilli.
8. The sixth layer of depth 48.26 - 82.60 m thickness 34.34 m with 16.50 ohm resistivity is fresh water.
9. The sixth layer of depth 82.60 with unknown thickness with 178.68 ohm resistivity is tuffan - lapilli.

D. Metesih area

1. At the top layer there is a layer with a value of 8.74 ohm, interpreted is soil (soil). This land has a thickness of 1 m.
2. The second layer with a diversity of resistivity values with a range of values from 900 ohm -1900 ohms. As mentioned earlier, the rocks on the Bone Onion are volcanic rock deposits. Then this second layer is lava. The rock has a thickness of 15 m thick.
3. The third layer is a thin layer with a value of 80.16 ohms. The layer that has a thickness of one meter is a volcanic tuff.
4. The layers have a large resistivity value that is above 300 ohms. Because it is located at the foot of Mount Ungaran then the layers are layers of lava. The layers become one layer of the same layer of lava with a thickness of 62 m

The correlation results in (Figure 9) show that a thin tuff-lapilli layer in the Metesih line with a thickness of about 1 meter thicker towards the Purwogondo line up to 40 m. Layers of till lapilli are known to have good porosity and permeability because they are composed of relatively uniform material and have good sorting so that the tuff layer can role as an aquifer. Meanwhile, above layers tuff lapilli layer of volcanic breccia. Based on the arrangement of these rocks can be interpreted that the aquifer belongs to the type of unconfine aquifer. In addition to the correlation line Medono - Ngabean there is also a layer of tuff lapilli under the layer of volcanic breccia so it also belongs to the unconfine aquifer.

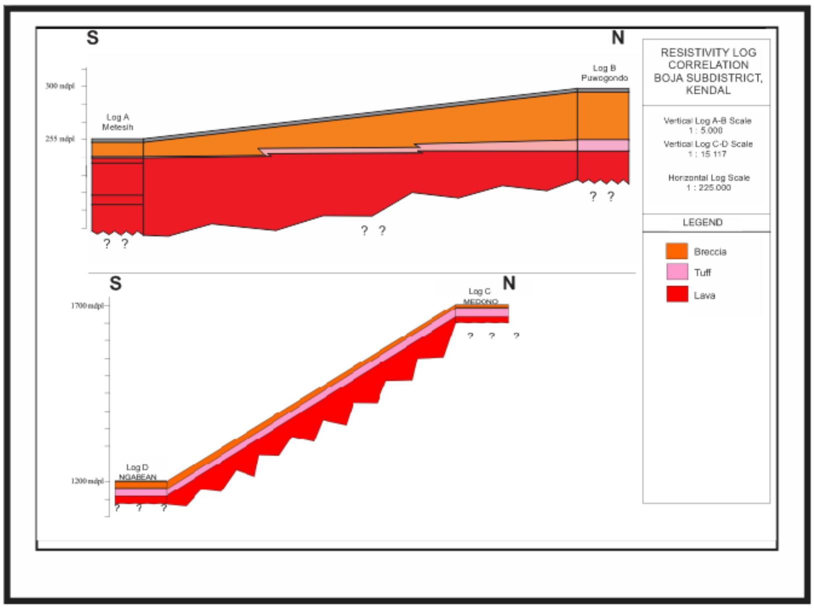

Figure 9 Correlation of Log Litology

The groundwater measurement results are used to create a soil flow map which can be seen in (Figure 10). On the ground flow map it is found that the direction of groundwater flow comes from the south toward the north. Based on the depth contour map of the Ground Water from the local soil surface, around the Boja area has a direction flowing from South to North visible in the contour part of the map and then from the Southwest to the Northeast. The more southerly the map of the groundwater depth is seen to increase as the elevation increases, while the center of the depth is not very varied but almost the same in the flat area, So it can be interpreted the direction of groundwater flow from the region that has the deepest elevation of Sayamsari spread The surrounding areas that have shallower groundwater elevations.

The direction of groundwater flow will go to the well of the pattern, seen from the ground water supplying the "V" river form where the groundwater level is higher than the surface water, the stream flow is called effluent where the source of the stream comes from the ground water.

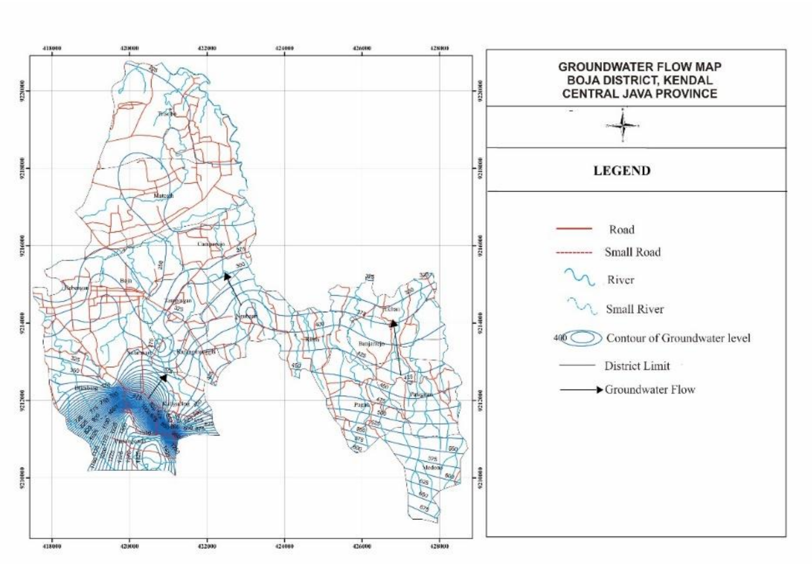

Figure 10 Groundwater Flow Map

Based on the observation of the surrounding lithology can be known some properties of rocks to the availability of groundwater which can be known in (Figure 11). Based on the availability of groundwater it can be seen that there are some elements of rock properties. In areas marked with blue is an item. This is a rock that has the ability to store water but only drain water in a limited amount. Areas with the potential of this territory are in the area Trisobo, Matesih, Boja, Campurejo, Tampingan, Karangmonggo, Kiris and some other areas. In addition, the area marked with a light blue color is an Iiklud which the layer is a rock that cannot drain water and the lithology around this area is andesite lava and andesite intrusion. Areas with Iiklud layer are located in Blimbing, Purwogendo, Medono. Potential aquifer marked with dark blue, which in this region consists of rock layers that have the ability to store and drain water. In this area can be seen that the lithology in the area with the potential of this aquifer consists of lapilli and tuff in some areas like Pasigitan Puguh and Banjarejo.

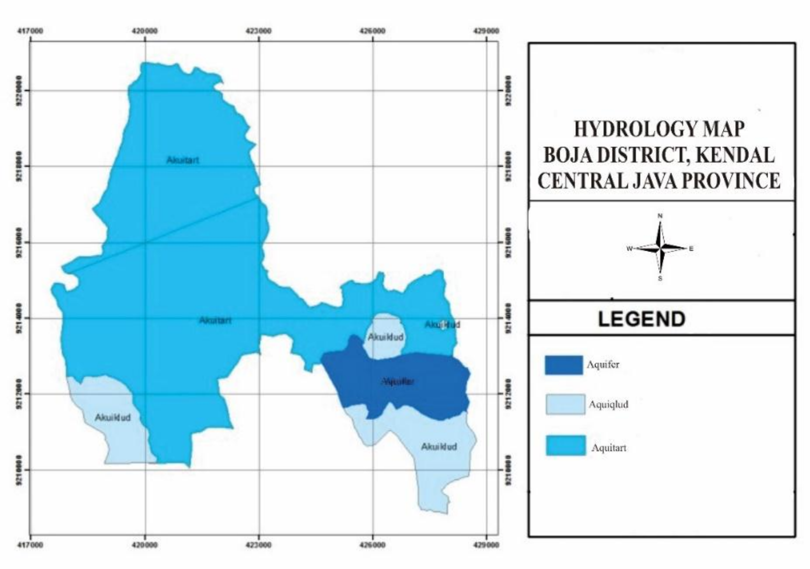

Figure 11 Hydrology Map

4.3 Flow Measurment

The river flow measurements were measured six times every six predetermined locations, the first river debit measurements were made at the time of hydrogeological mapping using floating method. Based on the data and the calculation result from the method resulted in the average of the discharge with five times the experiment reached 0.19644 m3/s.

4.4 Groundwater Quality

There were 73 points of interest obtained were 21 sample tests consisting of 17 samples from shallow wells and 4 samples from wells. Objects tested on groundwater samples are pH, DHL, hardness, TDS and turbidity. This groundwater content can be described as follows :

1. pH

Based on the results of laboratory testing on 21 samples pH values ranged between 5.71-7.27. Based on WHO water quality standards [11] and Permenkes [4] of 21 samples are generally eligible for consumption and used for daily purposes. There are 6 samples whose pH is quite far from the standard allowed. The dispersion of the pH content of the study area can be shown as (Figure 12).

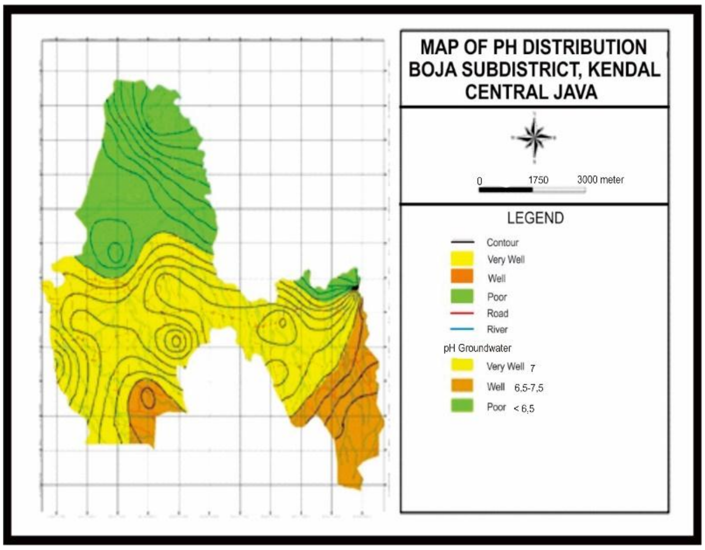

Figure 12 Water pH value range of Boja Regency

2. TDS

According to Bouwer [3] TDS is the content of ions containing minerals, as well as salts in certain volumes. Based on the result of laboratory analysis from 21 groundwater samples, it can be seen that TDS value in groundwater sample has 180 mg / L value. Based on WHO water quality standard [11] and Permenkes [4] from 21 samples generally meet Requirements for consumption and use for everyday purposes

3. Hardness

Hardness (total hardness), is the presence of Ca^{2+}, Mg^{2+} in water [5]. Based on the results of laboratory analysis of 21 groundwater samples, it can be seen that the value of hardness level in groundwater samples has values ranged between 0.8-74.1 mg/L Based on WHO water quality standards [11] and Permenkes [4] of 21 samples are generally eligible for consumption and used for daily purposes.

4. Turbidity

Turbidity usually shows the clarity level of soil samples from loose sedimentary materials both mineral and organic [1]. Based on the results of laboratory analysis from 21 groundwater samples, it can be seen that turbidity value in groundwater samples has values ranging from 0-19 NTU Based on WHO water quality standards [11] and Permenkes [4] of 21 samples are generally eligible for consumption and are used for everyday purpose.

5. Electric Conductivity (DHL)
Electrical Conductivity (DHL) is the conductive nature of electricity from water. Salt containing water will have a high DHL [5]. Based on the results of laboratory analysis of 21 groundwater samples it can be seen that DHL values in groundwater samples have values ranging between 80-419 μS / cm. Based on WHO water quality standards [11] and Permenkes [4] of 21 samples are generally eligible for consumption and used for daily purposes. The spread of the DHL research area can be shown as (Figure 13)

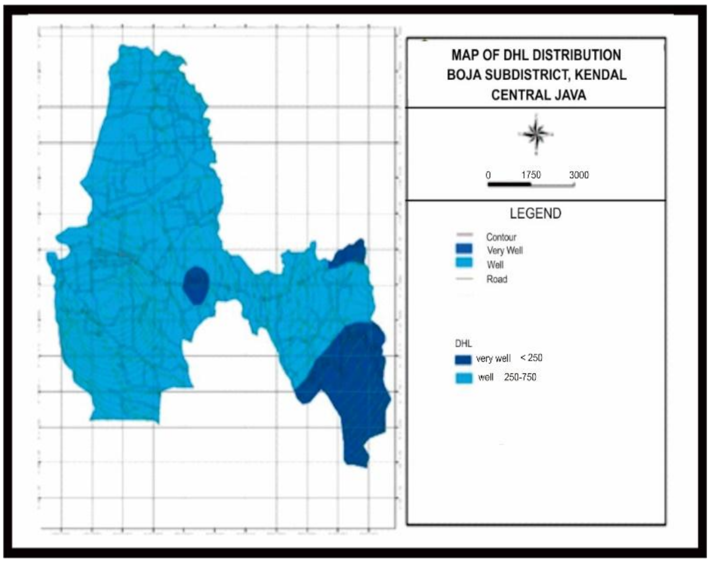

Figure 13 Map of DHL Water Distribution Value of Boja Regency

6. Groundwater Facies Analysis
Based on laboratorium analysis to groundwater samples, dominated element are magnesium and calcium. That's result processed by calculation in kurlov table and plot in piper diagram (Figure 14). Based on that's calculation showed facies groundwater in research area are facies calcium magnesium bicarbonate. Details result stiff diagram for all sample can be seen at (Figure 15).

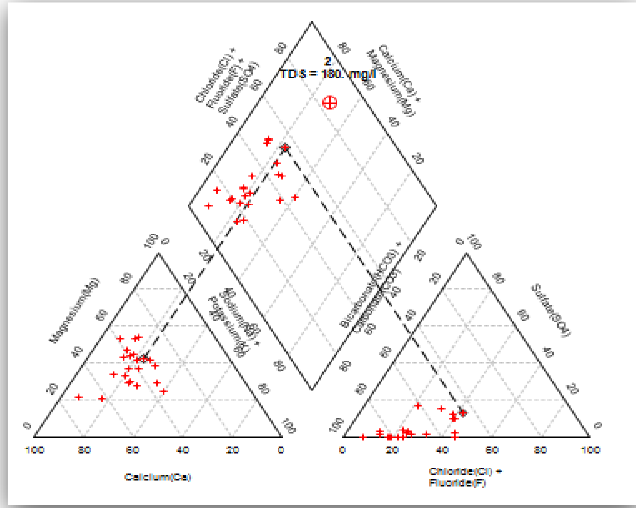

Figure 14 Piper Diagram Facies Groundwater in Research Area

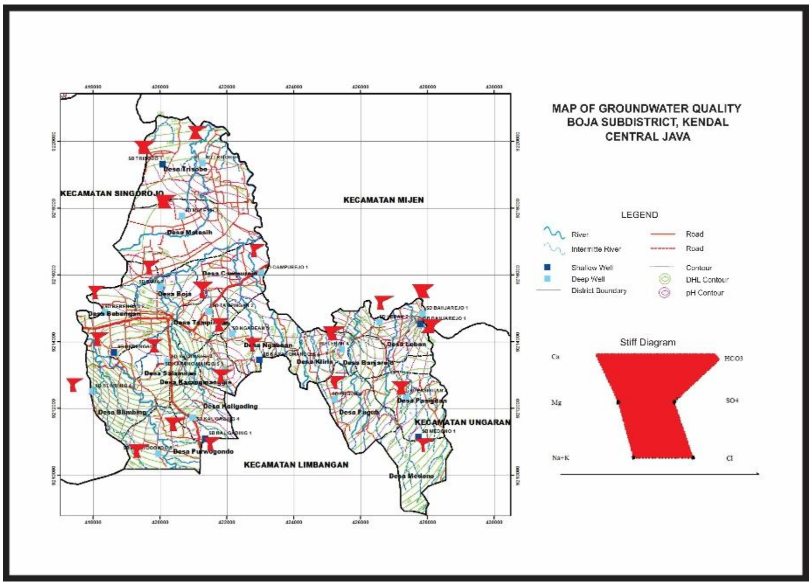

Figure 15 Quality Groundwater Map

5 Conclusion

1. Based on the geological mapping, it can be seen that the lithology found in Boja District are Tuff and Lapili as aquifer, alloclastic breccia and autoclastic breccia as aquitart as well as andesite intrusion and andesite lava as aquifug.

2. Based on the shallow well and deep well distribution maps, it can be seen that the deep wellness of the area is located at several points of location such as in the Trisobo, Babengan, Ngabean and Pasigitan areas. While the deployment of shallow wells is present in almost all areas.

3. Based on the depth contour map of the Ground Water from the local soil, around the Boja area has a direction flowing from South to North visible on the contours of the map and then from the Southwest to Northeast. The direction of groundwater flow will go to the pattern of the well, seen from the ground water supplying the "V" formed river where the groundwater level is higher than the surface water, the stream flow is called effluent where the source of the stream comes from the ground water. Based on the results of the correlation of geoelectric measurements shows that a thin tuff-lapilli layer in the Metesih line with a thickness of about 1 meter thicker towards the Purwogondo line up to 40 m.

4. Based on the results of groundwater sample processing using Kurlov table shows more dominating elements are magnesium and calcium. Based on calculations, groundwater facies can be known by plotting them into the Stiff Diagram. The plotting results show that groundwater in the study area is included in the Calcium Magnesium Bicarbonate facies. Based on the pH value, TDS, hardness, turbidity, DHL groundwater quality in the research area, most areas are eligible for consumption and used for daily purposes

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Hydrological Responses over the Upper Citarum Basin Based on the Spatial Plan of West Java Province 2029

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Abstract. In 2010, a spatial plan for West Java Province up to year 2029 was published (*Perda* 22/2010). The main purpose of this plan is the guidance of settlement area development. As the resulting change of land-use will most likely result in a change of the hydrological responses of the river basin, this study aimed to assess the hydrological implications of the Spatial Plan 2029 within the Upper Citarum Basin. To assess these implications, a hydrological simulation based on current and future land-use was performed using the JAMS/J2000 hydrological model. To investigate the baseline conditions, the land-use 2010 was used. Following, we extracted the settlement area from the spatial development plan in 2029 and then superimposed it to the land-use 2010. Expansion of settlement areas over UCB was projected two times higher for 2029 relative to 2010. Two different land-use scenarios (2010 and 2029), and similar climate scenario (1990-2030) were used for the hydrological simulation. From the simulation results, the mean monthly simulated river discharge increased by 1.8% in the 2029 scenario compared to the 2010. Greater changes were noticed in the surface runoff with monthly averages increasing by 8.9%, primarily because of the significant expansion of settlement areas. This application of the JAMS/J2000 proved to be an appropriate tool to assess the impacts of environmental changes to the basin's hydrological dynamics.

Keywords: *hydrological modelling; environmental impact analysis; land-use change; spatial planning.*

1 Introduction

Land-use change is one of the important human activity altering the hydrological cycle [1]. In global scale, association between climate change and land cover changes cannot be separated [2]. Combined effect of land cover and climate changes affect the hydrological regime. [2] concluded that climate change will have more influence the hydrological processes on a global scale, whilst on regional-scale (or smaller spatial scales), the impacts of land cover or land-use changes can be more important.

In Java Island, increases in population pressure has caused agricultural to expand and intensify [3]. Even further, more recent land use changes in the northern region of west Java (mostly the lowland area) caused the conversion into settlement and industrial area [4]. In 2010, a spatial development plan for West Java Province up to the year 2029 was published (*Peraturan Daerah Nomor* 22 *Tahun* 2010) [5]. The main purpose of this plan is the guidance of settlement area development. Therefore, it is important to explore how to identify the impacts of land use changes as a result of implementation of spatial plan on hydrological processes, which can provide information for water resource management and land-use planning.

Various researchers have studied to identify the impacts of land-use change on the hydrological response [6,7]. Based on [8], three major approaches can be implemented, such as paired experimental catchments, statistical method and hydrological modelling. Due to the paired catchment is expensive to conduct and lacks physical mechanism in the statistical method [7], makes hydrological model is useful for assessing the hydrological effects of environmental change in spatio-temporal detail [9]. Hydrological model provides a framework to conceptualize and investigate the relationships between climate, human activities and water resources [10,11,12]. In this study, hydrological model will be used to identify the impacts of spatial plan on hydrological responses.

2 Materials and Methods

2.1 River Basin Characteristics

The study area is situated in the Upper Citarum River basin (UCB), Java Island, Indonesia (Figure 1). This basin covers 1821 km^2, with the elevation ranges from 667 to 2589 m above sea level (m.a.s.l.). Several administrative districts are laid in the UCB. The Bandung Metropolitan Area are majority of administrative district in UCB. Bandung is the capital city of West Java Province, and the fourth large city in Indonesia. In term of climatological condition, the variations of rainfall in UCB relate to monsoon. In the southern hemisphere where is the western Java located, high rainfall occurs during west monsoon (wet season) and low rainfall during east monsoon (dry season) [13]. Wet seasons occurs from November to April. 70-80% of total annual precipitation happens during the wet season. The annual precipitation (mean air temperature) ranged between 1688 mm (18.3°C), and 2436 mm (31.8°C), with 2036 mm (21.4°C) average. Most areas of UCB are surrounded by volcanic mountain with 77.2% of total area and mostly located in high terrain position. Sedimentary structure is concentrated in the middle area of UCB.

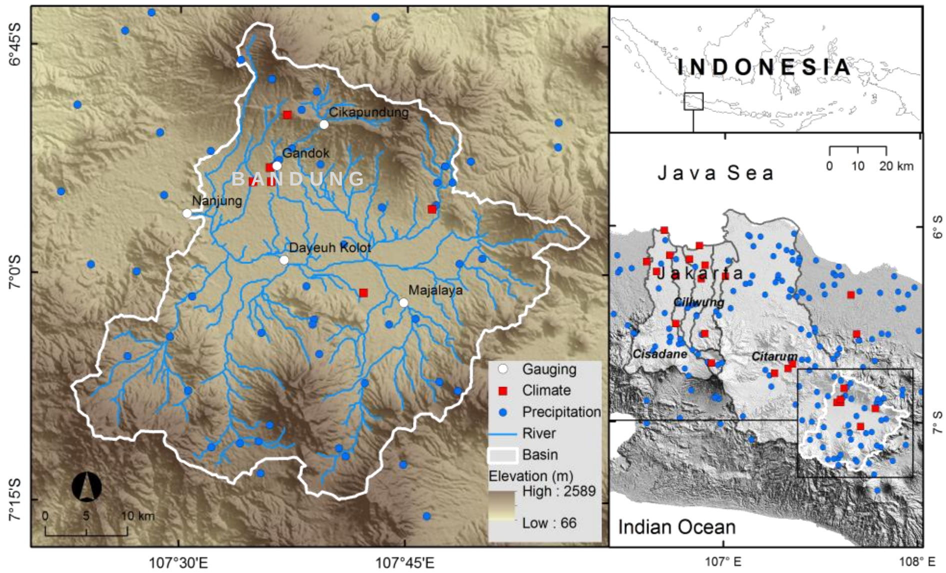

Figure 1 The upper Citarum River basin.

2.2 J2000 Hydrological Model

A fully physically-distributed hydrological model named J2000 [14] will be used in this study. The J2000 is executed in the Jena Adaptable Modelling System (JAMS) [15,16], which is a software framework for component based development and application of environmental models. The J2000 comprises modules (e.g. Interception, Infiltration etc.) and model parameters (e.g. *a_rain*, *MaxDPS* etc.) to represent the hydrological physical processes (Figure 2). The main inputs of the model are climatological data (e.g. precipitation, air temperature, humidity, wind speed, and solar radiation), a topographic data in Digital Elevation Model (DEM), land-use, soil and lithological condition. Representative of spatial distributed of topographic details, land-use, soil and geology is generated into Hydrological Response Units (HRUs), and used as model entities for J2000/JAMS.

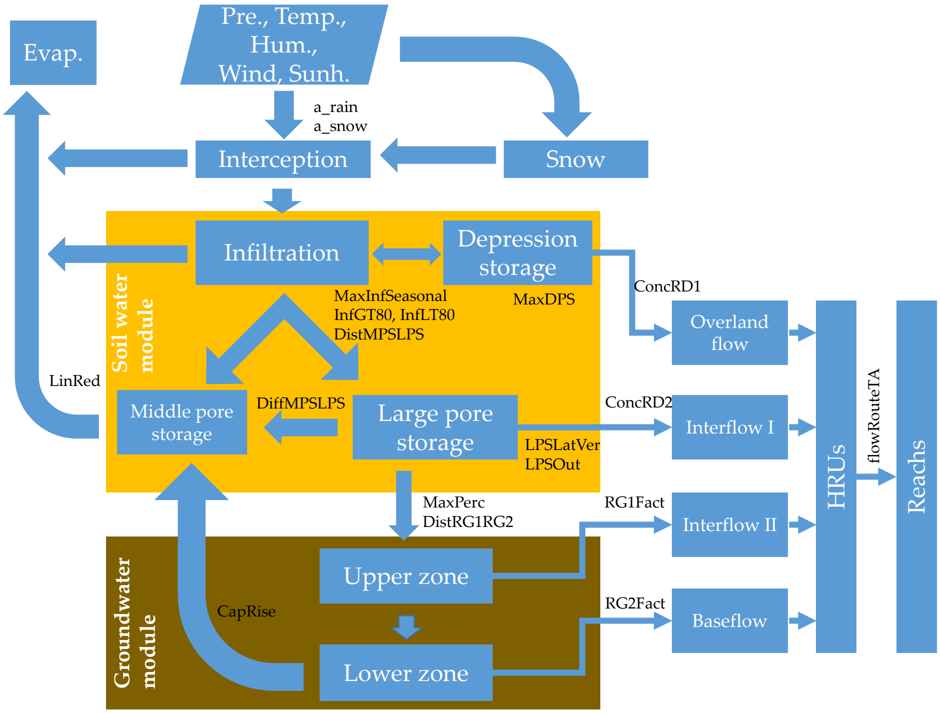

Figure 2 J2000 hydrological model conceptual (modified from [14]).

The J2000 simulates four runoff components originated from different sources. Surface runoff or overland flow (*RD*1) is produce by the runoff from paver or sealed areas; the excess of runoff from fully capacity of infiltrated soil (saturated soil) (infiltration-excess flow - Hortonian overland flow); the excess of water from high precipitation especially during the wet season. Interflow consists of slow direct runoff (Interflow I - *RD*2) and fast groundwater (Interflow II - *RG*1). *RD*2 is originated from the interflow from the unsaturated soil zone or lateral outflow from large pore storage of the soil. *RG*1 is formed by the inflow from the saturated weathering layer with high permeability. Baseflow (*RG*2) is come from the lower groundwater zone with long retention time.

The process begins with the capture of precipitation by plant canopy as an interception process. The interception module is calculated according to the [17], to estimate the maximum interception capacity depending on the leaf area index of the specific land-use. Soil water module consists of the infiltration and evapotranspiration processes, and two storages (middle pore storage - *MPS*, large pore storage - *LPS*). Maximum infiltration rate is calculated based on the soil water saturation or exceeding the maximum infiltration capacity. Excess water which is not able to infiltrate is transferred to the depression storage (DPS) If the DPS is exceeded the water becomes surface runoff depending on the local slope. Infiltrated water in *MPS* is reduced by evapotranspiration depending on *MPS* saturation. In this study, evapotranspiration is calculated according to the Penman-Monteith equation [18,19]. Water from *LPS* is distributed into interflow (lateral) and percolation (vertical) to recharge groundwater depending on the slope. Outflows from groundwater are calculated according to the retention coefficient and storage volume of the specific lithological condition.

2.3 Data Collection

Several data are used for an input of hydrological modelling. Climatic parameters (precipitation, air temperature, wind, humidity, and radiation) and geospatial data (topography, land-use, soil, and lithology) are required for hydrological modelling.

Observed climate data were retrieved from the Indonesian Meteorology, Climatology and Geophysics Agency (*Badan Meteorologi, Klimatologi, dan Geofisika* - BMKG) and *Dinas Pusat Sumber Daya Air Jawa Barat*. For future climate scenario, the global climate model output from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset [20] will be used. These data were downscaled as described by [21] using the bias-correction/spatial downscaling method [22] to a 0.5° × 0.5° grid, based on the 1950-1999 gridded observations of [23]. The data covers the period from 1950 to 2099. In this study, climate model named IPSL-CM4 (Institut Pierre-Simon Laplace, France) and UKMO-HadCM3 (Met Office Hadley Centre, United Kingdom) with A1B SRES (Special Report on Emissions Scenarios) were used. A1B means a balanced emphasis on all energy sources (fossil intensive and non-fossil energy sources) [24]. The A1 scenario family describes a future very rapid economic growth and global population. This A1 scenario might be suitable for the urban area development (e.g. Bandung Metropolitan Area).

Observed discharge was collected from the Water Research and Development Department, the Ministry of Public Works, Indonesia. Observed discharge in Nanjung station was used as investigation point-outlet of the UCB to calibrate and validate the hydrological model.

Soil information was retrieved from Indonesian Soil Research Institute with 1:250000 scale. The information of soil profile is available in soil depth and texture for different soil horizons. Soil information is required to estimate the volume of two soil storages (*LPS* and *MPS*).

Lithological data was collected from Indonesian Geological Department. The scale of the geological map is 1:250000. The parameterization of lithological formation is carried out to estimate the maximum storage capacity and retention coefficient of the upper and lower groundwater.

Topographic data as a digital elevation model (DEM) was obtained from the product of Shuttle Radar Topography Mission (SRTM) Version 4.1. SRTM has a 90-m spatial grid resolution and 16-m of vertical resolution at 90% confidence level [25]. The DEM was used to generate elevation, slope, aspect, and drainage network model.

Land use 2010 was collected from the Geospatial Information Agency of Indonesia (*Badan Informasi Geospasial*, Indonesia) with 1:50000 scale. Land use 2010 will be represented as a baseline scenario. In hydrological modelling, land-use information is parameterized into leaf area index data (*LAI*), albedo, surface resistance, the height of vegetation, and root depth. *LAI* is used to compute the rate of interception. Surface resistance, the height of vegetation, and root depth is required to estimate evapotranspiration in soil water process. Albedo is included for calculation of the radiation which is used for input of evaporation calculation.

2.4 Spatial Plan of West Java Province 2029

A spatial plan of West Java Province year 2029 was published in the Local Regulation Number 22 year 2010 (*Peraturan Daerah Nomor* 22 *Tahun* 2010) (Figure 3). The Spatial Plan 2029 has its purposes to maintain forest cover minimal 30% of the total catchment area, and a guidance for urban settlement area development. It is also employed for maintaining water catchment areas or hydrologically functioning areas to ensure the availability of water resources. The spatial plan has several land-use classes. However, the classification scheme is not similar with the current land use (year 2010) which we used for hydrological simulation in this study. The main classes in the spatial plan are divided into (i) protected zones (natural spaces, natural disaster area, water conservation zone, geological protection areas, protected forest), and (ii) cultivation areas (production forest, agriculture, rural and urban settlement). For this study, we only extracted the built-up area (rural and urban settlements) from the spatial plan 2029. Then, we superimposed the other classes from land use year 2010.

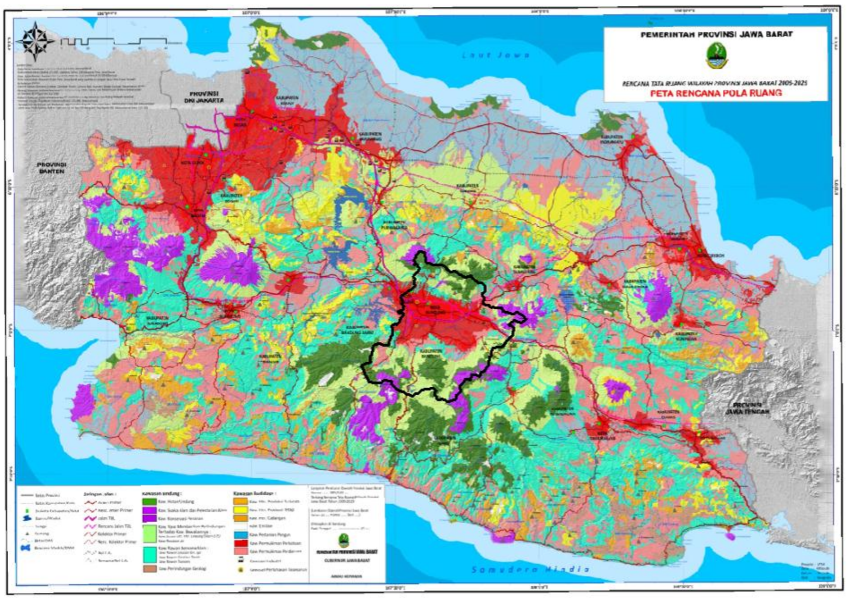

Figure 3 Spatial plan of West Java Province year 2029 in the Local Regulation Number 22 year 2010 (Peraturan Daerah Nomor 22 Tahun 2010). The Upper Citarum River basin (black-bold-line boundary)

2.5 Methodology

The J2000 hydrological model for the UCB was calibrated and validated using a split-sample approach [26]. Agreements between observed and simulated results were assessed using the Nash-Sutcliffe coefficient (E) [27], E with logarithmic values (ln E), and percentage of bias (P_{BIAS}). E is focused on the agreement of the peaks and high flows of the hydrograph. For the low flows condition, [28] suggested testing by ln E. Trend Analyzing for Time-series Data

Sen's method is used to estimate the trend (a change per time) in the time series data [29]. The significance of increasing or decreasing trends is tested by Mann-Kendall method.

The Mann-Kendall trend test [30,31] is one of the widely used non-parametric tests to detect significant trend in time series data. The Mann-Kendall test, as well as other non-parametric trend tests, is therefore more suitable for detecting trends in hydrological time series, which are usually skewed and may be contaminated with outlier [32]. The null hypothesis of no trend, H_0, i.e. the observations x_i are randomly ordered in time, against the alternative hypothesis, H_1, where there is an increasing or decreasing monotonic trend [33]. Analyzing the Impacts of Spatial Plan and Climate Changes

Implementation of hydrological simulation based on several scenarios were conducted. The scenarios were distinguished based on the different sets input of climate and land-use data. The scenarios consisted of:

i. Climate 1979-2009, land-use 2010
ii. Climate 1979-2009, Spatial Plan 2029
iii. Climate projection 2010-2030, land-use 2010
iv. Climate projection 2010-2030, Spatial Plan 2029

Comparison of the results from the scenario (i) and (ii) can analyze the individual impacts of spatial plan. The individual impacts of future climate projection can be obtained by comparing the results from the scenario (i) and (iii), which assumed the land use constant. Coupling implications of future climate and spatial plan will be assessed from the scenario (i) and (iv).

3 Results and Discussion

3.1 Data Exploratory

3.1.1 Climate

Before using the climate model as an input for hydrological modelling, the historical climate models were compared with observed ones (e.g. observed precipitation and temperature). Two main areas, in the upper and lower parts of Citarum Basin were investigated to compare the historical climate model and observed climate. Precipitation model in the upper and lower areas could replicate well the seasonal dynamics compared to the observation (Figure 4). Better agreement was noticed in the lower area with 8-12% annually bias (Table 1). In term of precipitation model, the IPSL model was better than HadCM3. Similar to the precipitation, temperature showed the better agreement in the lower area. Less variability of the elevations at the lower area will impact the good agreement of the climate model relative to the observed precipitation and temperature. The temperature bias of HadCM3 seemed lower than IPSL.

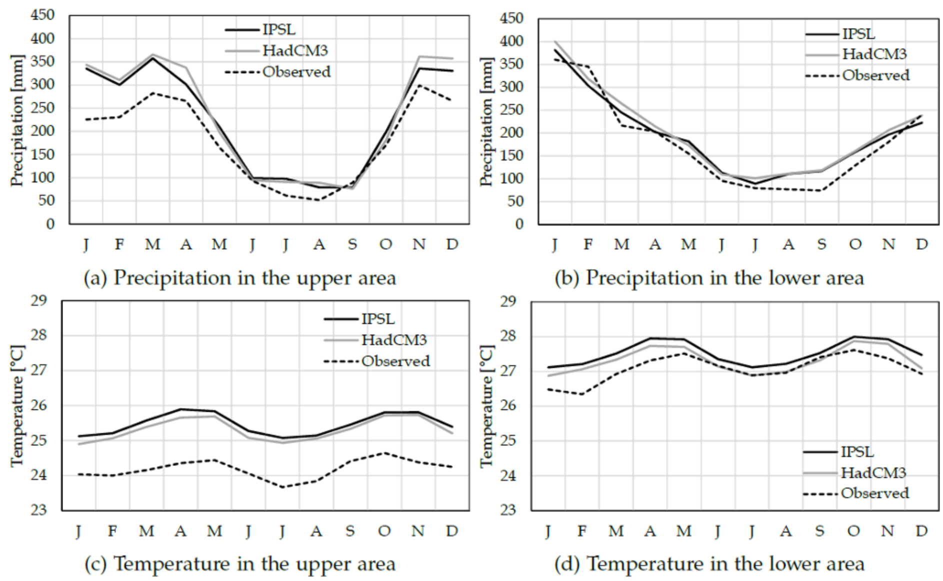

Figure 4 Comparison of model and observed precipitation and temperature in the upper and lower area

Table 1 Bias of historical climate models (IPSL and HadCM3) relative to the observed climate

			Climate model	
Parameters	**Area**	**Period**	**IPSL**	**HadCM3**
Precipitation	Lower	Annual	8%	12%
		Wet season	0%	6%
		Dry season	26%	27%
	Upper	Annual	24%	27%
		Wet season	25%	32%
		Dry season	21%	16%
Temperature	Lower	Annual	0.5°C	0.2°C
		Wet season	0.6°C	0.4°C
		Dry season	0.3°C	0.1°C
	Upper	Annual	1.3°C	1.1°C
		Wet season	1.3°C	1.1°C
		Dry season	1.3°C	1.1°C

Based on the good agreement of IPSL in precipitation model, then the IPSL climate model was applied for hydrological modelling. The future climate scenario was analyzed relative to the historical period from similar climate model over UCB. In term of mean monthly average, there was an increasing of mean monthly average temperature 0.36°C in the period of 2010-2030 relative to the period of 1990-2009 (Figure 5b). The precipitation increased 25% in the period of 2010-2030 relative to the period of 1990-2009 (Figure 5a). One should be noticed that the highest increasing of mean monthly was projected in December. It seemed that the beginning of wet season was projected to begin earlier in October.

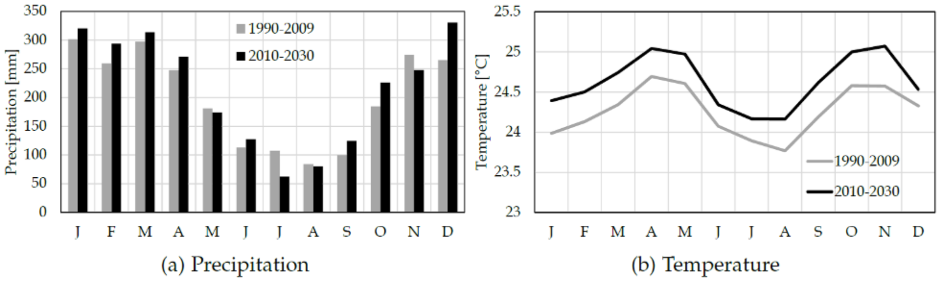

Figure 5 Comparison of mean monthly precipitation and temperature model for the period of 1990-2009 and 2010-2030 based on IPSL-CM4 over the Upper Citarum Basin

3.1.2 Land-use and Spatial Plan

In 2010, land-use of the UCB is dominated by rice with 27% (Table 2). Vegetation and horticulture crops were classified into agricultural area (16%). The tropical forests are covering about 14% in UCB. The built up-area is concentrated in the north-middle of the basin. The total of built-up area is 22%. We assumed the land use in 2010 as a baseline condition. Based on the spatial plan 2029 relative to the base condition (year 2010), the built-up area will plan to develop to 46% (33% urban, 8% rural settlements) of total UCB (Table 2 & Figure 6). The expansion of settlement areas will develop by buffering the surrounding of the current urban area (Bandung Metropolitan). The high decreasing was seen dominantly in rice class (-17%). In the West Java Province, the rice-field areas will move to the northern part outside the UCB. Forest cover area was maintained stable with 14% of the total UCB.

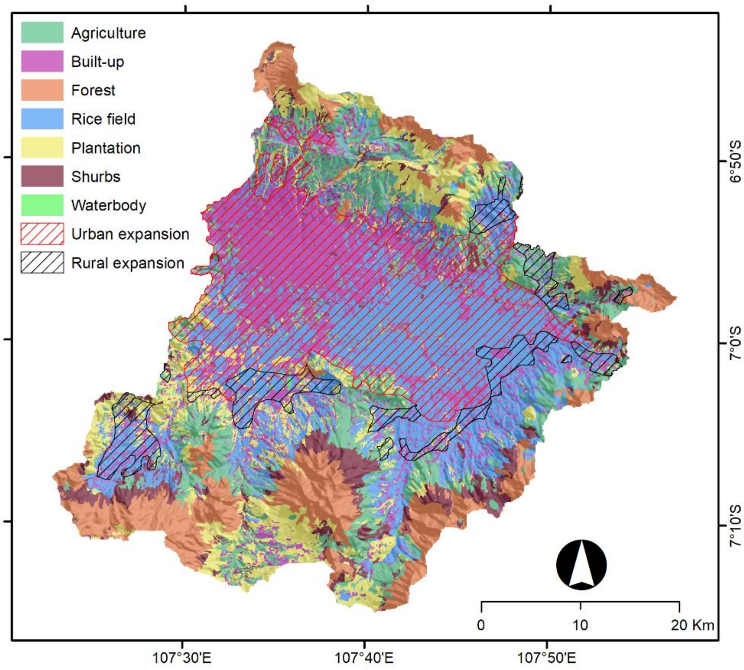

Figure 6 Expansion of built-up area (urban and rural settlements) based on the Spatial Plan 2029

Table 2 Area per class [in %] for land use 2010 and spatial plan 2029

Land-use class	Land use 2010	Spatial plan 2029
Agriculture	16	13
Built-up	22	46
Forest	14	14
Rice	27	9
Plantation	15	12
Shrubs	7	6

3.2 Calibration of J2000 Hydrological model

The J2000 model for the UCB was calibrated (validated) for the period of 2005 to 2009 (2001 to 2004). Observed runoff in Nanjung gauging station was used to compare the model output and the observed ones. For model calibration and validation, good objective functions were achieved: e.g. Nash-Sutcliffe efficiencies (E) by 0.79 and 0.76, ln E of 0.89 and 0.84, and a P_{BIAS} of -1.4% and -1.1%. It accommodated the seasonal dynamics during wet and dry seasons. The peak flows during wet season can be captured by the model (Figure 7). During the low flows month (July-September), the simulated discharges could catch the observed ones as shown by the large value of ln E.

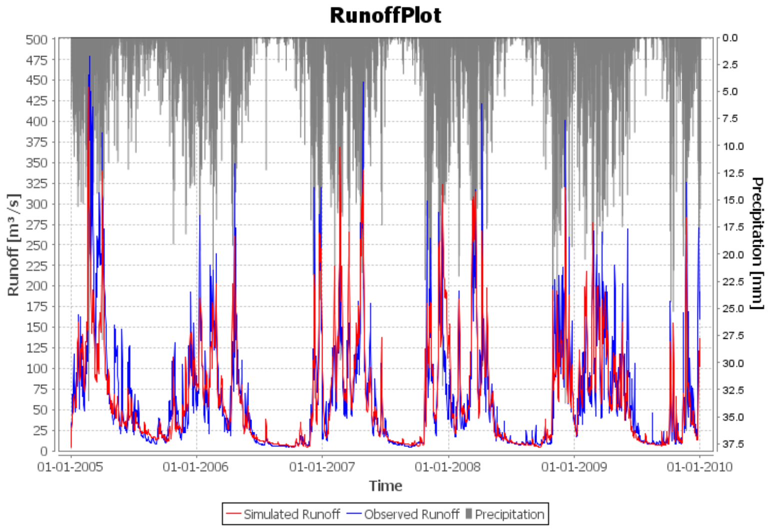

Figure 7 Calibration of J2000 hydrological model in UCB

The *MaxInfSeasonal* (maximum soil infiltration) in wet season was found as the most sensitive parameters to *E*. In UCB, the amount of precipitation during wet season was around 70-80% of total annual precipitation. High sensitive parameter was also noticed in *soilImGT80* (relative soil infiltration part on sealed urban area, with >80% sealing). This might be caused by 22% of sealed area (built-up) in the UCB.

3.3 Impact of Spatial Plan of West Java Province 2029 on Hydrological Dynamics

With similar climate dataset (1990-2030), two different land-use scenarios (2010 and Spatial Plan 2029) were used for hydrological simulation. The result showed that the mean monthly simulated discharge was increased 1.8% based on the Spatial Plan 2029 scenario compare to the baseline (year 2010) land use (Figure 8). For the seasonal analysis, 2.1% of discharge increased in wet season; whilst 1.1% in dry season. Mean monthly averaged simulated actual evapotranspiration (*AET*) changed by -2.1% (-5.1% in wet, 0.2% in dry season) based on the spatial plan scenario. The decrease in *AET* is caused by the expansion of the settlements. Because there are less plants that transpire water. This may also be the reason for the increase of *ET* in the dry season because the storages may last longer and were not already expired in the wet season. Large change was noticed in surface runoff (*RD*1) with monthly increasing average of 8.9%, and 8.7% (9.2%) in wet (dry) season. The greater increased of surface runoff, primarily because the significant expansion of built-up area. The precipitation excess on the ground will easily become surface runoff because the decreased infiltration caused by increasing of impervious surface. This result is linked with study of [34]. The study of [34] found that the surface runoff was the most sensitive variable effected by the impact of land-use change. [35] also reported that the impacts of built-up area expansion on hydrology associated with a more increase of high river discharge (wet season), than in low discharge (dry season) because the decreases infiltration caused by increasing of impervious surface.

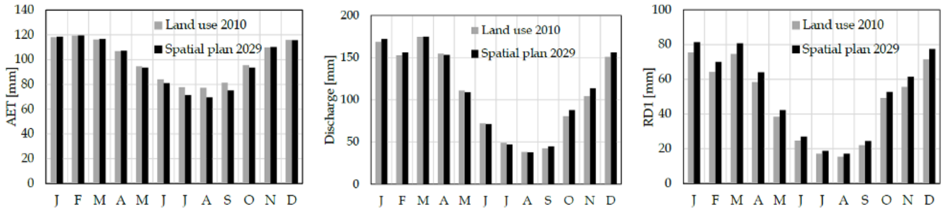

Figure 8 Spatial plan 2029 impacts on mean monthly simulated actual evaportranspiration (AET), discharge, and surface runoff (RD1) relative to land use 2010. Climate set IPSL-CM4 1990-2030

Trend testing was also evaluated to assess the long-term trend rate of the projected discharge outputs (Figure 9 & Table 3). Land-use scenario was assumed constant with the Spatial Plan 2029. For the all period (1990-2030), all trends showed the positive values for all model outputs (river discharge, actual evapotranspiration, and surface runoff) (see Table 3). The significant increasing trends (at $\alpha = 0.05$ (*)) were found during the wet season for all model outputs. The river discharge had also significant increasing trend in annual value. The trend rate for future period (2010-2030) seemed to be lower than the previous two decades (1990-2009).

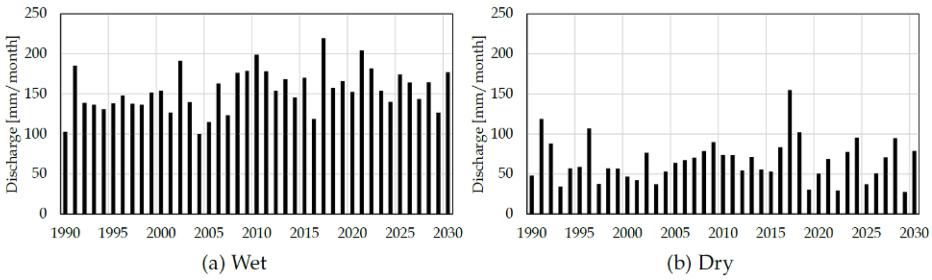

Figure 9 Annual simulated discharge in dry and wet seasons from 1990 to 2030 in the Upper Citarum Basin. Land use: Spatial plan 2029; climate model: IPSL-CM4

Table 3 Trend of selected model outputs in the Upper Citarum Basin. Land use assumed constant based on the Spatial Plan 2029 (* significance level α = 0.05)

[mm/year]	Period	1990-2030	1990-2009	2010-2030
Discharge	Annual	6.2*	9	-4.2
	Wet season	9.0*	15.7	-11.2
	Dry season	2.2	11.9	-3.7
Actual evapotranspiration	Annual	0.3	6.4	-1.8
	Wet season	0.9*	1.5	0
	Dry season	0.3	6.4	-1.8
Surface runoff	Annual	1.2	5.9	-2.2
	Wet season	4.2*	5.6	-4.6
	Dry season	1.2	5.9	-2.2

Coupling effects of projected climate (2010-2030) and spatial plan 2029 on simulated discharge was also evaluated (Figure 10 & Table 4). By implementing of spatial plan 2029 combined with future climate scenario, the projected discharge was increased by +14% relative to the assumed current state scenario (land-use 2010 + climate 1990-2009). The increasing was stronger during the wet season. The individual impact of future climate projection (2010-2030) will alter the seasonal pattern, more extreme during wet season (November-April), whilst lower in driest month (June-August) (see the dash line in Figure 10).

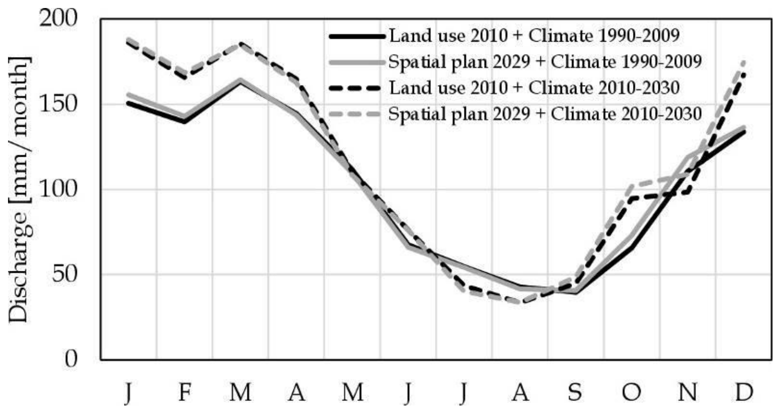

Figure 10 Comparison of mean monthly of simulated discharge based on land use 2010, spatial plan 2029, and future climate projection

Table 4 Mean monthly of simulated discharge based on land use 2010, Spatial Plan 2029, and future climate projection. The values in percentage represent the relative change to the scenario of Land-use 2010 + Climate 1990-2009

[in mm/month] [%]	Period	Climate 1990-2009	Climate 2010-2030
Land use 2010	Annual	102	114.2 [+12%]
	Wet season	140.3	161.2 [+15%]
	Dry season	63.6	67.2 [+6%]
Spatial Plan 2029	Annual	103.9 [+2%]	116.3 [+14%]
	Wet season	143.6 [+2%]	164.5 [+17%]
	Dry season	64.2 [+1%]	68.1 [+7%]

4 Conclusion

In this study, J2000 hydrological model was implemented to identify the impacts of the Spatial plan of West Java Province year 2029 on hydrological responses. Long-term trend of climatological dynamics was also investigated as an input for hydrological simulation. The changes of precipitation were more dominant in the changes of seasonal dynamics (wet season become wetter, dry season become drier) than the long-term trend (not significant trend). Land-use change because of spatial development plan implementation will enhance the seasonal changes due to climate changes on hydrological responses. The seasonal analysis showed a river discharge increase of 2.1% in the wet season and 1.1% in the dry season based on Spatial Plan 2029 relative to the current land-use scenario (year 2010). The greater impacts due to the spatial plan in UCB contributes dominantly to the change of surface runoff by 9.2% / 8.7% in the wet / dry season, mostly because of the significant reduction of infiltration due to the expansion of built-up area. Through this study, the hydrological model proved to be an appropriate tool to assess the impacts of environmental changes (e.g. land-use change and climate change) to the basin's hydrological dynamics, providing useful information for urban planning, environmental decision making and water resources management.

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The Role of Soil Pores In Generating Runoff In Steep-Slope Area Of Tropical Catchment

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Abstract. Soil pores may play roles in generating runoff in steep-slope tropical catchment. Because of these limitations of hydrological measurement techniques, the lack of study regarding the impact of rainfall and soil characteristics on runoff generation in tropical catchment as Indonesia represent a critical gap in the hydrology literature. This paper document the soil hydrology within the concept of the flow mechanisms, and the characteristics of soil such as soil hydraulic conductivity, humus on the surface, and the existence of root systems. We have found that in a situation that soil pores have been filled up, a continuation of rainfall of certain intensity may produce saturated areas and part of soil water may emerge to the surface as return flow together with the direct fall on the area. In addition, in most tropical area, macrospore of root systems exists in surface layer modifying rainfall to pipe flow that contributes stream flow quite instantly. On the basis of these findings, the study suggest that runoff generation occurs as a combination of surface and subsurface flow, with the subsurface flow is the predominant process on the upper and the middle slopes, while saturated overland flow is important processes at the bottom of the hillslope. The spatial variation of hydraulic conductivity decides flow generations, so that it can be analyzed through water dynamics in every layer in the area.

Keywords: *hydraulic conductivity, infiltration, overland flow, rainfall, return flow, runoff, steep-slope, subsurface flow, surface flow, tropical catchment.*

1 Introduction

Soil pores which are filled with air or water play significant role in storing and transporting water or nutrient. In total volume of surface soil, there is about 50% pore space and another 50% solid, mostly soil particles (45%), and organic matter (generally < 5%) (Blaskó, 2011). Soil pores exist between aggregates, with large size is macropores, play a major role in infiltration rates in many soils as well as preferential flow patterns, hydraulic conductivity and evapotranspiration. Micropores are small soil pores usually found within structural aggregates, with water within these pores is considered immobile, but available for plant extraction. The combination or arrangements of primary soil particle into aggregates establish soil structure.

Runoff in the form of infiltration or percolation flow through soil pores contributes a major source of discharge and non-point pollution in water bodies (Lang, 2013). The problem that often occurs in the determination the main mechanism of runoff generation is the interaction between the non-linear, complex, and dynamic factors such as climate, topography, nature of hydraulic soil, vegetation and land cover (Tarboton, 2003). At the same rainfall intensity, the runoff results are not always the same on a different steep-slope area. This is due to the characteristics of the soil greatly affecting the level of infiltration and saturation to rain water. So it is very difficult to determine the dominant mechanism for runoff formation in an environmental condition.

Numerous studies have been carried out in semi-arid catchments found that the main mechanism of runoff generation is Horton overland flow (Creutzfeldt, 2006; Mugabe et al., 2007). In 2012, the characteristic of runoff generation in the Upper Wei River basin was investigated, and the dominating runoff generation mechanism may change from the Hortonian or infiltration excess overland flow mechanism to the Dunne mechanism subsurface flow (Liu, 2012). For low-intensity events in semiarid areas, the main mechanism for runoff generation is the mixed model which combines saturated and Hortonian overland flow (Chamizo, 2012). The studies noted above were generally carried out on semi-arid catchment, and rarely on the tropical steep-slope catchment, where the rainfall-runoff data on a natural slope is very difficult to observe for the study of runoff generation. Tropical catchment usually have very pervious top layer constituted from humus and shallow root systems. This type of soil layer has large capability to store and transmit water therefore the mechanisms of runoff generation will be under the influence of the role of top soil layers. Concerns on tropical catchment have led to the development of concepts on runoff generation in relation to soil characteristics.

There have been many definitions on runoff generation. The eight main theory about runoff generation were defined, such as infiltration excess overland flow (Hortonian overland flow), partial area infiltration excess over land flow (partial contribution area), saturation excess overland flow, macrospore flow, subsurface stormflow, saturated wedge throughflow, groundwater ridging, and transmissivity feedback. However there are four major conceptualizations including infiltration excess in all or partial of hillslope, saturation excess or subsurface responses might all occur in the same catchment at different times or different place due to different antecedent conditions, soil characteristics or rainfall intensities (Beven, 2012). Lyon (2006) has shown the effect of misrepresenting the primary runoff mechanism in hillslope. That could wrong present concentrations, and fail to correctly locate critical source areas for implementation of best management practices. Thus, identification of the primary runoff mechanism is critical in selection of appropriate models in the mitigation of nonpoint source pollution. Correct representation of runoff processes is also critical in the future development of biogeochemical transport models, especially those that address nutrient fluxes.

2 Runoff generation in steep-sloped tropical catchment

The concept of runoff is formatted from three components, such as surface runoff (overland flow), subsurface runoff (interflow), and groundwater (base flow). All the runoff flows finally discharge to the stream or river so we can call runoff flow with the other name, stream flow. The generation of flows depicted in Figure 1 is described by taking account the soil characteristics and their role on temporary water table development.

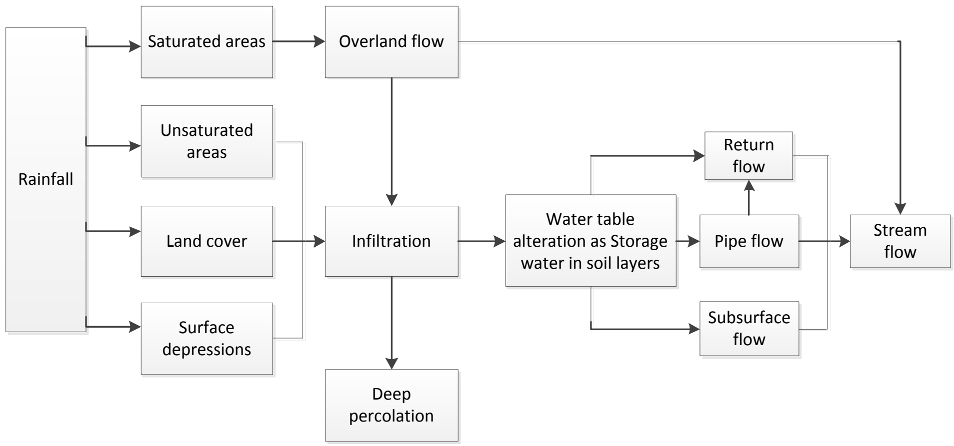


Figure 1 Stream flow generation.

Bonell and Bruijnzeel (2005) summarize the research activities concerning hydrology in the humid tropics with special regard to human activities. Their publication show that most investigations concerning runoff generation processes in tropical forests were carried out in South and Central America, Australia and South-East Asia. Most studies in the humid tropics revealed that lateral processes – mainly subsurface stormflow (interflow) – are predominant in tropical forest ecosystems (Giertz, 2006). Joseph Holden (2014) has found that infiltration – excess overland flow is more common in semi-arid regions where soil surface crusts have developed and rainfall rates can be rapid. It is also more likely in areas where the ground surface is often frozen. Soils with a deep litter layer, such as those within tropical rainforests, tend to have large infiltration capacities and so, despite high rainfall intensities, infiltration – excess overland flow is restricted. Only some parts of a river basin produce infiltration – excess overland flow at any given time and this is known as the partial contributing area concept (Betson, 1964). When the soil is saturated, the water table (highest point below which the soil or rock is saturated) is at the surface. Water can therefore leave the soil and run out over the surface, producing saturation-excess overland flow. Saturation excess overland flow is common in shallow soil or at the bottom of hillslopes, where water running through the soil will collect. In these zones the soil is kept saturated for longer, due to the delivery of water from a large upslope area and low gradient. Water can return to surface at this point after travelling within the soil, which is why it is sometimes referred to as “return flow”. Saturation-excess overland flow can occur long after it has stopped raining. If it is raining, then the additional rainwater will find it difficult to enter the soil if it is saturated and so saturation-excess overland flow can be mix of fresh rainwater and water that has been within the soil for some time.

Kirkby (1987) (cited in Bonell, 2005) identified the critical role of hydraulic conductivity in relation to rainfall intensity through the recognition of domains dominated by the combination of saturation-excess (saturation) overland flow and subsurface storm flow as against infiltration-excess, Hortonian overland flow (Figure 2).

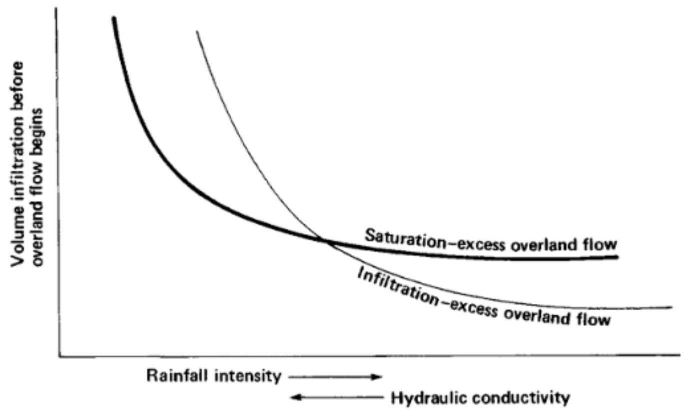


Figure 2 The relationship between the volume of rainfall which infiltrates before overland flow begins and rainfall intensity. Soil with low hydraulic conductivity will be dominated by infiltration-excess overland flow; those with high hydraulic conductivities by saturation-excess overland flow (After Kirkby, 1978)

Water moving through soil or rocks is called throughflow or interflow (subsurface flow). Giertz (2006) concluded in his study that interflow is the predominant process on the upper and the middle slopes, while saturated overland flow is important processes at the bottom of the hillslope.

3 The role of soil characteristics on runoff generation

3.1 Soil pores: Macrospores: root systems and earthworm activity

Water flows through two domains in soil: the soil matrix, consisting of both uniform saturated and unsaturated flow through fine pores, and preferential flow pathways, consisting of single or interconnected macropores (Ghestem, 2011). Macropores are defined as soil pores greater than 1.0 mm (Luxmoore, 1981), which conduct water near saturated conditions (Watson and Luxmoore, 1986). One way to classify macropores is to distinguish between biotic and nonbiotic macropores. Biotic macropores include root channels and animal burrows, whereas nonbiotic macropores are formed by freeze–thaw and wetting–drying cycles, the dissolution of soil materials, natural soil aggregation, and subsurface erosion (Aubertin, 1971). Giertz et al., 2005 shown the difference of soil physical properties (macroporosity) in their study mainly due to the different of land use. Meanwhile on savannah plots a mean density of 219 macropores/m^2 was observable, only 5, 8 or 60 macropores/m^2 exsisted on agricultural fields of cotton, yam, and maize, respectively. The surveyed macropore density varies between 45 and 700 m/2 depending on vegetation, climate, soil management, etc. (Ehlers, 1975; Trojan and Linden, 1998; Munyankusi et al., 1994; Zehe and Flu¨hler, 2001).

Macropores influence the infiltration of rainfall and therefore runoff and solute transport in natural soils, in which these structures are common (Larson, 1999). Infiltrating water flows rapidly in structural pore spaces such as worm channels, shrinking cracks, and root holes and can subsequently bypass portions of the soil profile (Weiler, 2003). The impact of macropores is governed primarily by the water supply to macropores, the water flow in macropores, and the water transfer from the macropores into the surrounding soil matrix (Beven and Germann, 1982; Faeh et al., 1997; Buttle and House, 1997). The causes and extent of preferential flow and particularly macropore flow, which is a subset of preferential flow, are poorly known (Flühler et al., 1996). The impact of the macroporosity on the infiltration process was shown by in-situ measurements of the saturated conductivity (Giertz et al., 2005). On agricultural fields the K_{sat} -value was two to five times (depending on soil type) lower than on savannah vegetation. Therefore for the surface runoff generation process, the land use is one of the most important factors.

Earthworm activity is a prime macropores generating factor in natural soils in many climatic regions (Weiler, 2003). Especially the anecic earthworm species Lumbricus terrestris generates vertically oriented, highly continuous channels (e.g.Langmaack et al., 1999). Different experimental studies have shown that the maximum flow rate in macropores that are built by anecic earthworm species lies within a narrow range of 1 – 7 cm^3s^-1 (Shipitalo and Gibbs, 2000).

3.2 Soil hydraulic conductivity

The runoff generation processes are mainly determined by soil properties and land cover (Giertz, 2006). Water can move through soil as saturated flow, unsaturated flow, or vapor flow. Saturated flow takes place when the soil pores are completely filled (or saturated) with water. Unsaturated flow occurs when the larger pores in the soil are filled with air, leaving only the smaller pores to hold and transmit water. Hydraulic conductivity is a soil property that describes the ease with which the soil pores permit water (not vapor) movement. In saturated soils, the hydraulic conductivity is represented as K_{sat}. In unsaturated soils, the hydraulic conductivity is represented as K. The soil hydraulic qualities depend on the type of soil, porosity, and the configuration of the soil pores (soil texture and structure). When soil is compacted, soil strength is increased and total porosity is reduced at the expense of the large pores. Thus, volumetric water content and field capacity are increased, while air content, water infiltration rate, and saturated hydraulic conductivity are decreased (Osman, 2013).

3.3 Humus on the surface

Humus create pores in the soil, thereby increasing a soil's ability to retain water. Vegetation increases soil hydraulic conductivity as root systems promotes hollows and littler of leafs crease humus. So that, vegetation and humus increase depression storage, and high infiltration rate indicates difficulties to achieve saturation condition. Spatial variability of humus layer thicknesses can have important impacts upon soil water dynamics, nutrient storage and availability, as well as plant growth (Bens et al., 2006).

Litter (dead leaves and branches on the soil's surface), animal dung, and dead remains of plants, animals, and microorganisms in various stages of decomposition constitute soil organic material. Microorganism, particularly bacterial and fungi, gradually decompose this material. During decomposition, essential nutrient mineral ions are released into the soil, where they may be bound to soil particles, absorbed by plant roots, or leached through the soil. Organic matter increases the soil's water-holding capacity by acting much like a sponge. For these reasons, gardeners often add organic matter to soils, especially sandy soil, which are naturally low in organic matter.

4 Soil characteristics of field experiment

Soil samplings were taken from the area with a slope that is assumed to be uniform (49%), and the size of 6 x 10 meters. The place is located in Institute

Technology Bandung campus, Jatinangor district. It is divided into three plots with different types of land cover as replication: plot with natural grass, plot with grass that has been cut and bare plot (without grass). For investigating the hydraulic conductivity of soil layers, we digged two holes at 10 cm and 20 cm of depth in each three part (upper, middle, and bottom part). Measurement of hydraulic conductivity and infiltration of soil in the field were calculated by using a constant head permeameter. In permeameter required hydraulic head constant in order to obtain discharge values of infiltration so that the value of hydraulic conductivity

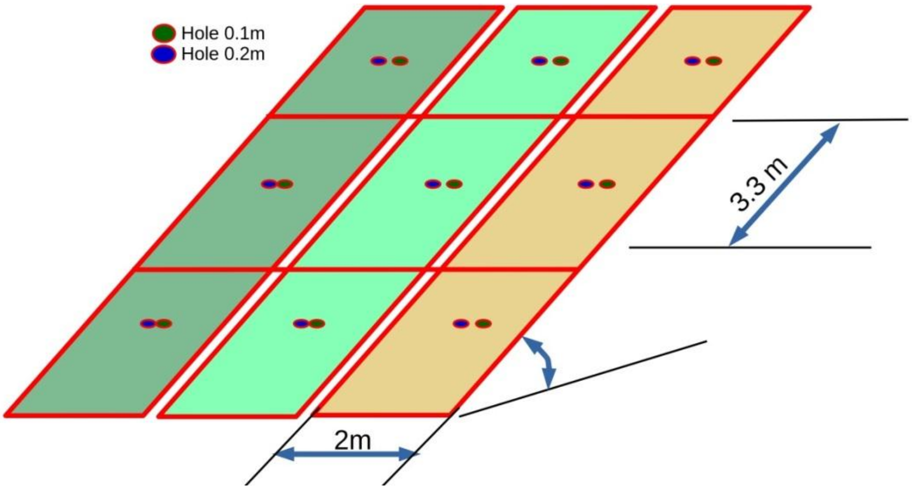


Figure 3 Position of soil hole for soil sampling in each plot

Other measurement of soil parameters such as bulk density, density, specific gravity, and texture carried out in accredited laboratories that referring to the ASTM standards (American Society for Testing and Materials International).

Initial experiment results and discussion is shown in these sub-chapter following

4.1 Hydraulic conductivity

Soil was assumed to be saturated before measuring hydraulic conductivity. For soil layer in the depth of 10-30 cm, hydraulic conductivity was measured by using constant head permeameter. There are three holes at 20 cm of depth, and two holes at 30 cm of depth were conducted. The decline of water was happened in all holes but very small. The hydraulic conductivity using infiltrometer can be dertermined at short time by using semi empirical equation proposed by Youngs (2001):

$$K = \frac{\rho g \eta R^4 (\Delta\theta)^2}{\sigma^2 t^2} \left[-0.365 + \sqrt{0.133 + \frac{I}{R^3 \Delta\theta}} \right]^4 \qquad (1)$$

Where I: the total volume of infiltration up to time t, R: the infiltration ring radius, Δθ: the change of the moisture content contain in the soil in the initial conditions and saturation, g is the acceleration of gravity, ρ, η, σ is the density, viscosity, and surface tension of water. If the unit used to express the value of K is in m/days, the value of ρgη/ σ2 = 0.0216 m^{-3} days to obtain K (m / day). These results are shown in the Table 1.

Table 1 K – results for different depth layer in the field

Depth	Hole 1		Hole 2		Hole 3	
	ΔH (m)	**K (m/day)**	**ΔH (m)**	**K (m/day)**	**ΔH (m)**	**K (m/day)**
0-10	0.02	0.00107963	-	-	-	-
10-20	0.001	0.001732982	0.0005	0.000866491	0.005	0.008665
20-30	0.0005	0.000866491	0.0005	0.000866491	-	-

From Table 1, it can be seen that hydraulic conductivity in the surface soil layer (depth of 0-10 cm) greater than two other layers (10-20 cm, and 20-30 cm). The value of the soil Ksat was very small, which was close to 0.

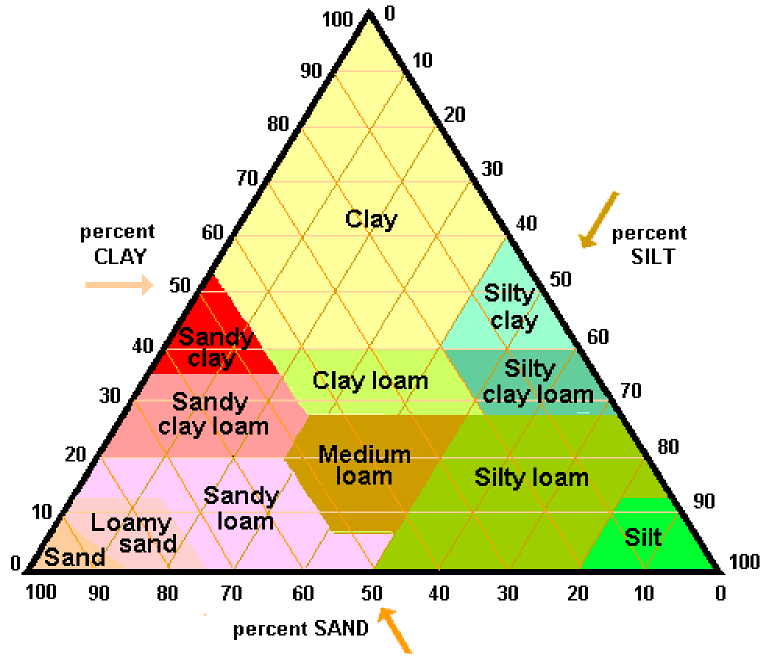
Table 2 Range of K-values by soil texture (Smedema and ycroft,1983)

Texture	Saturated hydraulic conductivity K (m/day)
Gravelly coarse sand	10-50
Medium sand	1-5
Sandy loam, fine sand	1-3
Loam, clay loam, clay (well structured)	0.5-2
Very fine sandy loam	0.2-0.5
Clay loam, clay (poorly structured	0.002-0.2
Dense Clay (no cracks, pores)	<0.002

Table 2 was the results from research on the relation between soil hydrolysis conductivity and soil texture proposed by Smedema and Rycroft (1983). Based on Table 2, the texture of surface soil layer in the study area is clay, because the value of K at saturation is less than 0.002 m/day . The soil tends to be neutral with pH values between 6.83 - 7.35

4.2 Soil texture and classification

Soil textures including the percentage of sand, clay, and silt that were determined in laboratory by using Sieve and Hydrometer method. Figure 4 shows the texture of three soil layers with the depth of each layer from 0-10 cm, 10-20 cm, and 20-30 cm. These layers have a high clay content ranging between 51-55%, the silt from 33-37%, and sand by 10%. So it can be seen by soil texture triangles that soil in the field is clay. Results from laboratory analysis showed the similarity result of soil texture with field method based on hydraulic conductivity obtained. We can conclude the namely of soil is dense clay.



Description: depth of soil layer a) 0-10 cm b) 10-20 cm c) 20-30 cm

Figure 4 Classification of soil research based on Soil texture triangle devised by the USDA (Source: USDA)

The texture of soil may affect the physical behavior of soil in general. In Table 3, it can be seen that the clay soil has low infiltration rate and high ability to hold water. In addition, the soil with small hydraulic conductivity that causes the low ability of water infiltration , and the vertical movement of water into the soil layer is very slow.

Table 3 Physical behavior of soil with different textures (Source: Osman 2013)

Texture	Infiltration	Capacity of hold water	Capacity of hold nutrient	Aeration	Workability	Leaching
Sand	Good	Low	Low	Good	Good	High
Silt	Medium	Medium	Medium	Medium	Medium	Medium
Loamy	Low	Good	Good	Low	Low	Low
Clay	Medium	Medium	Medium	Medium	Medium	Medium

4.3 Porosity

The results from laboratory showed that, the bulk density of soil was 2.58 g/cm3, particle density was 1.7 g/cm3, then soil porosity is 34.09 %. Osman (2013) suggests that the value of porosity value can be known from the weight content and particle density. The results of the analysis related to soil porosity have proved that the weight content is inversely proportional to the porosity of the soil. When compared with the Table 4, the estimated value of the total porosity in theoretically does not have much difference with the results of laboratory analysis.

Table 4 Relationship between weight content with soil porosity (Source: Osman, 2013)

Content weight (g cm^{-3})	Total porosity estimate (%)
1.20	55
1.30	51
1.40	47
1.50	43
1.60	39
1.70	35

In Table 5, the largest porosity of soil is 34.44% in layer depth of 0-10 cm among the three layers. The value is slightly larger than the soil at a depth of 10-20 cm (34.17%) and 20-30 cm (33.65%). This suggests that in a shallower soil layer, the soil surface has a larger pore volume than the underlying layer. However, the porosity value of the three soil layers are relatively lower compared to the porosity of clay soil in general which ranges from 40-70% (Osman, 2013).

Table 5 Comparison of different parameters soil physical research

Soil depth (cm)	Weight content (Bulk density g cm^{-3})	Specific gravity (Particle density g cm^{-3})	Porosity (%)
0-10	1.68	2.56	34.44
10-20	1.7	2.58	34.17
20-30	1.72	2.59	33.65
Average	1.7	2.58	34.09

5 Conclusions

Identifying the runoff generation mechanism and controlling factors is useful in the prediction of hydrological response. Therefore the studying about the mechanism of runoff generation under the effect of soil characteristics, such as hydraulic conductivity, the existence of root systems, and the moisture of surface soil were consider in this paper.

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Analysis of The Upper Citarum Watershed's Baseflow Use Filtered Smoothed Minima Method

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Abstract. Baseflow is component of streamflow originating from groundwater discharge and it takes important contributions for the streamflow during dry seasons or low precipitation. To knowing capacity of the Upper Citarum watershed to fulfill its hydrology function baseflow separation in this paper uses filtered smoothed minima method. Data that used is daily streamflow from Nanjung Station for 1918/19-1934/35 and 1976/77-2014/15. Annual baseflow value of Upper Citarum watershed is ranged between 16,6–53,6 m3/second for 1918/19-1934/35 period, and between 16,2–88,3 m3/second for 1976/77-2014/15 period. Spearman-Conley correlation test (α=5%) to annual baseflow in both periods shows there's no correlation and significantly trend. Kolmogorov-Smirnov test (α=5%) shows both periods have different distribution. Baseflow variability in Upper Citarum watershed is associated with climate variability and land use-land cover changes. Each of these factors has impact; with Indonesia wedged by Hindia and Pacific oceans, and building grows quickly in Upper Citarum watershed. Possibility of decreasing baseflow in Upper Citarum watershed could implicated drought in dry season and community that depend to that watershed. Then, water resource management and conservation need to improve watershed's quality, quantity, and continuity.

Keywords: *baseflow, climate variability, filtered smoothed minima method, land cover-land use changes, upper citarum watershed*

1 Introduction

Watershed is naturally able to maintain hydrological system properly. That is, the water that flowed able to meet the capacity quantitatively and qualitatively, and is also able to keep the flow fluctuations. However, human activities often disturb the balance of the environment, including watershed so that decrease its function.

In the discussion of the streamflow fluctuation, there are two components affecting streamflow condition that are surface runoff and baseflow. Baseflow is the components of streamflow originating from groundwater discharge and determines the streamflow volume during times of low precipitation [1].

Baseflow condition is influenced by infiltration of storm water to the aquifer. Groundwater contribution to the total streamflow can be known through baseflow value. Baseflow value can helps understanding the characteristics and capacity of the watershed, thus helps solutions and control to the hydrological functions.

Citarum watershed is one of eight critical watershed in West Java [2]. Critical condition of Citarum watershed indicates the declining of hydrological function. Poor condition at the lower course of Citarum watershed is the impact of damaged ecosystem, environmental contamination, and deforestation at its Upper course.

Research and assessment on hydrological functions at the Upper Citarum watershed is needed to establish proper solutions for critical condition of Citarum watershed. Calculation of baseflow helps identify and quantify the capacity of Upper Citarum watershed in completion of its hydrological function. After that, implication and factors affecting baseflow variability can be estimated to establish proper solution to improve quality, quantity, and continuity of water resources.

2 Methods

This research collects data of 56 years daily streamflow from Nanjung streamflow-gaging station to further calculate baseflow value. The data also gives initial descriptions about Upper Citarum watershed, such as area map, elevation map, and land use change map as supporting help in baseflow variability analysis.

Daily streamflow data is taken from streamflow hydrometry station in Nanjung on Upper Citarum. Data from Upper is chosen because condition on this area affects hydrograph condition on all along watershed. Observation periods is 56 years (1918-1935 and 1977-2015), with incomplete data for all of days in 1989. There is also incomplete data in some days of some years, but it can be settled with average data from other years at the exact same date.

Study about baseflow variability needs general condition data of observation area. The data consists of land use, morphology, geology, water resource infrastructures, and meteorology condition of the watershed. Those data have been taken from many sources and references, such as The Body of Citarum River Territory (BBWSC), The Research Center of Water Resource Directory, and some studies about The Upper Citarum.

2.1 Data Analysis

Daily streamflow data is calculated to obtain baseflow value to be tested later with Spearman-Conley correlation test. The output of data calculations is baseflow variability. The next step is analyzing general condition of observation area and maps related to the baseflow variability. Below is detailed explanation of data calculations:

2.1.1 Baseflow Separation

The method of baseflow separation in this research uses filtered smoothed minima refers to Aksoy et al. [3]. Generally, baseflow estimation is hydrograph separation to get *baseflow* value from proportion of baseflow contribution to the total streamflow. More specifically, baseflow separation is initiated with determination of turning points from 5-days non-overlapping streamflow data. The turning point is necessary to establish baseflow hydrograph. The followings are steps of determining baseflow value:

a. Divide the mean daily flow data into non-overlapping blocks of five days and calculate the minima for each of these blocks, and let them be called Q_1, Q_2, Q_3, …, Q_n
b. Consider in turn (Q_1, Q_2, Q_3), (Q_2, Q_3, Q_4), …, (Q_{n-1}, Q_n, Q_{n+1}). In each case, if 0,9 × central value (Q_n) < outer value (Q_{n-1} dan Q_{n+1}), then the central value is an ordinate for the baseflow line (QB). This procedure continues until all the data have been analysed to provide a derived set of baseflow ordinates QB_1, QB_2, QB_3, …, QB_n.
c. Estimate each day value of (QB_1, …, QB_n) by linear interpolation. If $QB_1 > Q_i$, then set $QB_1 = Qi$.
d. Calculate V_B, the volume beneath the recorded mean daily flows (QB_1) and last baseflow turning points (QB_n).
e. Calculate V_A, the volume beneath the recorded mean daily flows (Qi) for the period QB_1, …, QB_n.
f. The baseflow value is then calculate from **Equation 1**:

$$q_i = \frac{(1-BFI_{max})\alpha q_{i-1} + (1-\alpha)BFI_{max}QB_i}{1-\alpha BFI_{max}} \quad \textbf{(1)}$$

2.1.2 Outlier Detection

The detection of outliers contained in the annual baseflow value data series needs to be done to get more accurate results on the correlation test. Here are the steps for outlier detection method Box and Whisker plot can be done with SPSS (Statistical Package for the Social Science):

a. Determine Interquartile Range (IQR) value
   - Sort data based value;

- Determine the median (Q_2), which is the middle value of the data that has been sorted;
- Determine Q_1, the median worth of data is smaller than Q2;
- Determine Q_3, the median data value is greater than Q2.
- Calculating IQR from the difference between Q3 and Q1.

b. Drawing Box and Whisker Plot
   - Draw a box that connects Q_1, Q_2, and Q_3 as a representation of the quartile
   - Define the Upper limit or threshold value above the value Q_3 + 1.5 * IQR
   - Determining the lower limit or below the threshold value with the value Q_1-1,5 * IQR

c. Determine outliers, ie data with a value greater than the Upper threshold value or smaller than the threshold value below

2.1.3 Spearman-Conley Correlation Test

Spearman-Conley correlation test is non-parametric statistic method to test correlation of two consecutive value from a set of data [4], which in this paper is annual *baseflow* value. Followings are steps for Spearman-Conley Correlation Test:

a. State the hypotheses. For this test, the hypotheses are:
   H_0: The sequential value of *baseflow* are serially independent.
   H_1: Adjacent value of *baseflow* are serially correlated.
b. Set the second series of *baseflow* (x_t) by offsetting the actual series (y_{t-1}).
c. Identify the rank of each event in each series using a rank of 1 for the smallest value and successively larger ranks for events in increasing order.
d. Calculate Spearman coefficient (R_{sc}) using **Equation 2**,

$$R_{SC} = 1 - \frac{6\sum_{i=1}^{n}(x_i - y_i)^2}{n(n^2-1)} \tag{2}$$

e. Obtain the critical value of the test statisctic (α) which are Upper and lower tails, suggested α=5% for Spearman-Conley correlation test to obtain reliable result.
f. Make decision. For a one-tailed test, reject the null hypothesis if the computed R_{sc} is greater than the Upper and lower tails.

2.1.4 Kolmogorov-Smirnov Distribution Test

The Kolmogorov–Smirnov distribution test is used to test the null hypothesis that two independent samples are not different in distribution characteristics [4].

a. State hypothesis. For this test, the hypotheses are:
   H_0: daily baseflow in 1976/77-2014/15 is within 1918/19-1934/35
   H_1: daily baseflow in 1976/77-2014/15 is different with 1918/19-1934/35.
b. Make data range.
c. Determine data frequency ($f_1(x)$ dan $f_2(x)$) at both of data range.
d. Calculate cumulative frequency with adding current and previous frequency.
e. Determine cumulative probability ($P_1(x)$ dan $P_2(x)$) with dividing cumulative frequency and overall cumulative.
f. Calculate difference of cumulative probability between $P_1(x)$ dan $P_2(x)$.
g. Determine the maximum of that difference.
h. Calculate Random variable, χ^2, using **Equation 3**.

$$\chi^2 = 4D^2\left(\frac{n_1 n_2}{n_1+n_2}\right) \quad (3)$$

i. If χ^2 is bigger than χ^2_α, H_0 is rejected (H_1 is accepted).

Baseflow variability analysis is done qualitatively with many references about general condition at the observation area dan collected maps. Analysis starts with determining factors affecting baseflow contribution to the total runoff. Next, those factors are reviewed and compared with data from maps and general condition about Upper course of Citarum, and its correlation with baseflow variability from prior calculation. After that, implication and factors affecting baseflow variability can be estimated to establish proper solution.

3 Results and Discussion

Baseflow is the component of streamflow originating from groundwater discharge. Baseflow contributes to total river runoff during times of low precipitation or dry season. In the baseflow analysis daily data separated to three periods. First period is a base period, i.e. 1919 to 1935. The base period is used as a data comparison in which that period Upper Citarum watershed considered still in good condition, which is not much industries and houses. Then, the next period is the period of 1977 to 1996, and the period from 1997 to 2015. Years in this research is the hydrological year which referred to Naylor et al. [5].

All data streamflow in 1989 is not complete. The data is then filled with an average approach to improve the accuracy of the calculation. This is done because filtered smoothed minima method is very sensitive to the incompleteness of the data.

In the period 1918/19-1934/35, Upper Citarum's baseflow contributions ranged from 16.5 to 53.6 m^3/sec, with a minimum baseflow value in 1926 and a maximum in wet years in 1920. The period 1976/77-2014/15, Upper Citarum's baseflow contributions ranged from 16.2 to 88.2 m^3/sec, with a minimum baseflow value in 1980 and a maximum in wet years baseflow 2010. Separation results and comparison of streamflow can be seen in **Figure 1**.

In **Figure 1** looks baseflow and streamflow values from the period 1976/77-2014/15 (the analyzed period) even more volatile compared with the period 1918/19-1934/35. In fact, one of the values streamflow and baseflow in the period, i.e. in 2010 each value by 186.8 and 88.3, sticking-far greater than the value in the years surrounding that only ranged from 45.1 to 112, 2 (streamflow) and from 16.2 to 54.1 (baseflow). In the outlier analysis using box and whisker plot the results can be seen in **Figure 2** also shows that the greater range when compared to the base period.

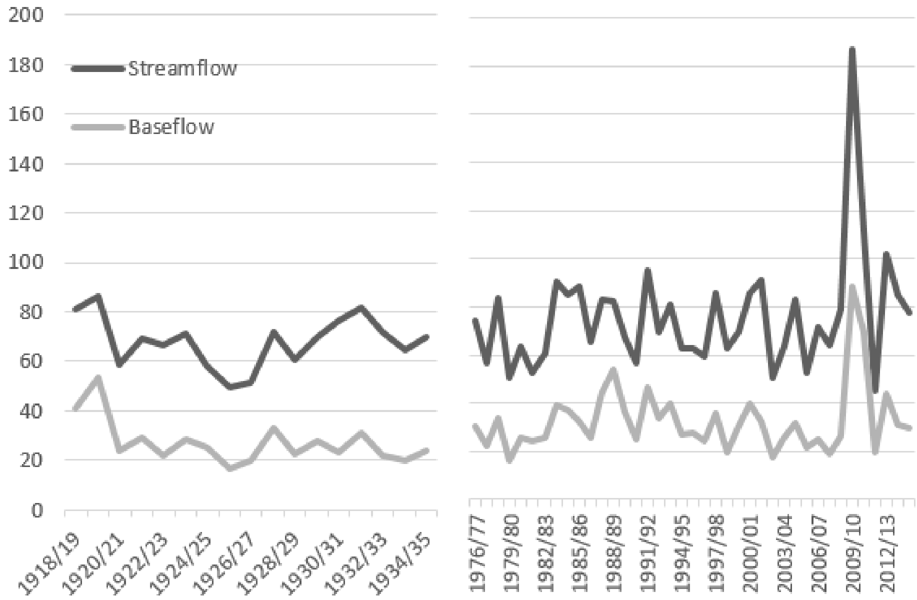

Figure 1 Graph comparison of annual streamflow and the Upper Citarum's baseflow in the period 1918/19-1934/35 and 1976/77-2014/2015

The detection of trends in the historical data can be done by separating the temporary outlier or data deviate much, in order to obtain more accurate results [4]. Therefore, the value of outlier detection performed on the data value of the annual baseflow Upper Citarum with Box and Whisker Plot method, with the following results.

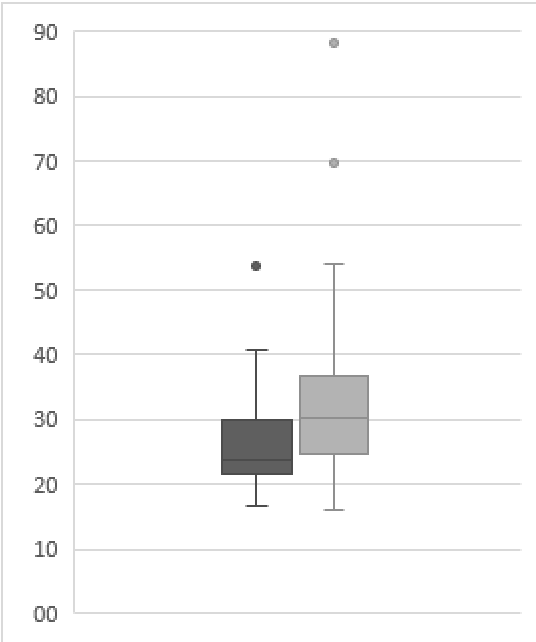

Figure 2 Box and Whisker Plot the Upper Citarum's baseflow 1918/19-1934/35 and 1976/77-2014/15

Box and Whisker Plot test to annual baseflow value Upper Citarum in **Figure 2** shows the value of the annual baseflow into data outliers, i.e. in 1918/19, 1919/20, 2009/10, and 2010/11. In the analysis box and whisker plot of the data is determined to be the normal range between lower threshold (Q1-1,5*IQR) and the upper threshold (Q3 + 1.5*IQR). The value appears as an outlier could be due to two things, namely an error of observation or data that is random variability [6]. Lower and upper threshold is obtained in base period for each by 11.1 and 39.4 so that appeared two outliers, the baseflow in 1918/19 is 40.8 and in 1919/20 is 53.6. Meanwhile, lower and upper threshold is obtained in analysis period for each by 7.1 and 54.4 so that appeared two outliers, i.e. baseflow in 2009/10 is 88.3 and in 2010/11 is 69.8. According to the records National Oceanic and Atmospheric Administration [7], in the years that indicate the presence of outlier values are indeed occur unusual climate phenomena, namely La Nina with a high level.

Then, Spearman-Conley test (α=5%) was conducted to determine trends and correlations on the value of the annual baseflow in both periods. Prior to testing, the value of which have previously been known outliers are removed from the population of the value to be tested in order to improve the accuracy of test results [4]. Level of significance using 5%. The amount of data for the base period of 16 units so that the lower and upper tail is respectively -0.479 and 0.350. Critical value (R_{SC}) for base period obtained at -0.029. Meanwhile, the amount of data for the analysis period is 30 units so that the lower and upper tail is respectively -0.335 and 0.267. Critical value (R_{SC}) of the analysis period amounted to 0.083. R_{SC} value of the second period is between the lower and upper tail. Therefore, the test results concluded in both periods that shows no correlation and trend. The absence indicating no significant changes in baseflow.

These results also show the effects of changes in land cover and land use does not have correlation with the baseflow variability that occurs [4]. The results can be received at a base period (1918/19-1934/35) given the changes in land cover and land use are still rare at that time. However, in recent decades, namely in the period 1976/77-2014/15, climate change and land cover-land use has been a lot going on [8] [9].

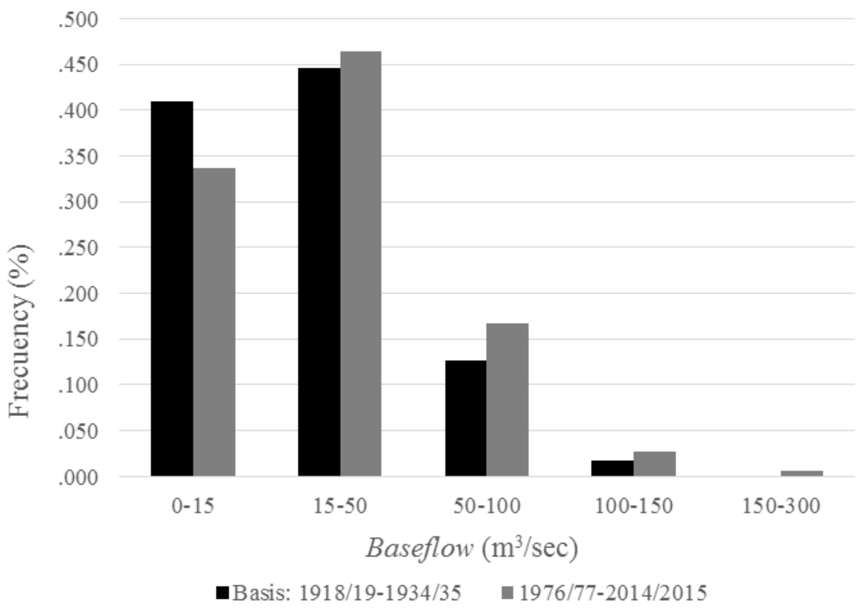

Figure 3 Comparison of the frequency of daily the Upper Citarum's baseflow in the period 1918/19-1934/35 and 1976/77-2014/15

Population baseflow value base period and the period of analysis and then try to see similar characteristics comparable distribution using the Kolmogorov-

Smirnov test (α = 5%). Chi-squared values ($\chi 2$) statistics obtained at 91.55 and $\chi 2$ for α = 5% amounting to 5.99. Because $\chi 2$ statistically greater compared with $\chi 2$, concluded that the two are different. In Figure 3 the value segment is the smallest visible base period has a higher frequency. However, the subsequent segments visible frequency keeps smaller base period. In fact, did not appear at all in the segment of the greatest value. This could be an explanation why not detected a significant change in the period of analysis.

Spearman correlation test results-Conley (α = 5%) showed data that is not correlated quite interesting. These results show the effects of changes in land cover and land use did not correlate with the variability baseflow [4]. However, in a larger scale not only cover and land use, there are several factors that actually influence the variability of river flows in maintaining hydrological functions, one of which is the natural factors such as climate variability [10]. The influence of climate variability strong enough to condition the flow of rivers in Indonesia, especially the Upper Citarum, given the position of Indonesia is flanked by two oceans, namely the Indian Ocean and the Pacific Ocean that has a direct relationship with the atmosphere above it. That is, these two factors have its own portion in influencing the Upper Citarum's baseflow variability.

Most of the Citarum's streamflow events that have a very high level is associated with La Nina phenomenon (see Table 1) [11]. Meanwhile, most of streamflow events that have extremely low levels found during a positive IOD (pIOD). This is in line with the results found in this study, the outlier values (outliers) baseflow that appear in the analysis period also occurred in the IOD and ENSO Grammar et al. (2011) found, namely in 2010 and 2011. However, not all of the value of baseflow in the IOD/ENSO into a value outlier.

In another study [12] shows that ENSO and IOD mutually reinforcing in influencing the climate that occurred in Indonesia. For example, the incidence of droughts in 1997/98 and 2006/07. In the both years were the result of the strengthening of the La Nina climate and positive IOD. However, ENSO and IOD could also weaken each other. In 2007/08 when weak positive IOD met with La Nina produce moderate precipitation across most of Indonesia.

The phenomenon La Nina / negative IOD causes the progress of time the wet season, so the duration of rain in West Java becomes longer. The duration of the wet season is longer, increasing the volume of rain that goes into aquifers and into the groundwater.

Table 1 Footage of the incident is very high and low streamflow along with climatic conditions in the same year

Extremely High-Streamflow		**Extremely Low-Streamflow**	
1974	(La Nina, nIOD)	1977	(pIOD)
1975	(La Nina, nIOD)	1982	(pIOD, El Nino)
1976	(La Nina, nIOD)	1982	(pIOD, El Nino)
1989	(La Nina, nIOD) [a]	1994	(pIOD, El Nino)
1998	(La Nina, nIOD)	1997	(pIOD, El Nino)
2000	(La Nina)	2006	(pIOD, El Nino)
2001	(La Nina)		
2001	(La Nina)		
2010	(La Nina, nIOD) [a]		
1992	(mEl Nino, nIOD)		
1986	(mEl Nino)		

In addition, other factors are anthropogenic factors. The Upper Citarum with high population density triggers rapid development in various sectors of the economy to settlements that have implications on deforestation. The forest area in the Upper Citarum decreased by 29.39% from 1983 in the amount of 45.59% of the total watershed area [13], became 16.20% in 2011 [14]. Changes in forest land use into the region woke up, it can be shut down and reduce the water catchment areas, and increasing the runoff coefficient. It has an impact on the increase in the volume of precipitation flow directly into rivers and reduce infiltration and percolation to enter the aquifer, so the baseflow contribution to the total flow of the river gets smaller and lower the value of the Upper Citarum's annual baseflow.

Other anthropogenic factors are expected to influence variability of the Upper Citarum's annual baseflow is the exploration of underground water. This relates to the water needs of the Upper Citarum continues to increase along with economic development and settlements are growing. Ground water exploration in the Upper Citarum to meet demand on water resources and support various human activities, such as household, industrial, and raw water taps, so that ongoing and difficult to control. The water needs of high net by industries operating in the Upper Citarum and public demand for clean water triggering the exploration, exploitation and even ground water, if the water needs cannot be fulfilled thoroughly by PDAM. Ground water exploration is done without consideration and in the long term, can lower the level of the Upper Citarum's ground water level and drought will impact on aquifers to land subsidence. Based on the consideration that the baseflow is dependent component of river flow with the groundwater, it can be estimated that the reduction in the level of the ground water level will impact on the baseflow contribution to the total river flow.

Variability can baseflow implications for the reduction in the quantity, quality, and continuity of water resources that could have an impact on various aspects of human life. Baseflow variability when in low conditions cause river flow at an outlet of the Upper Citarum during the dry season is getting smaller. Decreasing the Upper Citarum's flow can destabilize Saguling declining production during the dry season because it requires a large enough water resources to operate and drive the turbines. Instability of river discharge into Saguling can also cause damage to installations in Saguling.

In addition, a decrease in the quantity is also accompanied by a decrease in the quality of water resources. When the discharge stream, decrease the ability of the river to the thinning of the contaminant and the resulting concentration of pollutants in the river higher. Increased concentrations of pollutants can lead to decreased dissolved oxygen is needed in the decomposition of pollutants. The condition is exacerbated by domestic and industrial waste in the Upper Citarum entered the water bodies. Most domestic and agricultural wastes contain compounds derived from nutrients including detergents, human waste, agricultural waste and livestock waste. Compounds of nutrients, particularly phosphate (PO_3^-) and nitrate (NO_3), can lead to eutrophication and cause algal bloom. Uncontrolled growth of algae that can block the uptake of oxygen.

To avoid the extreme dryness of the river during the dry season and flooding during the rainy season, there should be efforts to conserving water resources. Based on the actual condition of the Upper Citarum with population growth and needs development, in the control of baseflow is often a clash between conservation and human interests. The condition is reducing the efficiency and effectiveness of the conservation of water resources.

Efforts are commonly done as measures of adaptation to climate anomalies is through a design discharge of floods and droughts. Mitigation is also done through policies regarding land conservation and water resources, as well as incentives for conservation practitioners and disincentive for those who pollute or action that is contrary to the conservation of water resources. The effort is aimed at reducing the rate of deforestation, forest land adds up to be able to exceed the minimum threshold is 30%, and reduced groundwater exploration in the Upper Citarum. The condition is caused by the need for high society to economic development and settlement, so as not to think of things related to environmental conservation.

Therefore, it is necessary among other alternative implementations Low Impact Development/Green Infrastructure (LID/GI). LID/GI is a regional planning approach with a simple technology to manage rainwater and maximize the absorption of water, to maintain the hydrological conditions. Implementation LID/GI may consist bioretention, recharge wells, buffer strips, rain harvesting and the use of permeable components as roads, sidewalks, or parking lots. Approach LID/GI can be implemented as environmental conservation efforts, without neglecting the needs of people and the development of water resources, it is estimated to be accepted by society.

Determining the right solution for controlling the Upper Citarum's baseflow requires further analysis associated risks, benefits, and possibilities of the various alternative solutions. Thus, solution implementation can take place with a serious and sustained, and can maintain a balance between the rapid development in the Upper Citarum and sustainability of water resources, both in terms of quality, quantity, or continuity.

4 Conclusion

According to data calculations and analysis, there are several conclusions:

- In the period 1918/19-1934/35 the Upper Citarum's annual baseflow ranged between 16.6 to 53.6 m^3/sec with the lowest annual baseflow in 1926 and the highest in 1920. The average of the Upper Citarum's annual baseflow 27.2 m^3/sec.

- Meanwhile, In the period 1976/77-2014/15 the Upper Citarum's annual baseflow ranged between 16.2 to 88.3 m^3/sec with the lowest annual baseflow in 1980 and the highest in 2010. The average of the Upper Citarum's annual baseflow is 32.7 m^3/sec.

- Detection of outlier values against the Upper Citarum's baseflow using box and whisker plot produces three outliers in the both period, that are the years 1918/19, 1919/20, 2009/10, and 2010/11.

- Spearman-Conley correlation test (α = 5%) of the annual baseflow in the second period showed no correlation and there is no significant trend.

- Kolmogorov-Smirnov test (α = 5%) of the annual baseflow in the second period also showed a different distribution between the two.

- Baseflow variability of the Upper Citarum is not able to be separated from the influence of climate variability and changes in land cover and land use.

Each of these factors has the same size of effect; Indonesia, which is flanked by the Indian Ocean and the Pacific Ocean the Upper Citarum sensitive to climatic influences, and with the rapid development in the Upper Citarum, making highly risk not able to maintain hydrological function.

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Inventory and Integrated Assessment of Rivers and Estuaries in Indonesia Case Study: Serayu River, Central Java

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Abstract. Proper Operation and Maintenance (O & M) activities are crucial to ensure that infrastructure will continue to function effectively and efficiently. Currently, due to lack of proper O & M, many facilities in Indonesia deteriorate significantly soon after they have been built and become non-functional before they reach their design life. In 2016, the Directorate General of Water Resources, Ministry of Public Works and Housing of Indonesia has launched a campaign to reactivate the O & M program to improve the sustainability of water resources in Indonesia. This campaign is known as “Gerakan Cinta Operasi dan Pemeliharaan Sumber Daya Air (CinOP SDA)”, which means the Movement for Love of Water Resources Operation and Maintenance. One of the programs is on River Maintenance and River Infrastructure O & M. A successful implementation of this program requires a thorough and actual information of river system and its infrastructures. This paper presents the necessary steps to conduct an inventory and assessment of a river system, which is carried out at the Serayu River in Central Java Province as an example. It is shown that the method is simple enough to be implemented to any river in Indonesia. The final products of this study are recommendations for the O & M activities and a database using GIS system of the Serayu River as an example. A manual for river inventory and assessment is also created, which can be readily applied to all Indonesian rivers and estuaries.

Keywords: *river; estuary; infrastructure; inventory; integrated assessment; sustainable; Serayu River; Operation and Maintenance; walkthrough; database.*

1 Introduction

Although currently the exact number of rivers in Indonesia is not available [1], it is safe to say that Indonesia has thousands of rivers which benefit its people tremendously as a source of food and drinking, household, and irrigation water. Many rivers are also used for transportation, recreation, and as a source of hydroelectric power and construction materials such as sand and gravel. On the other hand, rivers can bring disasters such as floods that can cause loss of property and even lives. The risk of flooding increases by population growth and unregulated use of rivers that can deteriorate their conditions and threaten their sustainability.

To maintain the sustainability of river system as well as to optimize the benefit and minimize the loss, the government has built some infrastructures on rivers such as dikes, weirs, and dams. Proper O & M activities are crucial to ensure that those infrastructures will continue to function effectively and efficiently. Meanwhile, the planning of O & M activities requires a thorough and actual information of river system and its infrastructures.

Until now, an integrated information on the condition of rivers in Indonesia has not been available. The existing data are not well-structured and difficult to access. Recognizing the importance of a detailed and actual river system information, the river and estuary data inventory throughout Indonesia needs to be completed immediately. What information needs to be inventoried, how to implement the procedures, i.e., what kind of necessary data assessment and analysis to be performed, and how the results are displayed, will be presented completely in the final product of this study by taking the Serayu River as an example.

Serayu River is located in Central Java Province (Figure 1). It spans from the northeast, with its source in the highlands of Mount Slamet in Dieng plateau, to the southwest and flows out to the Indian Ocean. The catchment area is about 4375 km^2 and the main river is about 180 km long with 11 tributaries [2].

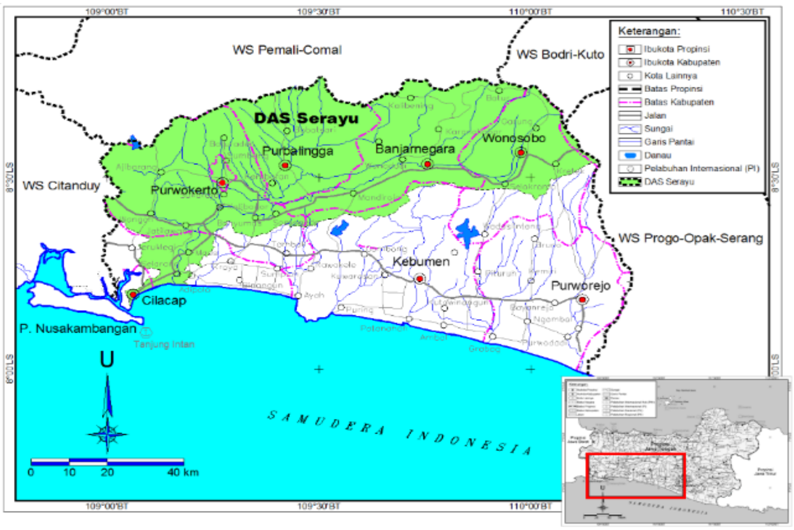

Figure 1 Map of the study location of Serayu River with its source in the highlands of Mount Slamet on Dieng plateau and empty out to Indian Ocean.

2 Purpose and Objectives

The purpose of this study is to implement inventory preparation procedures and subsequently to assess the condition of a river body and estuary system with the Serayu River taken as an example.

The objectives of this study are (1) to obtain technical data of the Serayu River system from its headwater to estuary, including its utilization, natural damages, and all of its infrastructures; (2) to identify and assess the condition of the Serayu River body system, its potential of disaster and development; (3) to provide recommendations for a sustainable management of the Serayu River in the present and future; and (4) to produce a manual of "Procedures for Inventory and Integrated Assessment of River and Estuary" that can be readily applied in Indonesia.

3 Method of Implementation

The method for inventory and integrated assessment of river and estuary implemented in this study is compiled based on (1) Technical Improvement Guidelines on Procedures of the Operation and Maintenance River and River Infrastructure [3], (2) Asset Management of River Infrastructure [4], (3) Circular Letter No. 05/SE/D/2016 on Guidelines for Operation and Maintenance of River Infrastructure and River Maintenance [5], and (4) Pilot Project of Inventory and Inspection of River Infrastructure for Analysis Study of Need Based Operation and Maintenance Cost at Serayu-Bogowonto River Basin [6]. The steps to carry out the inventory and assessment of river and estuary are as follows.

3.1 Secondary Data Collection

Secondary data collected are (1) map of the region; (2) data and information about existing river infrastructure; (3) data and information about monitoring post, heavy equipment, and other O & M support equipment.

3.2 River Walkthrough

River walkthrough is conducted by observing, taking notes, measuring, and documenting the physical condition and function of the river. If the depth and width of the river allow the boat to pass, then walkthrough is carried out through the waterway. Otherwise, walkthrough is carried out overland.

The expected result is to obtain a general description of the river, which includes: (1) Administrative regional boundaries from upstream to downstream; (2) Topographical conditions based on visual observation; (3) Land cover based on visual observation; (4) River utilization based on visual observations and interviews; (5) River basins based on visual observations; (6) Interviews; (7) Activities carried out adjacent to the river based on interviews; (8) Stakeholders related to the river; (9) Problems that often occur and expectations of community based on interviews; (10) Documentation in the form of photographs and videos by drone.

3.3 Inventory and Identification of River Infrastructure

Inventory and identification of river infrastructure are implemented by observing the physical condition of all infrastructure on the river together with the condition of their function.

Data of physical condition of each infrastructure include its dimension, condition of constituent material, condition of infrastructure body, and condition of infrastructure foundation. The condition of the infrastructure's function is presented in the form of a description of how well the infrastructure functions and the situation on the river adjacent to it. The inventory results are accompanied with photographs complete with notes and comments. Any damages found are also documented with photos. The description of the damages and the guideline for their locations are shown using sketches.

3.4 Performance Assessment of River and River Infrastructure

Infrastructure included in the performance assessment are [4]: (1) river dikes; (2) revetment: (3) jetty; (4) crib; (5) spillway; (6) flood gate; (7) flood pump; (8) rubber dam; (9) retention pond; (10) groundsill, sabo and check dam; (11) inspection road; (12) H3 monitoring station; (13) O&M office, laboratory, warehouse buildings, and guard house; (14) O&M heavy equipment and support vehicles; and (15) information and communication equipment. It is important to note that any infrastructure encountered during walkthrough (other than mentioned above) must also be inventoried.

Based on the actual field conditions, the river and its infrastructure are graded using certain criteria given in [6]. Table 1 to Table 6 show the criteria pertinent to the Serayu River. Subsequently, the performances of the river and each of its infrastructure are assessed using values given in Table 7 [4, 5] to determine their final performance grades.

Table 1 Assessment Criteria of Physical Condition for Natural River

No	Point	Physical Assessment Criteria
1	10	• River banks have been totally disturbed by humans so that no vegetation remains and human activities have dominated the waterline. • River environment is not maintained (it is not clean, it is not neat, buildings are placed haphazardly on the river).
2	25	• Most of the river banks are disturbed by human activities so that only a few vegetation remains and human activities have dominated the waterline. • Humans who use the river only maintain their own environment without regard to river conditions.
3	40	• A small part of the river bank is disturbed by human activity, but most of the river banks are still in good natural condition with indications of thriving native vegetation. • There is no non-organic trash in the river environment.
4	50	• River banks are still not disturbed with indication of thriving indigenous vegetation. • There is no non-organic trash in the river environment.

Table 2 Assessment Criteria of Function for Natural River

No	Point	Function Assessment Criteria
1	10	• The river surface is filled with water vegetation and/or trash, so the function of the river to drain the water becomes disturbed. • There is a landslide or plant on the river bank, so the ability of river to accommodate water is not optimal.
2	25	• The river surface is filled with water vegetation and/or trash, so the function of the river to drain the water becomes disturbed. • There is a small landslide or vegetation on the river bank, so the ability of river to accommodate water is not optimal.
3	40	• There are few water vegetation and/or trash, so the function of the river to drain the water becomes disturbed. • There are no landslides or vegetation on the river bank, so the river's ability to accommodate water is optimal.
4	50	• River surface clean from water vegetation and trash. • There are no landslides or vegetation on the river bank, so the river's ability to accommodate water is optimal.

Table 3 Assessment Criteria of Physical Condition for Movable Weir

No	Point	Physical Assessment Criteria
1	10	• There is a landslide on the movable weir. • The bridge floor is broken and collapsed.
2	25	• There are cracks at the crest and there are loose stones. • There are cracks, fractures, hollow part, and scouring at the tip of stilling basin. • The basic structure of the weir is eroded, hollow, and hanging. • The condition of the wing wall is cracked, broken, and there are loose stones. • The weir's gate is blocked, broken, cannot be closed/opened properly, the door handle is bent and the mechanism is damaged. • There is trash and landslides in the upstream river channel. • peilschaal is broken and unreadable.
3	40	• Crest conditions are not cracked or broken, and there are loose stones. • There is no hollow part and scouring on the stilling basin. • There are wild vegetation on the base of the structure and walls. • There is trash in the upstream river channel.
4	50	• The condition of the movable weir, consisting of the spillway crest, stilling basin, base of the structure, wing walls, gates, upstream river channel, and the peilschaal are not damaged and cracked, so the movable weir can operate optimally. • There is no trash and there is no landslides in the upstream river channel.

Table 4 Assessment Criteria of Function for Movable Weir

No	Point	Function Assessment Criteria
1	10	• There are landslides and collapsed structure, so its function to accommodate the flow of water and maintain the water surface elevation is not optimal.
2	50	• Infrastructure is in good condition, so its function to accommodate the flow of water and maintain the water surface height is optimal.

Table 5 Assessment Criteria of Physical Condition for Retention Pond

No	Point	Physical Assessment Criteria
1	10	• Erosion in the catchment area of the retention pond has increased. • Structure of existing retention pond collapsed, damaged, and destroyed.
2	25	• The inlet/outlet gate is blocked, broken, cannot be closed/open properly, the handlebars are bent, and the mechanism is damaged. • Crest of embankment around retention pond collapsed and leaked; slopes landslides and wild vegetation growth exist. • Embankment slopes have landslides, holes, and wild vegetation growth exists. • Retention pond full of sediment and of weeds. • Peilschaal is broken and unreadable.
3	40	• The inlet / outlet gate is not blocked, the gate is in good condition, can be closed/open properly, the handlebar is not bent, and the mechanism is in good condition. • Crest of embankment around retention pond are not collapsed and leaking, no slopes landslide, no wild vegetation growth. • Embankment slopes have no landslides and holes, but wild vegetation growth exist. • Peilschaal is readable and undamaged.
4	50	• The inlet/outlet gate is not blocked, in good condition, and can be closed/open properly, the handlebar is not bent, and the mechanism is in good condition. • No part of the crest of embankment around retention pond collapses or leaks, no slope landslides, and no wild vegetation growth. • No landslides, no holes, and no wild vegetation growth on embankment slopes. • Retention pond is clean from sedimentation. • Peilschaal is readable and undamaged.

Table 6 Assessment Criteria of Function for Retention Pond

No	Point	Function Assessment Criteria
1	10	• High sedimentation in retention pond; its construction has been disintegrated, so its function to store water is not optimal.
2	50	• The retention pond is in good condition, so its function to store water is optimal.

Table 7 Matrix of Physical Condition vs. Function for River and River Infrastructure

Assessment		Physical Condition: 50 Excellent	40 Good	25 Adequate	10 Poor
Function	10 Poor	60	50	35	20
	25 Adequate	75	65	50	35
	40 Good	90	80	65	50
	50 Excellent	100	90	75	60

> 70	Low Risk = Good Performance = Preventive Maintenance
50 – 70	Medium Risk = Adequate Performance = Corrective Maintenance
< 50	High Risk = Poor Performance = Rehabilitative

3.5 Follow-up Recommendations

The final objective of the performance assessment is the subsequent O & M follow-up plan, i.e., whether the river and its pertinent river infrastructure require a preventive (> 70), corrective (50-70), or rehabilitative (< 50) maintenance [3 - 5].

- Preventive maintenance is applied to river infrastructure that has a low risk of failure (> 70) or a good performance. This maintenance is a preventive measure with the following criteria.

    - Activities to maintain the infrastructure existence and in accordance with the level of performance of planned services.
    - Activities to be carried out continuously or scheduled periodically and do not require a design calculation.

- Corrective maintenance is applied to river infrastructure that has a moderate risk of failure (50-70) or an adequate performance. This maintenance is a corrective action with the following criteria.

- Activities to correct or refine ineffectiveness of performance.
- To make emergency repairs to deal with sudden infrastructure damage.

- Rehabilitative maintenance is applied to river infrastructure that has a high risk of failure (< 50) or a poor performance. This maintenance is a recovery act which include repairing and rebuilding activities.

4 Performance Assessment of Serayu River

In this study, a performance assessment is conducted on the Serayu River as an example. The main Serayu River is 176 km long and categorized as a natural river [4]. In this study it is divided into 3 (three) sections, i.e., upstream (48 km), middle (95 km), and downstream (33 km) sections.

The assessment results for the upstream, middle, and downstream sections of the river are shown in Figures 2, 3, and 4, respectively. The condition of the upstream section of the river (length of 48 km) is still very good (90) with no apparent effects from human activities. There are few locations of trash piles and sand mining in the middle section of the river (length of 95 km), but its overall condition is also good (80). The condition of the river decreases in the downstream section of the river (length of 33 km) with performance index of adequate (65). There are four locations of significant trash piles, and thirty locations of sand mining. Although sand mining activities have the benefit of maintaining river depth on those locations, but they also cause the river water to become murky. In addition, the loading and unloading activities have caused the destruction of the river bank. A regulation to control sand mining activities is needed to prevent more damages to the river.

There are six bridges, one movable weir, and one retention pond on the Serayu River. Bridges are not considered as river infrastructure, therefore they are inventoried only and are not assessed. The results of retention pond and movable weir performance assessment are shown in Table 8 and Table 9, respectively. Both the performance of retention pond and movable weir are good (90) and require only preventive maintenance.

1	River Name		:	Serayu
2	Location	a. Classification	:	Natural River
		b. Ordo	:	1
		c. River Basin	:	Serayu Bogowonto
		d. District	:	Cilacap, Banyumas, Purbalingga,
			:	Banjarnegara, and Wonosobo.
		e. Section	:	Upstream
		f. Length	:	48 km
3	River Condition			
		- Trash on the river bank	:	0 location
		- Sand Mining	:	0 location
		- Erosion of River Banks	:	0 location
4	Assessment of River Performance			
		- Physical Condition	:	40
		- Function	:	50
		- Total Performance Index	:	90
		- Performance Category	:	Good Performance - Low Risk
		- Assessment Background	:	Physical river : The river is in a good condition. There are no erosion and piles of trash.
				River function : The function of river to flow and hold water is very good.
		- Action Recommendation	:	(1) Maintain the river naturality. (2) Install a warning sign to prohibit dispose of trash in the river. (3) Ensuring business legality of sand mining.

Figure 2 Assessment result for upstream section of the Serayu River.

1	River Name		:	Serayu
2	Location	a. Classification	:	Natural River
		b. Ordo	:	1
		c. River Basin	:	Serayu Bogowonto
		d. District	:	Cilacap, Banyumas, Purbalingga,
			:	Banjarnegara, and Wonosobo.
		e. Section	:	Middle River
		f. Length	:	95 km
3	River Condition			
		- Trash on the river bank	:	1 location
		- Sand Mining	:	2 locations
		- Erosion of River Banks	:	11 locations
4	Assessment of River Performance			
		- Physical Condition	:	40
		- Function	:	40
		- Total Performance Index	:	80
		- Performance Category	:	Good Performance - Low Risk
		- Assessment Background	:	Physical river : The river is in a good condition. There are no erosion and piles of trash.
				River function : The function of river to flow and hold water is good.
		- Action Recommendation	:	(1) Maintain the river naturality. (2) Install a warning sign to prohibit dispose of trash in the river. (3) Ensuring business legality of sand mining.

Figure 3 Assessment result for middle section of the Serayu River.

1	River Name		:	Serayu
2	Location	a. Classification	:	Natural River
		b. Ordo	:	1
		c. River Area	:	Serayu Bogowonto
		d. District	:	Cilacap, Banyumas, Purbalingga,
			:	Banjarnegara, and Wonosobo.
		e. Section	:	Downstream River/Estuary
		f. Length	:	33 km
3	River Condition			
		- Trash on the river bank	:	4 locations
		- Sand Mining	:	30 locations
		- Erosion of River Banks	:	4 locations
4	Assessment of River Performance			
		- Physical Condition	:	25
		- Function	:	40
		- Total Performance Index	:	65
		- Performance Category	:	Adequate Performance - Medium Risk
		- Assessment Background	:	Physical river : There are sand mining activities that cause the river to be murky.
				River function : The function of river to flow and hold water is good. Sand mining activities actually have benefits for maintaining river depth, which means maintaining its function to flow and hold water.
		- Action Recommendation	:	(1) Install a warning sign to prohibit dispose of trash in the river. (2) Ensuring business legality of sand mining. (3) Write letters to the local government regarding business legality issues and loading and unloading activities that cause the destruction of the river bank. (4) Regular clean up of trash on the river bank. (5) Organize community involvement on river O&M activities.

Figure 4 Assessment result for downstream section of the Serayu River.

Table 8 Results of Movable Weir Performance

Assessment Component	Point (10 – 50)	Reasons
1. Top	40	Top is not cracked, broken, and there are loose stones.
2. Body	40	There is no hollow part and scouring on the stilling basin.
3. Foundation	40	There are wild vegetation on the base and walls.
4. Material	40	The material condition is overgrown with wild vegetation.
Value of physical condition *(Average component No.1 – No.4)*	40	Good

	Point (10 – 50)	Reasons
Function Condition Value	50	Infrastructure is still in good condition, so its function to accommodate the flow of water and maintain the water surface elevation is optimal.

Infrastructure	Movable Weir
Total Point	90
Risk of Failure	Low Risk
Performance of O & M	Good Performance
Action Plan for O & M	Preventive Maintenance


Table 9 Results of Retention Pond Performance

Assessment Component	Point (10 – 50)	Reasons
1. Top	40	Top of dam around the retention pond is in a good condition, slopes do not slide, no grass but wild bushes growth exists.
2. Body	40	The embankment slope does not slide, no holes, no grass but wild bushes growth exists.
3. Foundation	40	There are wild vegetation growths exist on the base and structure walls.
4. Material	40	Material of the retention pond is covered by overgrown wild vegetation and the structure is not damaged or collapsed.
Value of physical condition *(Average component No.1 – No.4)*	40	Good

Function Condition	Point (10 – 50)	Reasons
	50	Retention pond is covered with wild vegetation, but the reservoir is in good condition, so its function to store water is optimal.

Infrastructure	Retention Pond
Total Point	90
Risk of Failure	Low Risk
Performance of O & M	Good Performance
Action Plan for O & M	Preventive Maintenance

All of the inventory data and assessment results are displayed using a GIS system, which include documentations, maps, and performance assessment results. This GIS system for the three river sections of the Serayu River will be updated regularly as a record keeping of the data. The display of the GIS system for the Serayu River is shown in Figure 5.

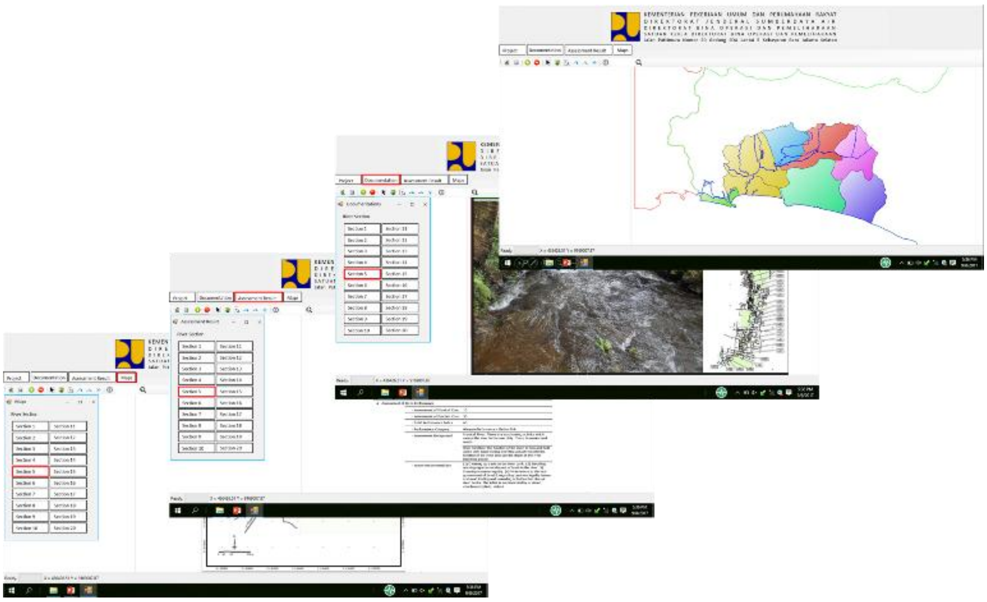

Figure 5 Display of GIS system for the Serayu River.

5 Summary and Conclusions

- In this study, the inventory and integrated performance assessment method of river and its infrastructure has been compiled and applied to the Serayu River as an example. It is shown that the method can be readily implemented to any river in Indonesia.

- For inventory and performance assessment, the Serayu River is divided into upstream (48 km), middle (95 km), and downstream (33 km) sections with the assessment results of good performance, good performance, and adequate performance, respectively. A corrective maintenance is required for the downstream section while for the upstream and middle sections of the river only a preventive maintenance is required.

- Infrastructure of the Serayu River are six bridges, one movable weir, and one retention pond. Bridges are not considered river infrastructure, so bridges are inventoried, but not assessed. The performance assessment results of retention pond and movable weir are both good and only a preventive maintenance is required.

- To maintain the preservation of Serayu River system, the inventory and performance assessment activities should be conducted annually, which requires 5 observers and 36 workers for the 176 km total length of the Serayu River. In addition, community involvement on the implementation of the O & M of the river and its infrastructure is also very important.

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Operation and Maintenance Cost at Serayu-Bogowonto River Basin. Ministry of Public Works and Housing of Indonesia, 2016.

Single Reservoir Operation Model Using Non Linear Program (Case Study : Darma Reservoir In West Java)

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Abstract. Darma reservoir is located in Darma district of Kuningan Regency of West Java, Indonesia. Darma Reservoir is used for various purposes such as drinking water supply, irrigation water supply, fish culture, flood control and recreation (tourism). The decrease of water reservoir capacity is caused several factors such as sedimentation,lack of environmental conservation, decreasing of rain water volume caused by global warming and seepage occurring in Darma reservoir. In this research, non-linear programming method optimization technique is used to solve non-linear relationship between optimized variables. By determining the maximum annual water supply to be the objective function and determining the constraint functions using the solver on Ms excel, the release value can be obtained. Release obtained based on calculation with non linear program method can be compared with the actual release based on the data obtained where it aims to evaluate the performance of non-linear methods to actual conditions based on efforts to meet the demands (irrigation and Drinking water supply). This research is expected to be an input/recommendation for Darma Reservoir managers/operator as the guidance of water regulation. Hopefully, the demands of water can be fulfilled and the rule of water release on Dharma reservoir can be optimal.

Keywords: *reservoir operation, decision making, non linier program, rule curve*

1 Introduction

Water is a very important resource for human and life activity. The need for water resources is proportional to the growing number of people and social life. Nowadays, many technical plans has been build to maintain the sustainability of the quality and quantity of water. One of the technical plan is reservoir construction. Reservoir is a container that can accommodate the water that is generally a form of ponds, lakes and also a particular building for a particular purpose. The Darma Reservoir is one of the artificial reservoirs built on the upper Cisanggarung river basin in the river basin area of Cimanuk - Cisanggarung River in 1924 to 1962, which is used for various purposes, namely, the provision of drinking water, water supply Irrigation for agriculture, fish farming, flood control, recreation (tourism).

Administratively, Darma reservoir is located in Darma district of Kuningan district of West Java province, about 12 km southwest of the city center of Kuningan regency. The catchment area of Darma Reservoir consist of Cisanggarung river with several tributaries such as Cikalapa River Basin (DAS), Cilame Watershed, Cimuncang Watershed, Cilandak Watershed and Cinangkas Watershed as well as several springs such as Citambang, Balong Beunteur and Cibuntu. Darma Reservoir can accommodate maximum water 40,200,000 m^3, this reservoir area reaches 425 hectare.

In the beginning of operation in 1962, Darma reservoirs served 22,060 ha of irrigated area, with 6,697 ha of Kuningan district and 15,363 ha of Cirebon Regency. Based on PANIR data in 2010/2011 due to the change of agriculture area function into various interests, the irrigation service area becomes reduced to 19,737 ha for the district of Kuningan and Cirebon.

The increasing number of population and growth of industry around the reservoir sites, both large and small, based on data from Ciamuk Water Resources Management Center (CISUK-Cisanggarung) stated that the capacity of water reservoir of Darma Reservoir is about ± 30 million m^3 from ± 40 million m^3. The decrease in water discharge capacity is caused by several factors besides the problem of the planet earth which is getting older, the lack of environmental conservation around the reservoir, the global warming causing the decrease of the rain water volume and the problem of the reservoir itself is the seepage factor occurring in the Darma reservoir. In this research, non-linear programming method optimization technique is used to solve non-linear relationship between optimized variables. By determining the maximum annual water supply to be the objective function and determining the constraint functions using the solver on Ms excel, the release value can be obtained.

2 Research Methodology

The research was started by processing data obtained from Dinas BBWS Cimanuk - Cisanggarung with data covering technical data of Darma Reservoir construction, water resource and irrigation requirements data, seepage data, inflow flow data and storage data.

The leakage calculation (seepage) is obtained from the calculation by finding the equation obtained by the volume and leakage curve obtained from BBWS Cimanuk-Cisanggarung data, seepage influences the significant storage changes as seen in the elevation and seepage relationship obtained by the equation as follows:

$$y = 1E - 91e^{0{,}289x} \tag{1}$$

Data analysis is done by two ways, that is calculate the average of inflow, accomodation, actual demand and release and calculate with non linear programming method. Release with non linear programming method is done by determining the purpose function that is maximun annual water supply, determine the constraint function then executed by using non linear program that is Ms excel (solver). Here is a calculation step by using solver as follow :

- Destination function : Maximize annual water supply = ($\sum R_t$)
- Constraints function :
  - Water balance equation $= S_t - S_{t-1} + R_t = I_t$ (2)
  - $S_t \leq V_{max\ Reservoir}$ (3)
  - $S_t \geq V_{min\ Reservoir}$ (4)
  - $R_t - b_t \geq V_{min\ (dt + pt)}$ (5)
  - $R_t - p_t \geq V_{min\ (dt + bt)}$ (6)
  - $V_{initial\ storage} \geq V_{end\ of\ storage}$ (7)
  - $S_t, R_t, b_t, d_t, p_t \geq 0$ (8)

3 Result and Discussion

3.1 Data processing

Based on data obtained from BBWS Cimanuk-Cisanggarung, so obtained data as in **Table 1** below.

Table 1 Required, inflow & average data collection, evaporation, seepage and actual release of Darma Reservoir

Period in 1 month	*Demand* (x 10^6 m^3)	Average Inflow (x 10^6 m^3)	Storage (x 10^6 m^3)	Evaporasi (x 10^6 m^3)	Seepage (x 10^6 m^3)	Release Actual (x 10^6 m^3)
			20,000			
Jan	7,281	24,894	26,943	4,28544	0,0214806	13,645
Feb	9,014	25,642	31,115	4,8384	0,0314258	16,600
Mar	19,771	63,305	34,367	4,55328	0,0506748	55,448
Apr	31,740	89,073	36,289	4,48416	0,0612400	82,606
Mei	42,792	87,585	36,231	4,6872	0,0628571	82,894
Jun	108,037	128,342	34,201	5,3136	0,0481060	125,010
Jul	166,681	170,048	29,837	4,874688	0,0300169	169,506
Agus	179,005	188,039	24,808	4,874688	0,0167835	188,176
Sep	181,825	198,621	20,104	5,49504	0,0094287	197,821
Okt	103,690	113,905	15,852	6,29424	0,0059598	111,857
Nov	26,704	36,240	16,773	5,00256	0,0064154	30,310
Des	17,237	31,856	19,739	5,3568	0,0093410	23,523

For the relationship between elevation and seepage can be seen in **Figure 1** based on data obtain

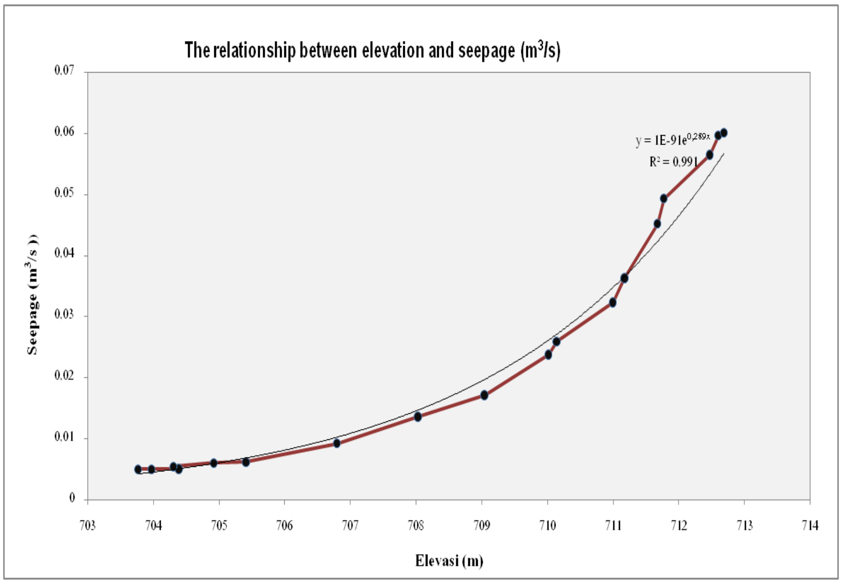

Figure 1 The relationship between elevation (m) and seepage (m^3/s)

3.2 Calculation Result

The results of the calculation with non-linear program method and actual release are shown in **Figure 2** following.

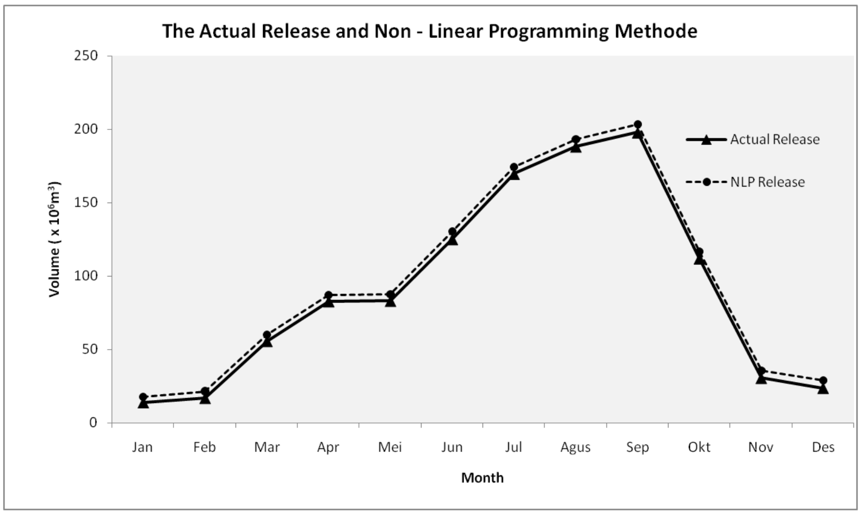

Figure 2 The actual release and release of non linear programs

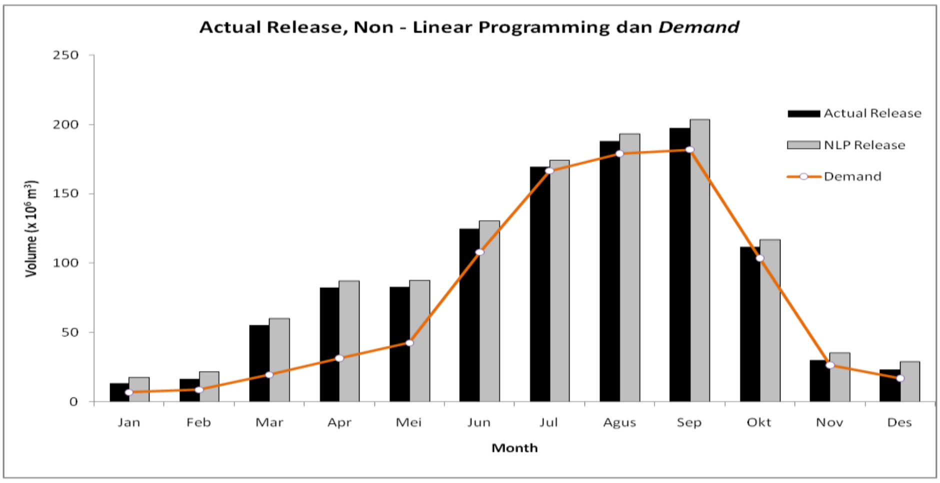

Figure 3 Actual and Non linear Programming on demand

Seen on **Figure 3** that the actual release and non linear programming are both able to meet demand needs.

To evaluate the performance of the non-linear method of the program based on the fulfillment of needs (irrigation and PDAM), the reliability of non-linear programming methods is presented in table (%) that meets the needs of non-linear release program that is **table 2** and **table 3**.

Table 2 Compliance of requirement (%) actual release

Period in 1 month	Demand (x 10^6)m^3	Actual Release (x $10^{6)}$ m^3	Compliance of Requirement (%)
Januari	7,281	13,645	187,407
Februari	9,014	16,600	184,161
Maret	19,771	55,448	280,452
April	31,740	82,606	260,256
Mei	42,792	82,894	193,711
Juni	108,037	125,010	115,711
Juli	166,681	169,506	101,695
Agustus	179,005	188,176	105,124
September	181,825	197,821	108,797
Oktober	103,690	111,857	107,876
November	26,704	30,310	113,506
Desember	17,237	23,523	136,469
	Average (%) Compliance		157,930

Table 3 Compliance of requirement (%) NLP release

Period in 1 month	Demand x 10^6 m^3	Non-Linier Programming x 10^6 m^3	Compliance of Requirement (%)
Januari	7,281	17,6905	242,979
Februari	9,014	21,4700	238,186
Maret	19,771	60,0524	303,738
April	31,740	87,1512	274,577
Mei	42,792	87,6436	204,811
Juni	108,037	130,3718	120,673
Juli	166,681	174,4112	104,638
Agustus	179,005	193,0677	107,856
September	181,825	203,3253	111,824
Oktober	103,690	116,7087	112,556
November	26,704	35,3193	132,263
Desember	17,237	28,8896	167,600
	Average (%) Compliance		176,809

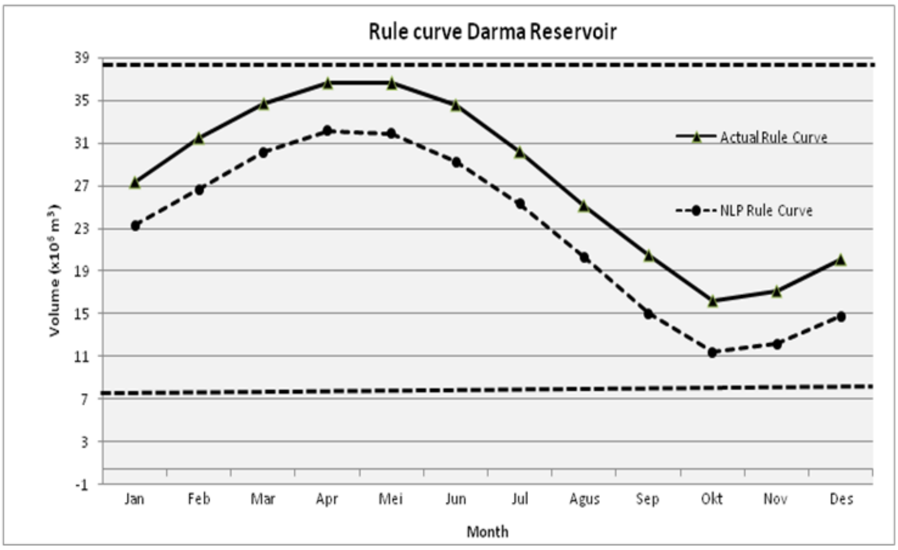

Figure 4 Rule Curve of Darma Reservoir by Volume

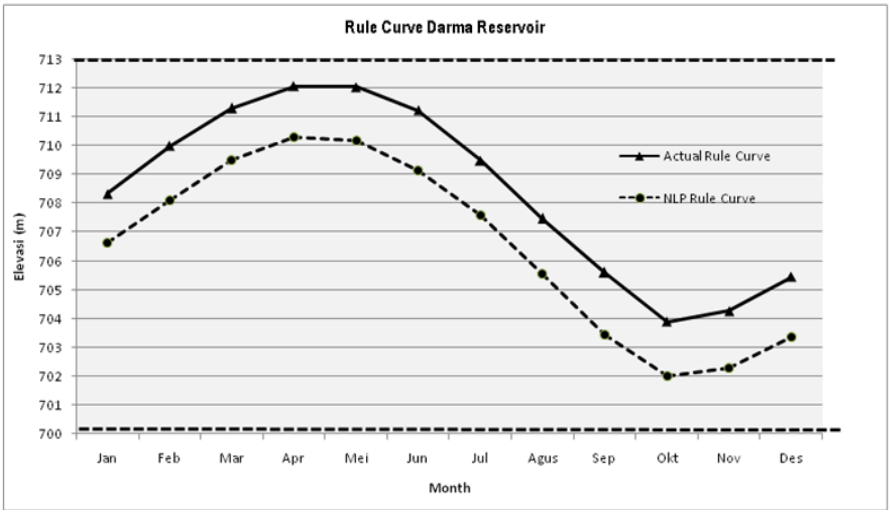

Figure 5 Rule Curve of Darma Reservoir by Elevation

Figure 4 and **Figure 5** are the rule curves of the Darma reservoir based on the volume and elevation, the rule curve in general the need of non-linear programming methods can be met and the water never overflow. The same pattern is seen in the figure based on both volume and elevation where the highest rule curve occurs in April and May and the lowest rule curve occurs in October.

4 Conclusion and Recommendation

From this reserach, it can be conlude Non linear program release meets the need for water utilization in reservoirs. Release value obtained with non-linear program is greater than the actual release. Release of NLP based on (%) fulfillment requirement every month has the same characteristic with actual release of each month that is above 100%, which means very guarantee water reservoir fulfillment requirement. So that non-linear program method can be input for Darma Reservoir managers as guidance of water management in fulfilling water reservoir requirement and water is not escaped from guard.

Nomenclature

y	= the amount of seepage (m^3/s)
x	= elevation equivalent to seepage value (m)
S_t	= storage at the end stage
S_{t-1}	= storage at an early stage
R_t	= total release
b_t	= release of raw water
d_t	= irrigation water release
p_t	= seepage
I_t	= inflow
$V_{max\ reservoir}$	= maximum volume in the reservoir
$V_{min\ reservoir}$	= minimum volume in the reservoir
$V_{min\ (dt + pt)}$	= minimum volume (irrigation release + seepage)
$V_{min\ (dt + bt)}$	= minimum volume (irrigation release + raw water)

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WATER AND WASTE ENGINEERING AND MANAGEMENT

The Use of $TiCl_4$ as Coagulant for Anionic Dyes in Textile Wastewater Treatment

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Abstract. Effluents from dyes wastewater that contains different types of dyes, which has very low biodegradibility because of its high molecular weight and complex structures. Method widely used to overcome this problem is by using coagulation. This study focused on the coagulation process with anionic dyes. Conventional coagulant will produce large sludge which will require further handling of sewage sludge. The coagulant used in this experiment is $TiCl_4$ that the sludge will be potentially reproduced TiO_2. TiO_2 itself can be used as photocatalytic agent in wide area including sewage treatment. This study conducted by $TiCl_4$ solution was tested on anionic dye solution sample. The result evaluated by zeta potential, TOC, COD and colour removal. This study indicates that Ti based coagulants are effective and promising coagulants for anionic dye wastewater treatment. The optimum condition is conducted at acid pH that is 2. $TiCl_4$ is able to reduce TOC and COD, color removal can achieved up to 97,17%. The optimum dossage of $TiCl_4$ was 0,125 mL/L. In addition, the flocculated sludge resulted can be recycled and reproduced TiO_2 which is potential as a photocatalyst agent.

Keywords: a*nionic dye, coagulant, reproduced, sludge,*$TiCl_4$*,* TiO_2

1 Introduction

Textile industries are one of the biggest users of water and complex chemicals in various processes. The unused materials from the processes are discharged as wastewater that is high in colour, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, temperature, turbidity and toxic chemicals. The direct discharge of this wastewater into the water bodies like lakes, river, etc may pollute the water and affects the ecosystem. Effluents from textiles industries ,wastewater, contains different types of dyes which has very low biodegradibility because of its high molecular weight and complex structures [7]. These effluents produce high concentrations of unorganic salts, acid and bases in biological reactors leading to the increase of treatment cost [3]. Moreover, conventional textile industries generate residuals of chemicals that evaporate into the air that we breathe or absorb through our skin. Some of the chemicals are heavy metals either in free form in effluents or absorbed in the suspended solid and are either carcinogenic [4].

Researchers has observed that coagulation/flocculation is one of the most common technology applied in textile industry. Regardless of the generation of considerable amount of sludge, it is still used in developed and in developing countries. Since the mechanism of coagulant applied to decolourise wastewater is still not absolutely clear, colour removal by coagulationist found in some cases very effective, in some other cases, however, has failed completely [13]. Coagulation of dye –containing waterwater- has been used for many years as main treatment or pretreatment due to its low capital cost [8]. Most commonly used salt coagulation method is using Fe and Al, which still requires further treatment. The most commonly used coagulants are alum sulfate, poly aluminum chloride, $FeSO_4$ and $FeCl_3$ [16]. However, the main drawback of conventional coagulant relies on the large quantity of sludge produced after treatment. In fact, the treatment of sludge after coagulation/flocculation is considered to be one of the most costly and enviromentally problematic challenges of all water treatment processes. To circumvent the issue of sludge disposal, a novel titanium based coagulant has been proposed by Shon et al [6].

The possibility of using titanium compounds as a coagulant in water treatment was first investigated by Upton and Buswell in 1937 [15]. They found that titanium sulfate ($Ti(SO_4)_2$) was better in removing fluoride due to quadrivalent cation than the trivalent alumunium or iron ion. They also noted that ilminite extract gave much better coagulation in the colored water than alumunium or ferric sulfates. Recent report showed that the removal of organic matter of different molecular sizes by Ti salt flocculation was similar to that of the most widely used Fe and Al- salt clocculation. The significant advantage of using titanium tetrachloride ($TiCl_4$) as a coagulant is that its flocculated sludge can be recovered to produce a valuable by product namely titanium dioxide (TiO_2) by thermal treatment, which is not possible with the conventional coagulants [2]. TiO_2 is the most widely used metal oxide, which applications include photocatalysis, cosmetics, paints, electronic paper and solar cell [10]. The toxicity of the supernatant after $TiCl_4$ coagulations is very low and the residual Ti salt concentration in the treated water meets The World Health Organization's (WHO) guidelines (0,5-15 μg/L) for drinking water standards [15]. Therefore, $TiCl_4$ is expected to be a promising alternative coagulant to the conventional commonly used.

2 Methodology/ Experimental

2.1 Water Source and Coagulant

$TiCl_4$ solution (20%, density = 1,150g / mL) was obtained from Merck and used directly without specific treatment. The solution is then referred to as a stock solution. Deionized water was used for all the reagent preparations. The artificial waste water used was made from anionic dyes. Reactive dyes prepared at 100 ppm in alkaline condition with sodium chloride addition as simulation like in real reactive waste water and continously stirring for 1 hour.

2.2 Jar Test

The coagulation test was conducted using jar tester at different initial pHs. The test solution pH was controlled by adding NaOH or HCl. Determination the optimal dosage was conducted after measuring the available initial pH. Then, a two-stage mixing process, including rapid (1 min stage at 100 rpm) and slow mixing (10 min stage at 20 rpm) was followed by a settling stage for 30 minutes.

2.3 Analysis

The performance of the coagulant was evaluated by measuring the colour, TOC, COD, Potential Zeta and XRD. The measurement of colour absorbance was done by Spectrophotometer Shimadzu, Zeta Potensial by electroforetik methodes. This experiment was carried out at Analysis Chemical Laboratory of Polytechnic STTT Bandung. The analysis was carried out at Pharmacy Department of ITB, while SEM EDX was done at PPPGL. The zeta potential of solution and SEM EDX evaluation were carried out at optimal dossage.

3 RESULTS AND DISCUSSIONS

3.1 Effect of Initial pH and Zeta Potential

The performance of initial pH for each coagulant, the performance of coagulant by measuring colour absorbance, and the suitable pH gain if the colour absorbance getting lower after processing by coagulant are shown in Table 1.

Table 1 Effect of initial pH using $TiCl_4$ coagulant

pH	% Colour Removal
Acid	93,66
Neutral	0
Base	0

From the data above, it can be observed that the use of a coagulant $TiCl_4$ optimal process takes place at acidic pH condition. Acidic condition on coagulant $TiCl_4$ is obtained by dissolving it into a dye solution. Hydrolysis of metal ions occurs immediately upon contact with water and neutralization capabilities of coagulant is associated with the positive charge of the hydrolyzed species. Charge neutralization capability of $TiCl_4$, shows that the hydrolysis of the less positive events is supportive to the efficient coagulation. Anionic dyes organic matter is removed mainly by the complexation of dyes organic matter with soluble metal species into insoluble precipitates at pH<6, while the adsorption onto precipitated metal hidroxides predominated the dyes organic matter removal process at PH>6 [9]. Thus, in this study, the dyes organic matter was likely to be removed by charge neutralization between the negatively charged organic matter and the postively charged metal hydrolyzates at pH<6. In addition, at pH>6, the adsorption and sweep flocculation were assumed to play a dominant role during the coagulation process.

As noted by Zhang, the flocs formed by sweep flocculation were larger than those by charge neutralization and hence need further aggregation [11]. During the coagulations process, sweep coagulation and adsorption play important role to facilitate the floc aggregation besides charge neutralization [5]. For $TiCl_4$, at base pH, the negative charge of the dye will probably be neutralized by the positive charge coagulants hydrolyzed to produce flocks with a positive charge due to an excess of positive charge hydrolization on the surface of the flocks. At pH base, a fast bulk hydrolysis occurred, generating the type of coagulant with a positive charge, resulting in a precipitant Ti $(OH)_4$. Then, $TiCl_4$ was not able to achieve perfect neutralization.

Ray [10] reported that flocs produced by bridging flocculation can be much larger than those formed simply by charge neutralization and hence further aggregation. However, the positive charges were not enough for full charge neutralization, yielding the flocs with negative charges. When the initial pH is between 6 and 9, the polymeric hydrolyzates with high positive charges and large surface area are formed [13]

3.2 Analysis of Potential Zeta

Potential Zeta is a parameter of electrical charge between the colloidal particles. The higher the zeta potential value the more it will prevent the occurrence of flocculation (colloidal merging events from small to large). The mechanism depends on the stability of colloidal dispersions zeta potential. The zeta potential repel shows the levels between same charged particles adjacent to each other. Colloids by the high value of the zeta potential is electrically stable, while colloids with low potential value tends to coagulate / flocculation. The anionic dyes processed with various coagulants and measured in each pH. The zeta potential obtained 1 min after $TiCl_4$ addition was found nearly the same as that obtained after 10 min mixing.

Table 2 shows that the zeta potential value will decrease along with the increasing pH. The data showed that the values were higher (less negative) at pH 2 than those ato other acidic pH. Within all the $TiCl_4$ doses, which may be due to the more positive nature of Ti hydrolysis products, and also partly to the more positive. The initial pH variations also affect the results of coagulation/flocculation process. The initial pH influences the value of the zeta potential solutions related to the ability of hydrolysis coagulants. The important mechanism for particle removal depends on the pH. For example, the main NOM removal mechanism at pH,6 is dominated by complexation of NOM soluble metal species into insoluble precipitates, while adsorption onto precipitated metal hidroxides dominated the mechanism at pH>6 [8]. It contrary with this research that pH 2 has better colour removal than the others. In general, particle removal at acidic pH was dominated by the complexation with dissolved metals into unstable precipitant. However, the coagulant mechanism varies with the type of coagulant and conditions

Table 2 Zeta potential measurement

Material	Potential zeta (mV)	Colour Removal (%)
pH 2	-0,43	93,59
pH 3	-5,94	79,27
pH 4	-6,58	15,39
pH 5	-8,07	-
pH 6	-19,57	-

With the increasing pH value, the zeta potential decreased to be more negative. The difference in the effect of initial solution pH on floc zeta potential correlated well with the coagulant hydrolyzates. The relative importance of coagulation mechanisms for particle organic matter removal (anionic dyes) depends primarily on pH. Generally, the main colour removal mechanism at pH < 6 is dominated by complexation of anionic dyes with soluble metal species into insoluble precipitates, while adsorption onto precipitated metal hydroxides dominated the mechanism at pH > 6 [17].

However, the possible dominant coagulation mechanisms varied with coagulation conditions[14]. For $TiCl_4$ at pH 2 the negative charges of anionic dyes were possibly neutralized by the positively charged coagulant hydrolyzates, generating the flocs with positive charges due to excess of positively charged hydrolyzates adhering to the surface of aggregates. At pH > 2, bulk and rapid hydrolysis occurred, generating coagulation species with less positive charge, probably involving $Ti(OH)_4$. Thus, the TiCl4 is unable to achieve complete neutralization, resulting in the flocs with negative charges. This probably led to the decrease in colour removal as shown in Tabel 2. The colloids are easily adsorbed, neutralizedand co-precipitated by the hydrolyzates, producing the flocs with positive charges. The slight decrease in color removal removal at high pH values could be attributed to the mutual repulsion between particles with same charges.

At pH 7, there is not only charge neutralisation mechanism but also sweep flocculation, which allows for enmeshment and adsorption of the foulants into and onto the hydroxide precipitates allowing for better turbidity removal at relatively lower dose. Zeta potensial measurement are often carried out to assess the changes in floc surface charge to evaluate the ability of a coagulant in destabilizing the constituents in feed water. The changes in floc zeta potential are also generally used to determine which coagulantion mechanism is involved (charge neutralisation or sweep flocculation). Zeta potential values would have been close to zero so the mechanism is involved charge neutralisation and sweep flocculation (adsorption and enmeshment in metal hydroxydes precipitates) Most studies that the predominant coagulation mechanism for $TiCl_4$ was charge neutralisation.[6]

Potential zeta measurements are used to assess local charge changes in order to evaluate the ability of coagulant in stabilizing the particle in a processed solution system. This potential floc zeta change is usually used to determine which mechanisms occur (charge neutralization or sweep flocculation). For algae it is not only the mechanism of charge neutralization. In contrast to other results indicating that the main mechanism that occurs is for $TiCl_4$ is the charge neutralization. High doses are required for the occurrence of sweep flocculation (adsorption and trapping in hydroxide metal deposits). In the condensation of the amorphous cationic the hydroxide precipitate present in the water may cause the sweep of the foculation and cause adsorption on the negative part of the particle. A large negative value (-8.3 - -12.3) is the result of which not only neutralizing the charge as well as sweep flocculation [6].

3.3 Analysis of Optimum Dossage

The optimum dosage test results can be seen in Table 3. It can be seen that the higher the concentration, the higher% color removal will occur. However, at the concentration point 0.75 (mL / L) there is a decrease in color removal, this is because the TiO_2 particles have become bulk particles so optimum is used at concentration 0.125 mL / L for 100 ppm anionic dye .

Table 3. Dossage to color removal

Dossage (mL/L)	% Colour Removal
0.075	90.09
0.1	95.93
0.125	97.17
0.15	97.64
0.175	61.14

As the $TiCl_4$ concentration increased, the negative charge of colloidal particle decreased and isoelectronic point appeared at about 0,125 mL/L. It is worthwhile to note that when the zeta potential was close to the isoelectric point at this concentration, it achieved the highest removal efficiencies. Flocculation phenomenon was likely to be attributed to simpel charge neutralization [16]. As the coagulant dosage further increased, the positive charge became more dominant, which led to electrostatic repulsion between particles. According to the zeta potential results, charge neutralization is believed to play a major role during the flocculation process using $TiCl_4$ coagulant. High coagulant dosages are necessary to overcome the ion transfer mechanism, leading to more efficicient destabilisation. It is interesting to note that $TiCl_4$ performed better at lower doses (removal efficeincy higher than 70%) [6].

3.4 Analysis of TOC and COD

Parameters measurement included TOC (Total Organic Carbon) and COD (Chemical Oxygen Demand). Testing was conducted with varying concentrations $TiCl_4$ coagulant applied on anionic dyes artificial wastewater. The data showed that there is be potential to decrease the TOC and COD value. Because the artificial waste is possible obtained a very small value. There is a decrease in COD and TOC due to the flocculation process so that some particles have been deposited. But to a certain point there will be an increase in TOC and COD this is possible due to the bulky nature of $TiCl_4$, thus affecting the TOC and COD values.The data of TOC and COD measurement can be seen in Table 4**.**

Tabel 4. Analysis of TOC and COD

$TiCl_4$ (mL/L)	TOC (ppm)	COD (ppm)
0,075	24,897	19
0,1	9,009	20
0,125	3,447	8
0,15	2,69	9
0,175	32,792	18

3.5 Analysis of Sludge

The sludge (the settled flocs produced after TiCl4 coagulation) was incinerated at 500^0C for 30 min. The incinerated sludge changed from black to white with the increase in temperature. The black color might be attributed to the remaining organic matter at low temperatures.

XRD images were analyzed to identify the crystal structure of particles after inceneration. The XRD results can be seen in Figure 1 below. Measurement with X-Ray diffractometer shows the peak showing d value which is the peak of the identity of the anatase crystal phase form. The TiO_2 with anatase structure is generally accepted as the most active and efficient photocatalyst comapared to rutile and brookite [1]. The difractogram pattern of characterization results using XRD for TiO_2 shows the peaks of identity appearing in the region 2θ = 250, 36,10, 47,910. From the 2θ point can be seen the value d from each peak produced. The picture shows the value of d 3.55; 2.89 and 1.89 which is the peak of the identity of the anatase crystals [11]. Based on the standard for the diffraction of TiO_2 JCPDS 21-1272 for the anatase released by the International Center for Diffraction Data, the value d: 3.52 ; 2.38; And 1.89 Å is the identity of TiO_2 anatase.

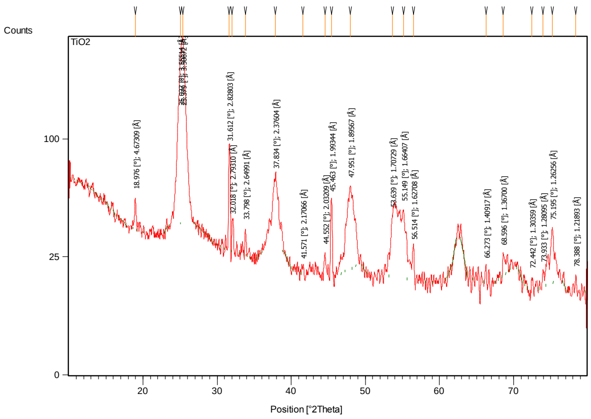

Figure 1. Diffractogram of TiO_2 sludge
The diffraction intensity at the 2θ angle observed shows the dominance of the difraktogram profile of the anatase structure

The anatase crystalline phase formed is the most suitable crystalline phase when TiO_2 is used as a photocatalytic agent.

4 Conclusion

Based on the experimental results, the conclusion is as follows:

1. $TiCl_4$ was a promising coagulant in textile wastewater treatment in color removing anionic dyes.
2. $TiCl_4$ had best performance in acidic condition up to 97 % in color removal.
3. The sludge from the $TiCl_4$ as a coagulant can be processed further to obtain TiO_2 and potentially used as photocatalytic agent
4. The compound TiCl4 has potential to overcome the limitations of the use of conventional coagulant

5 Acknowledgement

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Development Of Bacterial Cellulose(Bc)/ ZnO Membrane From Nata De Coco To Remove Azo Dyes In Artificial Textile Wastewater

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Abstract: Membrane technology is one of the advanced water treatment technology which could remove azo dyes and organic compound in wastewater of textile industries effectively. Bacterial cellulose based membrane, compared with other membranes which are made of polysulfone or polyethersulfone, is cheaper due to coconut water is abundant in nature. Cellulose is commonly extracted from wood. However, in order to minimize the wood use in the process of membrane development, utilizing other resources containing the same characteristic with cellulose from wood is one of the feasible way. Nata de coco, a bacterial cellulose (BC) produced in the fermentation of coconut water, is the potential substance used in this research. Previous research has successfully synthesized cellulose acetate from nata de coco and raw materials. The purpose of this research is to attempt the capability of membranes of bacterial cellulose (BC) without converted into cellulose acetate with variation of ZnO concentration as photocatalyst. Characterization of BC/ZnO membrane use flux, rejection, FTIR, SEM, EDS and tensile strength. The BC/ZnO membrane was tested on a textile material containing Reactive Black 5 (RB 5) at a concentration of 20, 40 and 60 ppm. The result showed that color removal efficiency was achieved at optimum concentration 60 ppm with variation membrane BC/ZnO 0,22 gr with UV. Operating pressure 8 atm makes the BC/ZnO membrane as the ultrafiltration membrane. The capability of BC/ZnO in removing RB 5 dye is 99,09%. Kinetic model is Adam- Bohart with (k') 57,90 x 10-5 l/m.minute with absorbance capacity (a0) 15458 mg/l and R^2 97,13%.

Keywords: *bacterial cellulose, reactive black 5, ultrafiltration membrane, nata de coco*

1 INTRODUCTION

High demand of water in textile industries produces abundant liquid waste. In the production of 1 kilogram of textile alone requires 200 liters of water (Parvathi, C., 2009). The main problems of textile waste are dyeing substances, suspended solids and organic matters (Widjajanti, 2011). Besides lowering the aesthetical value, the degradation of dyeing substances may produce carcinogenic and toxic compounds (Shawabkeh RA, et al, 2005). Dyeing substances can as well block the penetration of sunlight to the water and inhibit photosynthesis (Gong, R et.al, 2005). This potentially degrades the water quality and kills the aquatic biota due to the lack of O_2 and the contamination of toxic substances. (Widjajanti, 2011). One of the dyes used in the textile industry is Reactive Black 5 which is azo dyes compound.

Textile waste has a high potential to be recycled due to its abundance and the demand of water with intermediate purity level. The recycling of textile waste will reduce ground or river water use to maintain the sustainability.

An alternative process to treat dyeing substances in azo dyes form of textile industries is by using membrane technology. One of the most common polymers used in membrane manufacturing is cellulose acetate. Cellulose is widely used because of its abundance in nature as a component of the wood pulp. However, the increasing use of cellulose threatens the availability of woods that hence lead to the development of nano fiber yielded from bacteria or known as bacterial cellulose (Bhanthumnavin, 2016). Bacterial cellulose (SB) is produced through fermentation of coconut water by *Acetobacter xylinum* (Yulina and Gustiani, 2014). In Indonesia, coconut water has an enormous potential to be used as raw material for membrane manufacturing. Annually, more than 900 million liters of coconut water produced in Indonesia. According to USDA National Nutrient Database for Standard Reference, coconut water contains 94,99% water; 0.72% protein; 0.2% fat; 3.71% carbohydrates and 2.61% sugar.

One of the techniques to increase the effectiveness of SB is through a ZnO modification. Previous research has mentioned that SB can be modified into hollow-formed fiber and immobilized by ZnO. The combination of hollow fiber membrane and ZnO can remove colour in textile waste up to 90,32% (Yulina and Gustiani, 2014). However, the use of diamine cupriethylene to convert SB into hollow fiber can potentially pollute the environment due to its chemical nature. Thus, this research aims to examine the potential of SB for membrane manufacturing through hot press method.

In addition, this study also investigated the kinetics rate of SB/ZnO membrane to remove the Reactive Black 5 dyeing compound and organic substances based on the flux value. The kinetics of photocatalytic reaction rate of the membrane were analyzed as well by using the kinetical equation of Bohart-Adam reaction (Gustiani, 2014).

2 METHODOLOGY

In this study consists of three stages of the methodology of preparation phase, stage of research, and the stage of analysis and interpretation of results.

2.1 Research Phase

The research stages are cellulose bacterial characterization, and color effluent treatment process. Analytical phase performed is measurement of Scanning Electron Microscope (SEM), Fourier Transform Infrared (FTIR), Energy Dispersive X-Ray Spectroscopy (EDS), flux, rejection and decolorization Reactive Black 5 dye.

2.2 Nata de coco drying

Nata de coco / biocellulose in gel form resulting from coconut water fermentation process, washed with water until neutral pH, then soaked in 2% NaOH solution and in the NaOH solution condition at 80-90ºC, then washed again until neutral pH (Gustiani et al., 2009). Nata de coco is pressed with a pressure of 250 kgf / mm^2 at 120ºC (Piluharto, 2008). This result is used as a membrane.

2.3 Analysis Phase

- Scanning Electron Microscope (SEM)
  Determination of membrane morphology by looking at cross-sectional structure of membrane, pore and fiber diameter on membrane is done by using analytical scanning electron microscope (JSM-6510LA).

- Fourier Transform Infrared (FTIR)
  FTIR (Fourier Transform Infrared) spectroscopy is an infrared spectroscopy equipped with Fourier transform for spectral detection and analysis. The infrared spectrum is generated from the pentrasmisian of light passing through the sample, measuring the light intensity with the detector and compared with the sampleless intensity as a function of the wavelength. The obtained infrared spectrum is then plotted as the intensity of the energy function, the wavelength (mm) or the wave number (cm-1) (Marcott, C., 1986).

- Flux
  The performance or efficiency of the membrane process is determined by two parameters, namely the selectivity and the flux / permeation rate (l / m2.hour or kg / m2.hour or mol / m2.hour) or the permeability coefficient (l / m2.hour.bar). Flux is the amount of permeate produced on membrane operations per unit of membrane surface area and time union. Flux can be expressed as follows (Mulder, 1996):

$$J = V/ (A.t)$$

Where:
J = volume flux (l / m^2.jam)
t = time (hours)

A = membrane surface area (m^2)
V = permeate volume (l)

- Rejection
  The selectivity of a membrane is a measure of the ability of a membrane to hold or pass a molecule. Membrane selectivity depends on inter-surface interactions with molecules, molecular size, and pore size of the membrane. Selectivity is generally expressed by one of two parameters, namely retention / rejection (R) or separation factor (α). According to Mulder (1996) the value of rejection of a solute solid (solute) is expressed in the following equation:

  R (%) = (1-Cpermeat / Cfeed) x 100%
  Where:
  R = percentage of prisoners
  Cpermeat = concentration of particles in permeate
  Cfeed = concentration of particles in the feed

- Measurment of Reactive Black 5
  To see the color degradation, sampling every 15 minutes was analyzed using spectrophotometer at a maximum wavelength of 597 nm (Fill, M and Delia Teresa Sponza, 2004). The absorbance value obtained is treated using the equation of the Reactive Black 5 dye calibration curve.

3 RESULTS AND DISCUSSION

3.1 Characteristics of Bacterial Cellulose Membranes

Flux

Based on Figure 1 The average flux value on the membrane with 2 atm pressure was 11.76 L /m^2.hour while on the membrane with 5 atm pressure the resulting flux was 22.07 L / m^2.hour and on the membrane with 8 atm pressure yielded a flux of 36.37 L / m^2.hour. It can be seen that the greater the pressure the greater the flux produced. At each operation time at 8 atm pressure has the greatest flux value compared to the 5 atm and 2 atm pressure.

This is because pressure is the main driving force (driving force) on the operation of the membrane (Notodarmojo and Anne Deniva, 2004). The pressure applied to the feed will cause the particles smaller in size than the membrane pores to pass through the membrane, while a larger size of the pore will be retained.

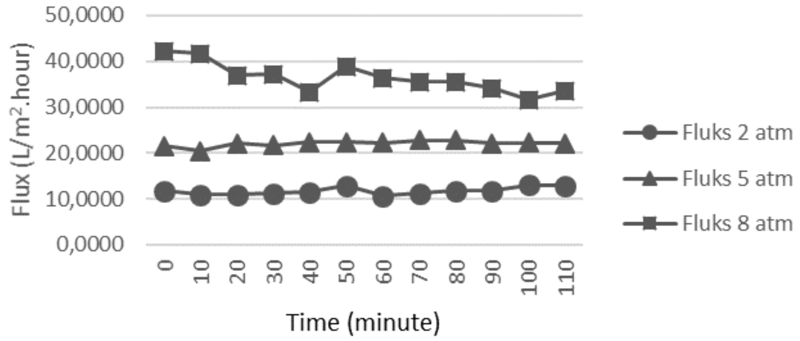


Figure 1 Graph of the relationship between flux and pressure

Based on Fig. 2 membranes without ZnO, the average flux value of 33.57 L / m^2.hour, membrane with ZnO concentration of 0.1% with soaking for 2 hours has an average flux value of 6.71 L / m^2.hour, whereas with the same concentration through 20 hours of immersion yielded a larger mean flux value of 25.71 L / m^2.hour. At 0.2% ZnO concentration also showed the same pattern. The membrane with ZnO concentration of 0.2% and 2 hours of immersion time had an average flux value of 6.44 L / m^2.hour, while with 20 hours of soaking the flux value was 15.92 L / m^2.hour. This is thought to be due to the deformation of the membrane due to the length of the immersion time causing a widened pore size.

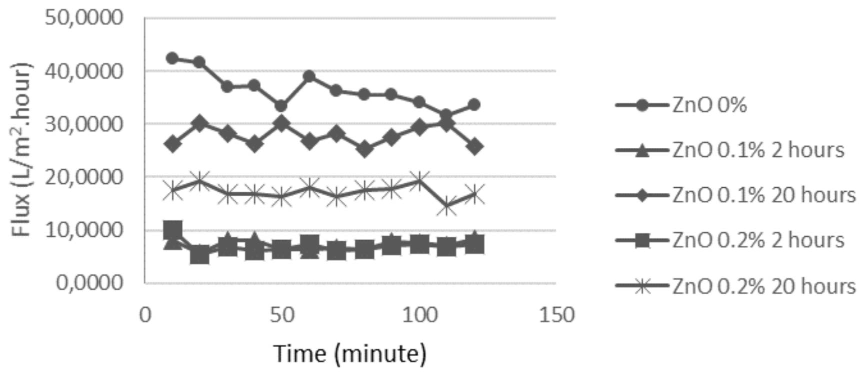


Figure 2 Graph of fluid cell membrane flux value with ZnO variation

ZnO concentration also influences in showing the amount of flux produced. The higher the ZnO concentration the smaller the flux value this is due to the increasing number of ZnO nanoparticles attached to the membrane and causing the pore in the membrane to shrink.

Rejection

The value of the dye rejection on the membrane differs for each amount of ZnO used. Ideally the more the amount of ZnO on the membrane surface, the higher efficiency value of degradation obtained, but in this experiment does is only apply if we compare the ZnO concentration but if it compared by the immersed time than it is not work.

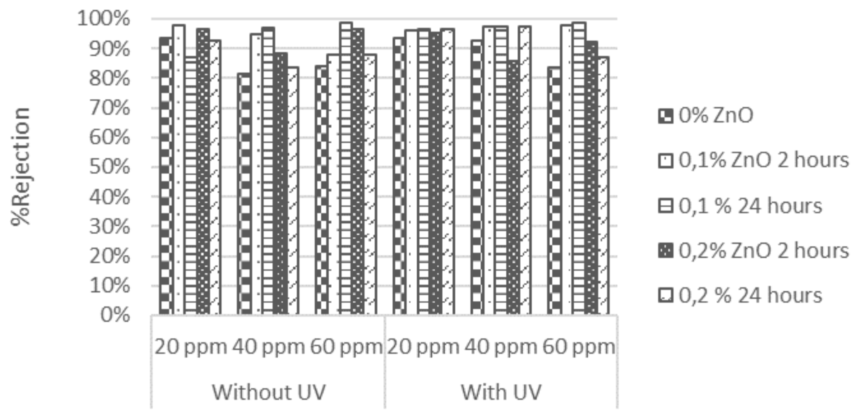


Figure 3 Graph of BC / ZnO membrane rejection coefficient

If the flux of the membrane is high then the rejection will be low, and vice versa if the rejection is high then the flux will also be low. This is in accordance with the results obtained. The highest value of rejection coefficient is on variation of BC / ZnO membrane with addition of ZnO concentration 0,1% at 2 hours and 24 hours immersion time. If clearly seen that both variants of the membrane are the membrane with the lowest flux. Normally a good membrane has a high surface porosity (pore fraction / surface area) and a narrow pore size distribution is possible, so an optimization of membrane treatment for high flux and rejection is required (Mulder, 1996)

FTIR

From Table 1 we can find the peak of wave number 3350,35 cm^{-1} for SB membranes without ZnO and SB / ZnO 0,2% 2 jam. And 3352, 28 cm^{-1} for 0.1% 2 mole SB / ZnO membrane, SB / ZnO 0.1% 24 hours, SB / ZnO 0.2% 24 hours. The peak in the range of numbers represents the vibration of the O-H functional group. In addition there are vibrations of the bending O-H functional groups in the range of 1649,14 cm^{-1}, 1656,85 cm^{-1} and 1654,92 cm^{-1} wavelengths. The functional C-O functional group can be seen in the wave numbers 1058.92 cm^{-1}

and C-H bending at wave numbers 615.29 cm^{-1} and 617.22 cm^{-1}. All these vibrations represent the vibration of cellulose (Fan, 2012) .

Table 4 FTIR interpretation of bacterial cellulose membrane (BC / ZnO).

Wavelenght number (cm^{-1})					
Without ZnO	ZnO 0,1% 2 hours	ZnO 0,1% 24 hours	ZnO 0,2% 2 hours	ZnO 0,2% 24 hours	Vibration
3350.35	3352.28	3352.28	3350.35	3352.28	O-H stretch
2918.3	2920.23	2920.23	2918.3	2918.3	C-H stretch
2854.65	2854.65	2856.58	2856.58		
	1741.72	1743.65	1741.72		C=O stretch
1649.14	1656.85	1654.92	1649.14	1654.92	O-H bend
1363.67	1371.39	1369.46	1367.53	1369.46	C-H bend
1236.37	1240.23	1240.23	1240.23	1236.37	C-O acetyl
1163.08	1163.08	1163.08	1163.08	1163.08	
1058.92	1058.92	1058.92	1058.92	1058.92	C-O stretch
898.83	898.83	898.83	898.83	898.83	
615.29	617.22	617.22	617.22	615.29	C-H stretch
559.36	559.36	555.5	559.36	559.36	

SEM

According to Figure 4 the ZnO can be attached to the BC membrane by immersion. The weakness experienced in the hot press method is during the pressing of ZnO nanoparticles, some of which are attached to the surface of teflon (press tool). This causes the amount of ZnO nanoparticles attached to the membrane surface to be reduced and difficult to measure (Gustiani, 2014).

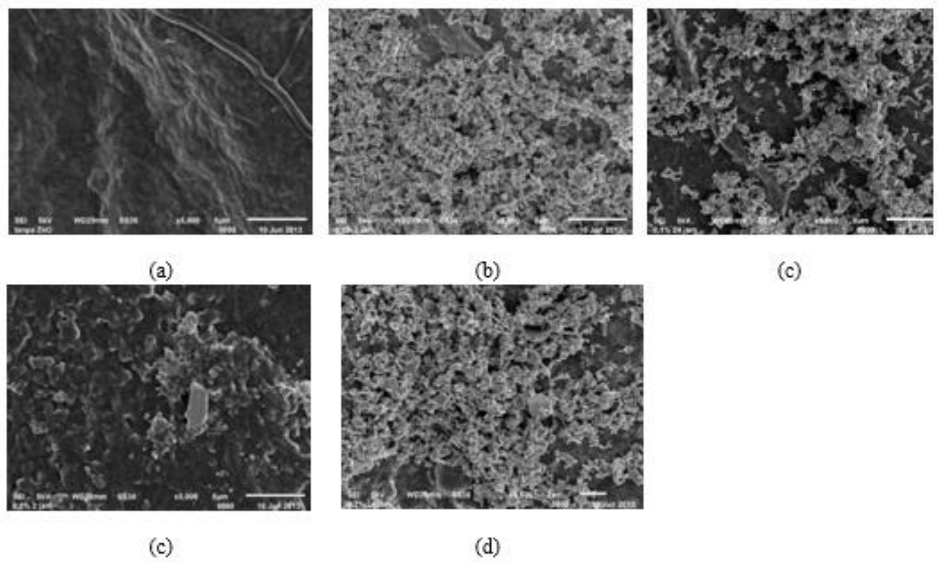
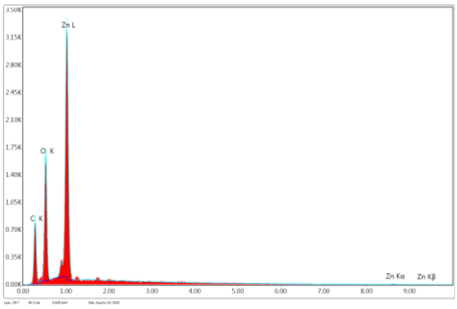
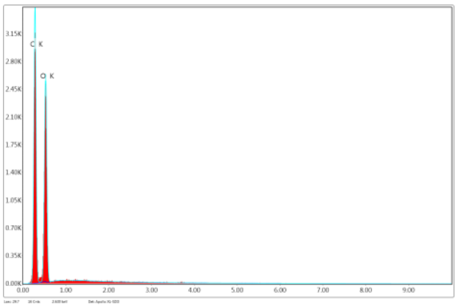


Figure 4 Surface membrane BC / ZnO (a) ZnO concentration 0% (b) ZnO concentration 0.1% immersion 2 hours (c) ZnO concentration 0.1% immersion 24 hours (d) ZnO concentration 0.2% immersion 2 hours e) ZnO concentration 0.2% immersion 24 hours.

EDS

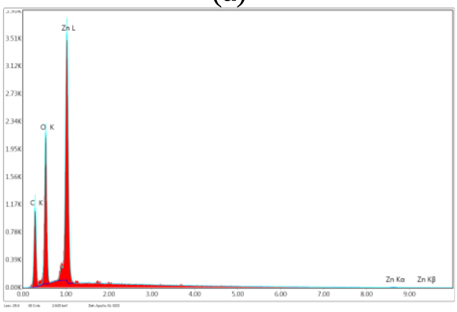
Figure 5 shows the results of the Energy Dispersive X-Ray Spectroscopy (EDS). This analysis is used to observe the elements in the membrane. Based on the EDS image, it can be seen that the image (a) does not show the presence of ZnO spectrum in spectrum of 1.012. There is only C and O spectrum. This refers to the cellulose component. Whereas, in the other four images there are 3 spectrum which is the spectrum of C, O and Zn. This means that Zn successfully attached to the BC membrane.

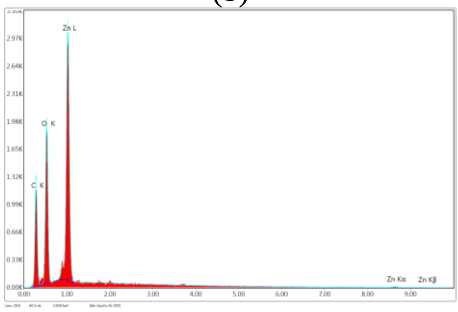




(a)

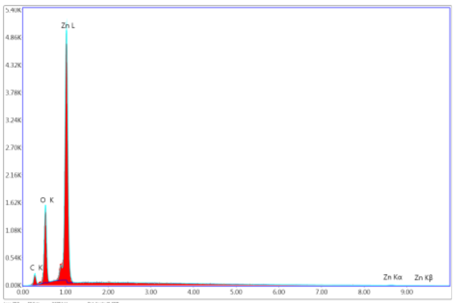
(b)





(c)

(d)



(e)

Figure 5 EDS result (a) ZnO concentration 0% (b) ZnO concentration 0.1% immersion 2 hours (c) ZnO concentration 0.1% immersion 24 hours (d) ZnO concentration 0.2% immersion 2 hours e) ZnO concentration 0.2% immersion 24 hours.

Tensile Strength

Based on Table 2 it can be seen that tensile strength (KT) on SB membrane ZnO 0% is 0.1783 N / mm2. While the addition of ZnO photocatalyst can increase the KT value to 0.4343 N / mm2 for SB 0.1% ZnO 2 hours, 0.3336 N / mm2 for SB 0.1% ZnO 24 hours, 0.3443 N / mm2 for SB 0 , 2% 2 hours and 0.3062 N / mm2 for SB 0.2% ZnO 24 hours. Addition of ZnO can increase the tensile strength of the SB membrane because the crystalline ZnO adds an amorphous membrane tensile strength value of SB. With the increased mechanical properties of the membrane, the membrane will be better when diguanakan (Setiawan, 2012)

Table 2 Tensile strength of SB / ZnO membrane

Membrane Type	Surface Area (mm^2)	F_{max} (N)	K_T (N/mm^2)
0% ZnO	75	13.3708	0.178277
0,1% ZnO 2 hours	75	32.5658	0.434211
0,1 % ZnO 24 hours	75	25.0174	0.333565
0,2% ZnO 2 hours	75	25.822	0.344293
0,2 % 24 hours	75	22.9644	0.306192

Decolorization of RB 5

From result of rejection also got result of measurement of RB dye 5. In processing with membrane of BC / ZnO this color decline happened very significant. The following table illustrates the efficiency of RB 5 dye removal based on BC / ZnO membrane variation.

Table 3 Decolorization of RB 5

Type of Membrane	Without UV			With UV		
	20 ppm	40 ppm	60 ppm	20 ppm	40 ppm	60 ppm
0% ZnO	93.57%	81.34%	83.83%	93.59%	92.75%	83.41%
0,1% ZnO 2 hours	97.76%	94.62%	87.95%	95.96%	97.52%	97.97%
0,1 % 24 hours	87.00%	96.77%	98.61%	96.70%	97.20%	99.09%
0,2% ZnO 2 hours	96.45%	88.44%	96.44%	95.16%	85.89%	92.39%
0,2 % 24 hours	92.45%	83.47%	88.06%	96.59%	97.40%	86.95%

Based on the data table 3 can be seen that with the addition of ZnO obtained higher removal efficiency of RB 5 dye. However, the longer period of immersion does not indicate a higher allowance this is caused by ZnO excessive that causes agglomeration which ultimately cover the surface of membrane pores.

Figure 6 Decolorization of RB 5 20 ppm

Figure 7 Decolorization of RB 5 40 ppm

Figure 8 Decolorization of RB 5 60 ppm

Table 4. The coefficient value of determination in photocatalytic membrane reaction of Boharts-Adam equation

Concentration of RB5 (mg/L)	k'	a_0	R^2
20	57,90 x 10^{-5}	15458	0.9713
40	41,92 x 10^{-5}	16447	0.8496
60	16,52 x 10^{-5}	57285	0.9249

4 CONCLUSION

Based on the results of the experiment it can be concluded that the SB / ZnO membrane is capable of reducing the RB 5 dye and has the potential to process textile waste into recycle water (reuse water) which can be used for processes requiring intermediate water. The optimum condition of the SB membrane was by adding ZnO of 0.1% 24 hours immersed time. The optimum waste concentration to be processed is at 20 mg / l and at the operating pressure of 8 atm. The kinetics used to describe the RB 5 removal mechanism is the Adam-Bohart kinetics model. With kinetic rate value (k ') 57,90 x 10^{-5} l / m.min and absorbance capacity (a0) 15458 mg / l and value R^2 equal to 97,13%.

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Time Motion Study of Municipal Solid Waste Transfer System in Bandung City

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Abstract. An increase of population in Bandung. Leads an increasing to municipal solid waste generation, and force the municipalities to make the system more efficient, including the transfer system as a part of the municipal solid waste management. Efficient means getting more with less capital (collect more garbage using less tools, less manpower and less time). So, time motion study of municipal solid waste transfer system was needed because it is important to know the time consumed for doing the motion element of municipal solid waste transfer system. The main objective of this study was to measure the time consumed and to determine which scenario that less time consuming. The results of the time motion study showed that between a different type of transfer system, the time consumed was different. Motion time for collection vehicle at SCS (Stationary Container System) transfer station was less than HCS transfer station because the process of garbage unloading at HCS (Hauled Container System) transfer station consume more time. So, it is recommended for Bandung city to use HCS type of transfer station.

Keywords: *hauled container system, municipal solid waste, stationary container system, time motion study, transfer system*

1 Introduction

The number of people in Bandung, which continues to grow from year to year, Leads to an increase in municipal solid waste (garbage) generation. Increasing in MSW generation is a major factor that led a challenge in waste management for municipalities in developing countries (Guererra et al [1]). According to Bentes et al [2], increasing of the waste amount, forcing the municipalities to make the municipal solid waste management system more efficient, technically feasible, environmentally effective and have a sustainable economic principle. With increasing of municipal solid waste generation from year to year, municipalities in Bandung constantly working to improve the performance of municipal solid waste management to be more efficient. Meanwhile, according to Essien et al [3], efficiency means getting more with a little capital (collect more waste using less tools, less manpower and less time). To determine the effectiveness of municipal solid waste management requires monitoring and evaluation of the system (Matsui et al, [4]).

According to Minister of Public Works Regulation no. 3 year 2013 concerning the Implementation of Household Waste and Household Waste and Household Waste Handling Utility [5], garbage collection and transport using direct system or using a transfer system/indirect system, the transport process can use a container load system (Hauled Container System = HCS) or fixed container system (SCS). According to PD Kebersihan [6], Bandung has 184 transfer station and 162 units of container. Therefore, as part of the efforts to find a garbage collection system that is most efficient for Bandung City reviewed from the time consumed, time motion study of municipal solid waste transfer system was needed.

2 Methodology

This study was conducted in Bandung, West Java Province Indonesia. The number of samples for this study were 8 samples of municipal solid waste transfer station in Bandung city (Pasar kordon, Karasak, Cicaheum statiun, Patrakomala, Palasari, Gudang Selatan, Sadang Serang, and Orari), these samples was chosen because it the type and the area of transfer station would represent every type of transfer station in Bandung city, the sample location shown in **Figure 1**.

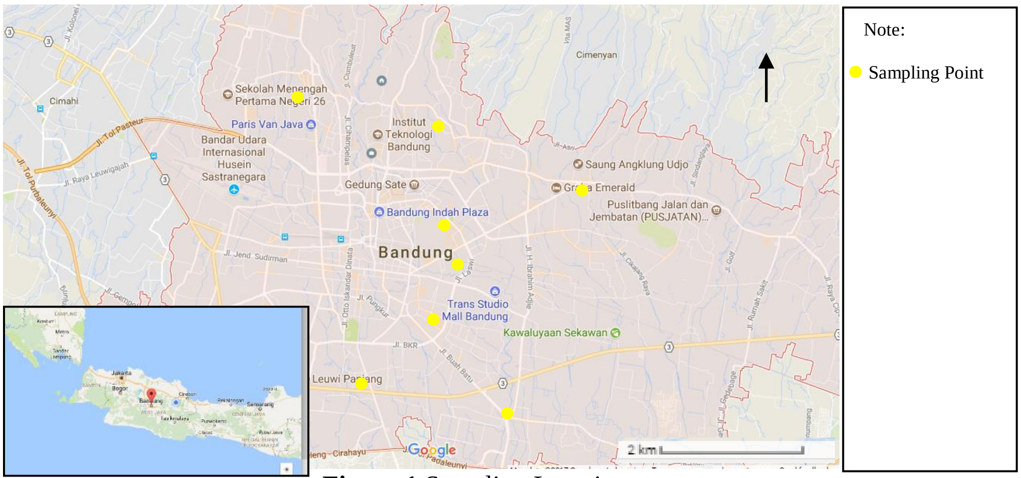

Figure 1 Sampling Location
Source: google corp [7]

For doing time motion study of municipal solid waste transfer in Bandung city. First, the general motion elements of MSW transfer system were determined.

Then, the samples were followed in two days of municipal solid waste transfer activity to monitor the movement time of each motion element. In this study the movement time was monitored by video recording and stop watch, and the garbage weight was measured using weigher.

3 Result and Discussion

3.1 Motion Elements of Municipal Solid Waste Transfer System Identification

3.1.1 Motion Elements of Collection Equipment

Motion elements of collection equipment at transfer station were (**Figure 2)**:

a. Waiting in line, this element happened usually because there was no enough space to unload the waste from all of the collection equipment or the transfer station had been full of waste, so to unload the waste the operator need to wait for truck to come and take the waste
b. Parking was the collection equipment movement from the parking point to the point near the container or waste pile
c. Maneuver is adjusting the position of the collection equipment with the container to make the process of waste unloading easier.
d. Unloading is an activity when garbage is unloaded from collecting equipment and inserted into container at transfer station.
e. Wasted time is time spent for activities that was not related to waste transfer such as drinking, eating, chatting or going to the toilet.

parking maneuver unloading

Figure 2 Motion elements of collection equipment

3.1.2 Motion Elements of Truck

Motion element of transfer truck at transfer station were (**Figure 2)**:

a. Parking was the truck movement from the parking point to the point near the container or waste pile.

b. Arrival Maneuver is adjusting the position of the collection equipment with the container to make the process of waste unloading easier.
c. Loading is activity when container dump truck is filled by garbage from transfer station (SCS) or when arm roll truck put the empty container and take the full container
d. Covering with a net is an activity after the truck is finished being filled with garbage then the trash in the container of the truck is covered by a tarpaulin and a net so that when it is transported to the landfill it would not fall or hit by rain water.
e. Departure Maneuver is the activity of adjusting the position of the carrier to finally depart from of the transfer station and go to the landfill.
f. Wasted time is time spent for activities that was not related to waste transfer such as drinking, eating, chatting or going to the toilet.

parking arrival maneuver

Loading covering departure maneuver

Figure 3 Motion elements of truck

3.2 The Result of Municipal Solid Waste Transfer System Time Motion Study

3.2.1 Movement Time of Collection Equipment at Transfer Station

Movement time of collection equipment at transfer station is shown in **Table 1.**

Table 1 Movement time of collection equipment at transfer station

Equipment Type	Transfer Station Type	Motion Elements	Time (Min.)	SD	Velocity (ton /min)	SD
Cart	HCS	Waiting in Line	11.37	2.25	-	-
		Parking	0.37	0.25	-	-
		Unloading	37.85	13.49	11.12	2.82
		Wasted	50.11	15.17	-	-
		Total	90.74	13.12	-	-
	SCS	Waiting in Line	14.78	4.18	-	-
		Parking	0.78	0.18	-	-
		Unloading	21.59	17.17	16.21	3.01
		Wasted	39.26	9.77	-	-
		Total	78.51	10.53	-	-
Motorcycle	HCS	Waiting in Line	21.11	3.32	-	-
		Parking	1.11	0.32	-	-
		Maneuver	0.35	0.12	-	-
		Unloading	41.99	16.13	15.31	2.43
		Wasted	53.42	10.50	-	-
		Total	99.22	15.63	-	-
	SCS	Waiting in Line	18.69	6.25	-	-
		Parking	0.69	0.25	-	-
		Maneuver	0.46	0.16	-	-
		Unloading	27.86	11.36	19.20	2.01
		Wasted	21.22	7.67	-	-
		Total	67.25	13.15	-	-
Pick Up Car	HCS	Waiting in Line	14.76	1.54	-	-
		Parking	0.11	0.05	-	-
		Maneuver	0.74	0.17	-	-
		Unloading	59.77	12.41	18.44	2.31
		Wasted	30.21	9.31	-	-
		Total	70.81	16.77	-	-
	SCS	Waiting in Line	1.53	0.46	-	-
		Parking	0.19	0.03	-	-
		Maneuver	0.67	0.16	-	-
		Unloading	40.05	15.22	25.71	3.04
		Wasted	0.71	0.21	-	-
		Total	63.45	12.53	-	-

Table 1 show that there is no significant difference of waiting in line time for each type of equipment and the type of transfer station, the average time was about 17.5-1.5 minutes but it was different for pick up car at SCS type of transfer station, the time was about 1.53 minutes. This could happen because the sample that using pick up car was only one sample, and the sample operates at the time although the density of transfer station was quite high, at 5:00 a.m. to 06:00 a.m,

but the container hadn't been filled and even though the container had already been filled, another truck with empty container usually would come at 06:00 a.m.

There was no significant difference for maneuvering time of different equipment type and transfer station type, the average time was about 0.2-0.7 minutes. This could happen because of the skill from the operator to maneuver the equipment could affect the time consumed as Essien et al [3] said that operator skill affect the time consumed to operate the truck.

Unloading time at SCS transfer station tends to be faster than at HCS transfer station. This could be due to the height of the container at the HCS transfer station which complicates unloading process. In addition, the unloading process from a cart was faster than from a motorcycle or pick up car. This can happen because the container volume on the car is bigger so it can contain heavier garbage than in a motorcycle and a cart so that the unloading of the waste must be spending more time (Rochaeni [8]). But if the weight was measured and the velocity was calculated, the type of equipment didn't affect the process.

There was no significant difference of wasted time for each type of equipment and transfer station, the average wasted time is about 15-60 minutes but it was different for the car at SCS transfer station, the time was about 0.71 minutes. This could happen because the sample using the car was only one sample, and the sample operates at 05.00 a.m. to 06.00 a.m., one day after the garbage collection.

The total time at the transfer station for pick up car was faster than a cart and a motorcycle. This was because of pick up car operates at SCS transfer station around 05:00 a.m. to 06:00 a.m., so that the container was not full and garbage can be directly unload (the waiting in line time was faster). In addition, for the total average time required for SCS transfer station was faster than HCS transfer station, this was because the time required for unloading at SCS transfer station was less than HCS transfer station so it affects total time in transfer station.

3.2.2 Movement Time of Truck at Transfer Station

The movement time of truck was shown in **Table 2**.

Table 2 shows that the total truck activity time at HCS transfer station is less than SCS transfer station this was due to the time required for loading at SCS transfer station was longer than HCS transfer station. In addition, the number of operator at SCS transfer station also affecting the total time of truck activities at transfer station, with more operator, the time consumed was faster especially in loading process.

Table 2 The movement time of truck

Transfer Station Type	The Number of Operator	Motion Element	Time (Min.)	SD	Velocity (ton/min.)	SD
HCS	2	Parking	2.88	1.19	-	-
		Arrival Maneuver	1.53	0.46	-	-
		Loading	3.96	1.22	2.74	0.54
		Covering	14.21	3.65	-	-
		Departure Maneuver	3.51	1.52	-	-
		Wasted	14.56	4.52	-	-
		Total	40.25	18.64	-	-
SCS	2	Parking	2.91	1.76	-	-
		Arrival Maneuver	1.76	1.02	-	-
		Loading	111.91	39.21	0.07	0.01
		Covering	13.42	2.54	-	-
		Departure Maneuver	1.03	0.34	-	-
		Wasted	9.50	1.32	-	-
		Total	130.55	33.41	-	-
	5	Parking	2.76	1.3	-	-
		Arrival Maneuver	2.19	0.91	-	-
		Loading	73.22	11.24	0.13	0.04
		Covering	10.21	2.73	-	-
		Departure Maneuver	1.12	0.12	-	-
		Wasted	14.15	4.19	-	-
		Total	101.76	21.34	-	-

4 Conclusion and Recommendation

From time motion study conducted on municipal solid waste transfer system in Bandung, it could be concluded that:

a. Type of transfer station and affected the time consumed for collection equipment activity at transfer system. At SCS transfer station, unloading activity would be faster than in HCS transfer station.
b. The type of transfer station affects the time consumed for truck activity at the transfer station. The loading process at HCS transfer station was faster than at SCS transfer station. In addition, the number of operator at SCS transfer station also affecting the total time of truck activities at transfer station, with more operator, the time consumed was faster especially in loading process.

From the time motion study on the transfer system it is known that the most technically efficient transfer system reviewed from the time of the collection equipment was SCS transfer station while when reviewed from the time for the truck was HCS transfer station.

Therefore, it is recommended for Bandung city to use HCS transfer station and to reduce the time consumed for collection vehicle at HCS transfer station, it is necessary to build transfer depo. So, for unloading the waste from collection vehicle at HCS transfer station, the operator just need to drop the garbage just like at SCS transfer station.

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Leachate Treatment Using Anaerobic-Aerobic Biofilter and Denitrification Process

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Abstract. Most of the leachate treatment in Indonesia using pond system, that is maturation ponds, anaerobic ponds, stabilization ponds, and continued using wetland. The weakness of this technology is long retention time between 30-50 days, thus the pond requires a large area. In addition, the processed leachate still do not meet quality standards that are allowed to be discharged into the environment. To overcome these problems, one alternative is to use a combination of processing leachate within anaerobic-aerobic biofilter and denitrification. The technology is expected to shorten the retention time so that the land required for the processing of leachate is not too extensive. The processed leachate is also expected to meet the quality standards are allowed to be discharged into the environment. The experiments were conducted by using two fixed bed anaerobic reactors with effective volumes of 60 liters each, two fixed bed aerobic reactors with 40 liters and 10 liters volumes, and a denitrification reactor with a volume of 5 liters filled with limestone and sulfur. Both anaerobic and aerobic reactor are filled with a honeycomb type plastic media. The experiment Results show that leachate treatment using anaerobic - aerobic biofilter and the denitrification process with a total hydraulic retention time of 12 day, the retention time in the anaerobic reactor 8 (eight) days , the retention time in the aerobic reactor 3 (three) days and retention time in the denitrification reactor 1 (one) day can be generated COD removal efficiency of 97 %, ammonia removal efficiency of 97.56 %, TSS removal efficiency 87.5 % , and nitrate removal efficiency of 86.4 %

Keywords: *Anaerobic, Aerobic, Biofilter, Denitrification, Leachate.*

1 Introduction

The main environmental problem at the site of the landfill of waste is the infiltration of leachate water and will further contaminate the surrounding soil and aquifer. Improvements in the field of landfill technology are aimed at reducing the production of industrial water, collection and treatment of leachate water before disposal into public waters [1] (Farquhar, 1989). Currently, waste management in Indonesia, especially domestic waste, mostly using sanitary landfill system. Under these conditions of management, most waste is only piled up in an open landfill area. So that when it rains, the waste water seepage known as leachate water will come out. And if not managed and processed properly, it will potentially pollute the surrounding environment. In most landfills, leachate water is formed by seepage of moisture content in the waste as well as by external sources such as the influence of drainage, rainwater and so on through the waste pile. Leachate water contains suspended and dissolved solids, organic and inorganic chemicals contained in high concentrations of waste such as Ammonia, Nitrate, Nitrite, Sulfide, heavy metals, nitrogen and so forth. With the high concentration of pollutants, the potential for environmental pollution is enormous.

Leachate treatment of most of the landfill in Indonesia, still using the pond system, which is using the anaerobic pond, aerobic pond, stabilization pond, and continued by using wetland [2]. The weakness of the system requires a relatively long residence time between 30 - 50 days, so the pond requires a large area. In addition, the processed leachate still does not meet the quality standard that is allowed to be discharged to the environmental. One of the alternatives to overcome these problems is to develop leachate processing technology using anaerobic - aerobic biofilter and denitrification system. With the technology is expected to shorten the residence time, so the land needed for leachate treatment is not too broad. Processed leachate products are also expected to meet the quality standards that are permitted to be discharged to environmental bodies. The research objectives are to examine the effectiveness of leachate treatment with anaerobic-aerobic biofilter and the denitrification process using limestone and sulfur.

2 Characteristics and General Condition of Leachate Treatment In Indonesia

Leachate is a liquid waste that arises from the entry of external water into the pile of waste/garbage, dissolving and rinsing dissolved matter, as well as organic matter from the biological decomposition process. From there it can be predicted that the quantity and quality of leachate water will vary greatly and fluctuate [3] (Rowe, 1997). Leachate water can be defined as a liquid that infiltrates through a pile of waste and has extracted both dissolved and suspended materials [4] (Tchobanoglous, 1993). In most landfills, leachate water is formed from liquids entering landfill areas from external sources, such as surface drainage, rainwater, groundwater, and liquids produced from waste decomposition, whereas leachate water generated from moisture content from the waste can be ignored in the calculation because the amount is relatively small. The quality of leachate varies greatly depending on garbage composition, the age of garbage, climate, and hydrogeology [5] (Keenan, 1984). Leachate has distinctive characteristics, namely high organic content, metals, acids, dissolved salts, and microorganisms.

Such characteristics make leachate extremely dangerous for the environment with potential for contamination in excess of some industrial waste.

The characteristics and quantity of leachate are influenced by several characteristics such as garbage characteristics and composition, landfill cover type, season, pH and humidity, and age of landfill. Characteristics of leachate in Indonesia taken from several cities in Indonesia based on landfill age can be seen in Table 1 [2]. In general, leachate derived from the new waste pile has a very high BOD and COD, but the longer the landfill, the quality of landfill leachate will also decrease. Leachate has a high nitrogen content and high conductivity, it is due to a number of minerals dissolved by the leachate flow, so that the conductivity becomes high. The concentration of heavy metals is sometimes high and the color is light brown to black that is difficult to remove.

Leachate treatment plants in the landfill area in Indonesia, in general, has not operated in accordance with the existing technical criteria. Some of the things that cause less optimal of the operations leachate treatment in landfill area are limited funds allocated for the operation and maintenance of leachate treatment plant in the landfill, limited human resources who are competent to operate leachate treatment plant, there is no good control and monitoring for leachate treatment plant operations, and less attention to policy makers in the landfill [2]. Most of the leachate treatment in Indonesia is still using the pond system due to low operational costs but requires a long retention time. For anaerobic ponds require a residence time of 20 to 50 days with a BOD removal efficiency of 50 - 85%, facultative ponds require 5 to 30 days of residence with BOD removal efficiency of 70-80%, while the maturation pool requires 7-20 days' residence time with removal efficiency BOD 60-89% [2].

Table 1. Characteristics of leachate in Indonesia based on landfill age

Parameter	Units	Landfill Age		
		1 Year	5 Years	16 Years
BOD	mg/L	7,500 – 28,000	4,000	80
COD	mg/L	10,000-40,000	8,000	400
PH		5.2-6.4	6.3	-
TDS	mg/L	10,000-14,000	6,794	1,200
TSS	mg/L	100-700	-	-
Specific Conductance	microhms/cm	600-9,000	-	-
Alkalinity ($CaCO_3$)	mg/L	800-4,000	5,810	2,250
Hardness ($CaCO_3$)	mg/L	3,500-5,000	2,200	540
Total P	mg/L	25-35	12	8
Ortho P	mg/L	23-33	-	-
NH_4-N	mg/L	56-482	-	-
Nitrate	mg/L	0,2-0,8	0,5	1,6
Calsium	mg/L	900-1,700	308	109
Chloride	mg/L	600-800	1.330	70
Sodium	mg/L	450-500	810	34
Potassium	mg/L	295-310	610	39
Sulfate	mg/L	400-650	2	2
Mangan	mg/L	75-125	0.06	0.06
Magnesium	mg/L	160-250	450	90
Ironi (Fe)	mg/L	210-325	6.3	0.6
Zinc (Zn)	mg/L	10-30	0.4	0.1
Copper (Cu)	mg/L	-	<0.5	<0.5
Cadmium	mg/L	-	<0.05	<0.05
Lead (Pb)	mg/L	-	0.5	1

Source : Annonim-1, 2012.

3 Material And Research Methodology

3.1 Research Sites

The research was conducted in the laboratory of Center for Environmental Technology, Agency for Assessment and Application ofTechnology at Puspiptek Serpong – South Tangerang.

3.2 Tools and Materials

3.2.1 Materials

The materials used in this research are:

a. Leachate : Leachate to be processed is leachate from the Bantar Gebang landfill Area.
b. Biological Sludge : Biological sludge used is obtained from the process of bacterial culturing in a reactor that has been filled with a plastic honeycomb tube medium as a place of microbial attachment. The bacteria breeding process is done by using domestic wastewater, which is circulated into the reactor for one week, then in leach water leachate gradually. The microbial breeding process carried out for one month.
c. Sulfur rocks : Sulfur rocks are used as a buffer medium in a denitrification reactor. The sulfur rock in this bioreactor acts as a proton donor (H +) which will react with the nitrate compound to turn into the intermediate compound nitrite, and eventually into nitrogen gas.
d. Limestone Rock : In addition to sulfur rocks, in denitrification bioreactors are also filled with limestone used as a buffer medium. Limestone serve as alkalinity suppliers of wastewater, making the pH neutral.

3.2.2 Process Equipment

The equipment used in this research is bench scale reactor consisting of:

a. Anaerobic Bioreactor : The anaerobic bioreactors used in this study were rectangular-shaped bench scale reactors, made of an acrylic material with dimensions of 30 cm long, 15 cm wide, and 150 cm high. Inside the reactor is filled with a honeycomb type plastic media that serves as a media attachment of microbes. In this study used 2 (two) units of the anaerobic bioreactor.
b. Aerobic Bioreactor : The aerobic bench scale bioreactor used in this study is rectangular and made of acrylic material. This bioreactor has dimensions of 20 cm long, 15 cm wide, and 150 cm high. Similar with anaerobic bioreactors, aerobic bioreactors are also filled with a honeycomb type plastic biofilter media. Other equipment in the bioreactor are blowers and a diffuser that serves to exhale air.
c. Denitrification Bioreactor : Denitrification reactor used has a volume of 5 liters, rectangular shape and made of plastic material. In this bioreactor is filled with sulfur rock and lime rock as a microbial buffer medium.

3.2.3 Experiment Procedure

The research was conducted using a Bench Scale reactor with a combination of anaerobic-aerobic biofilter process with a honeycomb type plastic medium, and denitrification process with sulfur and limestone filling media. The first waste is pumped into a settling bath which aims to precipitate solid particles before entering the biological reactor. After that waste water is fed to the anaerobic biological reactor. In this reactor, the wastes are contacted with microorganisms attached to biofilter media in the absence of air (anaerobes). Then the waste into the aerobic biological reactor and then flowed to the denitrification reactor. The diagram of leachate treatment with anaerobic-aerobic biofilter and denitrification process with sulfur and lime filling media can be seen in Figure 1.

4 Result And Discussion

Experiments were conducted for approximately 3 months, using a continuous bench scale reactor of anaerobic- aerobic biological processes and denitrification. In the early stages, microbial seeding is done in the anaerobic - aerobic biofilter reactor. Microbes used for seeding process, taken from the domestic wastewater treatment plant at Geostek Building-Puspiptek Serpong. The process of bacterial culture in the reactor is carried out by using domestic wastewater that is circulated into the reactor for one week, then the leachate is loaded into the reactor.

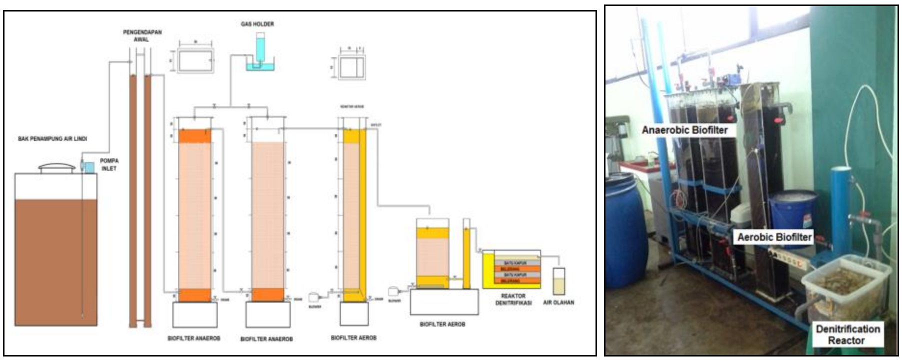

Figure 1. Diagram of leachate treatment process using anaerobic-aerobic biofilter process and denitrification process filled with sulfur and limestone.

4.1 Anaerobic Processes

In this research used 2 units of an anaerobic reactor. Each tank, filled with honeycomb type plastic biofilter media that serves as a place of microbial attachment. The retention time in each anaerobic reactor is 4 days. So the total retention time in the anaerobic reactor is for 8 days. With a retention time of 8 days, the removal efficiency of COD in the anaerobic reactor was 90.16%. The mean inlet COD concentration was 7847.69 mg/L and the anaerobic outlet concentration was 754.50 mg/L. While for Total Suspended Solid (TSS), the removal efficiency in the anaerobic reactor was 16.1%, with an average inlet concentration of 374.76 mg/L and an average outlet concentration of 314.50 mg/L.

Nitrogen parameters analyzed in this study include ammonia, nitrite, and nitrate. For ammonia and nitrate parameters, the efficiency of the decrease in anaerobic reactors for each parameter was 61.7% and 91.8%. As for nitrite parameters, an increase of average inlet concentration of 19.82 mg/L to 48.64 mg/L at the average outlet concentration of anaerobic reactor.

4.2 Aerobic Process

Such as anaerobic process, in the early stages of the study carried out acclimatization of microbes first using domestic waste from WWTP Geostek Building. Originally retention time in the aerobic reactor was 2 days, but because the concentration of COD outlet of the aerobic reactor was almost the same as the COD concentration of anaerobic outlet, so did the addition of aerobic reactor capacity. So the total retention time for the aerobic reactor is for 3 days. The addition of the aerobic reactor was conducted on November 7, 2014, or on the 11th day of the study.

With the retention time, able to reduce COD to 96.9%. The average COD concentration of outlet on the aerobic reactor was 238,60 mg/L. While the efficiency of TSS decrease was 79.2%, with average outlet concentration of 77.77 mg/L. The efficiency of ammonia decrease in the aerobic reactor was 94,1% with average ammonia outlet concentration 172,43 mg/L.

4.3 Denitrification Process

The function of the denitrification process is to reduce the nitrate and nitrite contained in leachate water. In denitrification reactor used sulfur and lime rocks. Sulfuric rocks serve as proton donors (H^+) which will react with the nitrate compound to turn into intermediate compounds ie nitrite, and eventually into nitrogen gas. In our research, the denitrification process uses a unique way of reacting nitrate and nitrite with sulfur rock and lime rock with the help of autotroph microbes.

The retention time in the denitrification reactor for 1 day, able to decrease the ammonia concentration up to 94,6% with average outlet concentration equal to 160,03 mg/L. The efficiency of nitrate reduction was 87.5% with an average outlet concentration of 224.22 mg/L. For COD concentrations of denitrification reactor outlets, not too far away with aerobic reactor outlets. This is because the function of this denitrification reactor aims to reduce the content of nitrite and nitrate in leachate water. The concentration of COD outlet at this reactor was 238,60 mg/L.

4.4 Efficiency of Anaerobic-Aerobic Processing Process and Denitrification

In this study, the total residence time used was 12 days, ie retention time in anaerobic reactor 8 (eight) days, the retention time in aerobic reactor 3 (three) days and denitrification reactor 1 (one) day. From the results of the above study, it is seen that the concentration of COD from 7847.69 mg/L decreased to about 238.60 mg/L with an average removal efficiency of 97%. For TSS parameters, Inlet concentration of 374.76 mg/L dropped to 54.87 mg/L with a removal efficiency of 85.4%. The percentage decrease of ammonia and nitrate are respectively 94,6% and 87,5%.

4.4.1 Concentration of COD

The result showed that the average COD inlet concentration was 7907,65 mg/L, Anaerobic COD 774,82 mg/L, Aerobic COD 473,41 mg/L, and COD Denitrification equal to 129,38 mg/L. Graph of inlet and outlet COD concentrations as well as the treatment efficiency of each reactor can be seen in Figure 2.

From the figure can be seen know that the efficiency of COD processing on the anaerobic reactor is above 90%. This indicates that the microbes in the reactor have functioned optimally. But the efficiency of COD concentration in an aerobic reactor at the beginning of the study was very small, under 5%. This is because the residence time in the aerobic reactor is less. On the eleventh day of the study, an aerobic reactor was added so that the total residence time in the reactor would be 3 (three) days. With the addition of aerobic reactor, the efficiency of COD processing in aerobic reactor becomes high, that is 81,59%. From the biological processing sequence, anaerobic - aerobic and denitrification biofilter, average COD total processing efficiency with a residence time of 12 days (residence time in anaerobic reactor 8 days, 3-day aerobic reactor and 1-day denitrification reactor) is 98,33%.

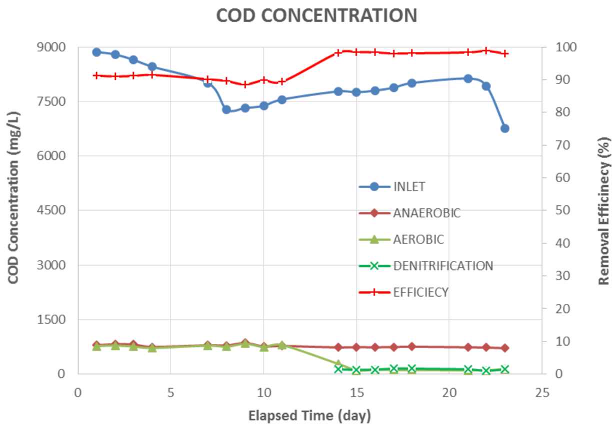

Figure 2. COD concentrations

4.4.2 pH Water Before and After Processing

Leachate characteristics in Bantar Gebang landfill, tend to be alkaline. From the observation of pH during the research it can be seen that the average pH of inundation leachate is 8,59, mean pH value for anaerobic biofilter is 8,5 and aerobic biofilter is 7,8. But when it goes into the denitrification reactor, the pH value rises to 10.6. This is because the waste is contacted with alkaline limestone rocks, and sulfate rock that serves as an H^+ donor has not functioned optimally at the beginning of the study. On the 21st day, the pH of wastewater discharged from the denitrification reactor gradually declined, albeit still alkaline. The pH observation chart of each reactor during the study can be seen in Figure 3

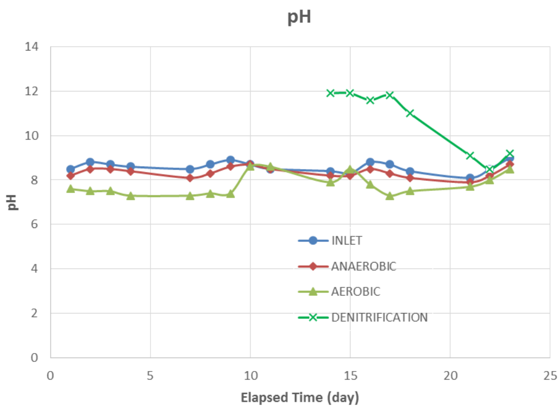

Figure 3. The pH observation chart of each reactor during the study.

4.4.3 TSS concentrations

The graph of TSS concentration in each reactor and its processing efficiency can be seen in Figure 4.

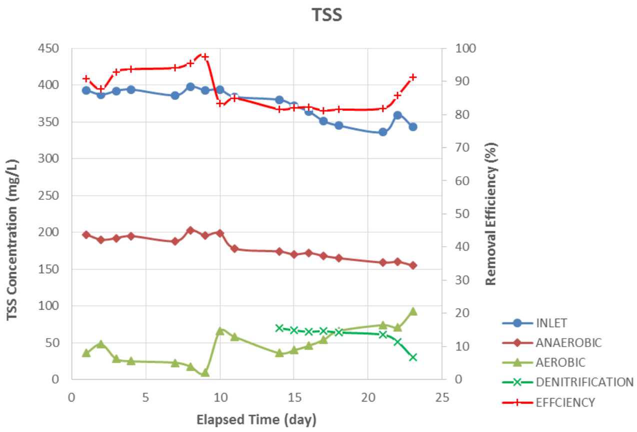

Figure 4. TSS Concentration

The average concentration of TSS (Total Suspended Solid) contained in the leachate during the research process amounted to 374.8 mg/L. After going through an anaerobic-aerobic biofilter process, the mean TSS concentrations decreased to 180.1 mg/L and 46.6 mg/L, respectively. So the total processing efficiency in the anaerobic-aerobic biofilter is 87.57%.

The use of denitrification reactors started on the 11th (eleven) days of the study. At the beginning of the waste into the denitrification reactor, the TSS concentration coming out of the denitrification reactor actually increases. This is due to limestone rock used as a buffer medium has not reacted optimally with the waste, so that still formed limestone and sulfate deposits in the waste. But on the 18th (eighteenth) day of research, the efficiency of denitrification reactor processing increased up to 67.7%. So overall the average TSS processing efficiency using anaerobic-aerobic and denitrification biofilter is 87.5%.

4.4.4 Ammonia Concentration

Ammonia concentrations before and after the treatment of each reactor during the study can be seen in Figure 5.

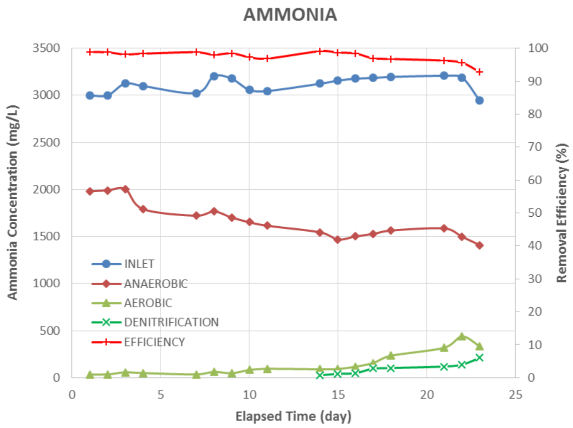

Figure 5. Ammonia concentrations before and after the treatment of each reactor

From the results of the study, it can be seen that the average of inlet ammonia concentration is 3113,12 mg/L, ammonia concentration of anaerobic reactor 1666,82 mg/L, concentration of ammonia aerobic 134,67 mg/L. The efficiency of ammonia processing in anaerobic, aerobic, and denitrification reactor are 46,4%, 91,35%, and 55,87%, respectively. While the total ammonia removal efficiency using anaerobic-aerobic biofilter and denitrification was 97.56%.

4.4.5 Nitrite Concentration

In conventional leachate treatment, the common problem that often happened is still high concentration of nitrate and nitrite at treated waater. Theoretically, the denitrification process present in wastewater treatment will generally take place under anoxic conditions where the ratio of COD is high nitrate, ie above 1: 10. Organic carbon will be used by conventional denitrification microbes as an energy source. In leachate water, generally the numbers are not sufficient, so the denitrification process can not take place perfectly. The impact that arises is the high concentration of nitrate and nitrite in the processed water.

In the process of biological processing, nitrification reaction occurs ammonium to form nitrite. This is why the concentration of nitrite in the anaerobic - aerobic biofilter reactor is higher than the concentration of nitrite in inlet waste. In addition, the condition of nitrite is also influenced by pH. When the pH of alkaline waste, the value of nitrite concentration tends to be high. The optimum pH for the denitrification reactor is 7.4 - 7.6. Nitrite concentrations in inlet, anaerobic reactor, aerobic reactor, and denitrification during the study can be seen in Figure 6.

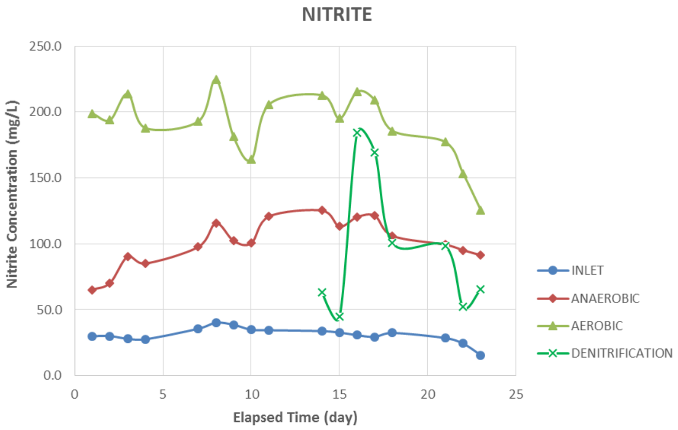

Figure 6. Nitrite Concentration.

4.4.6 Nitrate Concentration

The average concentration of Nitrate found in leachate during the research process amounted to 2627.24 mg/L. After going through an anaerobic-aerobic biofilter process, the mean TSS concentrations decreased to 475.71 mg/L and 357,08 mg/L, respectively. So the total processing efficiency in the anaerobic - aerobic biofilter is 86.41%.

The use of denitrification reactors started on the 11th (eleven) days of the study. At the beginning of the waste into the denitrification reactor, the efficiency of the reactor is 39.48%. But the next day the reactor efficiency fell drastically to 7%, this is because the microbial conditions in the reactor have not been stable. But on the 16th day onwards, the efficiency of nitrate gradually rose to over 60%. Nitrate concentration in leachate before and after processing in each reactor can be seen in Figure 7.

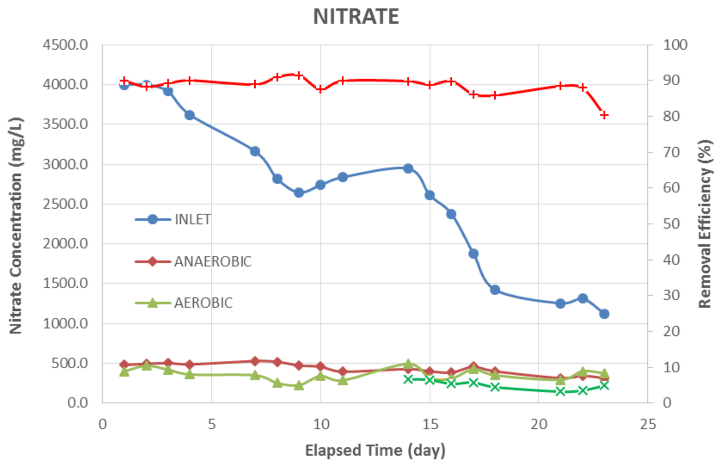

Figure 7. Nitrate Concentration

4.4.7 Sulfate Concentrations

The result showed that average inlet sulfate concentration was 67,47 mg / L, sulfate Anaerobic 57,0 mg /L, Aerobic sulfate 24,76 mg / L, and Denitrification sulfate 15,13 mg / L. Sulfate concentrations before and after processing, as well as the treatment efficiency of each reactor during the study can be seen in Figure 8. It can be seen that the efficiency of sulfate processing in the anaerobic reactor is still below 20%. The highest percentage of sulfate processing occurred in aerobic reactor, ie 56.75%.

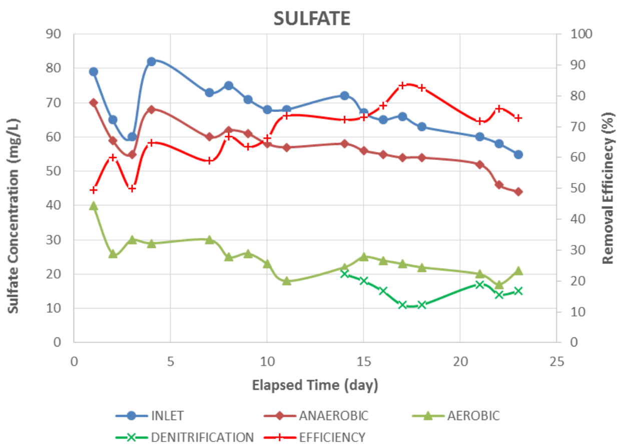

Figure 8. Sulfate Concentration

The sulfate concentration in the denitrification reactor is relatively low, indicating that the sulfur rock in this reactor has not worked optimally. This is evidenced by the still high pH bit in the denitrification reactor. Because the sulfur rocks here function as donor H^+ so that the pH of the denitrification reactor is neutral.

5 Conclusion

From research of leachate water treatment technology with the anaerobic-aerobic process and denitrification can be drawn the following conclusion:

a. Anaerobic process using biofilter reactor filled with honeycomb tube palstic media can reduce the content of organic pollutants in leachate. The efficiency that can be obtained is 90.16% with a residence time of 8 days.
b. Aerobic process using bioreactor filled with honeycomb tube palstic media, under 3 days residence conditions can reduce organic pollutants in leachate water to 81.59%
c. Leachate treatment with a combination of anaerobic-aerobic biofilter process and denitrification process with limestone and sulfur with a total residence time of 12 days ie residence time in anaerobic reactor 8 days, 3-day aerobic reactor and 1-day denitrification reactor can decrease COD concentration with total removal efficiency of 98.33%.
d. The combination of anaerobic-aerobic bioreactor and denitrification process can reduce nitrate compound contained in wastewater by 88.47%.
e. Denitrification reactors have not functioned optimally in reducing nitrite. The efficiency obtained in reducing nitrite is 48.12%. This is due to sulfur rocks that become reactor stuffing material has not function optimally.

Acknowledgement

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Effect of Co, Zn and Mn metal towards ethanol formation in anaerobic process of palm oil mill effluent (POME)

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Abstract. The palm oil is a significant contributor to Indonesia's economy and a vital employer to some region. Palm oil mill effluent (POME) is one of by product in palm oil industries and has potential to be utilized as a substrate for ethanol production by anaerobic processes. The anaerobic treatment produces by-products such as Total Volatile Acids (TVA), ethanol, and various gasses until acidogenesis stage. Microorganism needs micronutrients as environmental factors that affects anaerobic process, such as heavy metals. In this experiment, artificial POME has been used as a substrate and was added by Zn, Mn and Co as a micronutrient. The experiment using Circulated Bed Reactor (CBR) for 48 hours with sampling every 12 hour. The results showed that Zn, Mn and combination of Zn-Mn produced the highest ethanol with the concentration is 9353.84 mg/L.

Keywords: *anaerobic process; ethanol; metal addition; palm oil mill effluent; total-volatile acid.*

1 Introduction

Palm oil industry has been a significant economic contributor for countries such as Malaysia, Thailand, Indonesia, Colombia, and other tropical countries. When high export and production has been documented in almost every literature of palm oil or Palm Oil Mill Effluent (POME) treatment, it is no wonder such heavy production of this effluent has become the source of water pollution [4]. POME is a wastewater produced from empty palm bunch extraction in palm oil mill. Typical characteristics of POME is shown at Table 1. The effluent is in form of a thick, brownish liquid with high level of BOD and COD [3].

Hence, Indonesia as maritime country that is transitioning towards industrial country faces a challenge regarding energy supply. For the last 10 years (2003 – 2013), Indonesia's final energy consumption has experienced significant growth from 79 million Tonnes Oil Equivalent (TOE) to 134 million TOE, or in average 5,5% growth per year [10]. This phenomenon causes the shifting of trends of energy development towards environmental-friendly, with more concern are put towards renewable energy sector. The source of alternative energy is from vegetable sources. Renewable energy supply in Indonesia is experiencing fastest growth compared to other kind, whereas it has 40% increase along projection period until 2035 [10].

Table 1 Typical characteristics of POME

Parameter	Unit	Range
pH	-	4-5
Biological oxygen demand (BOD)	mg/L	25,000-65,714
Chemical oxygen demand (COD)	mg/L	44,300-102,696
Total solids (TS)	mg/L	40,500-72,058
Suspended solid (SS)	mg/L	18,400-46,011
Volatile solids (VS)	mg/L	34,000-49,300
Oil and grease (O and G)	mg/L	4,000-9,341
Ammonia nitrogen (NH_3-N)	mg/L	35-103
Total nitrogen (TN)	mg/L	750-770

The aim of this study was to determine effect of the metal addition such as Zn, Mn and Co for the ethanol production from the conversion of palm oil mill effluent (POME) by anaerobic processes.

2 Material and Method

2.1 Bioreactor and biomass

Preparation stage of the experiments includes apparatus and materials. Apparatus includes : *Circulating Bed Reactor* configuration, pumping system, N_2 gas tube. Reactor used made of *acrylic* with 13.5 cm diameter, and 45 cm height. The full volume of reactor is 6 L and its operational volume is designed to 3.5L. It is completed by 6 sampling ports and 1 port for air recirculation pump on the bottom part of reactor. In upper part there is also a hole for air recirculation pump, and also a gooseneck. The air recirculation, after nitrogen flushing, will keep the inside of the reactor oxygen free (anaerobic).

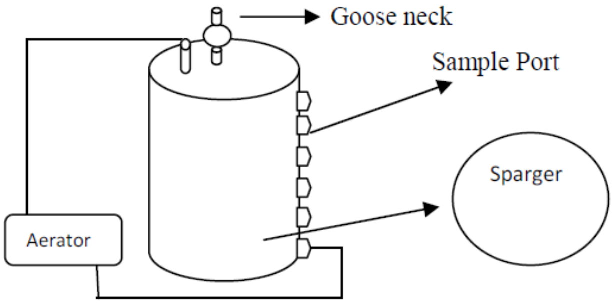

Figure 1. The scheme of *Circulating Bed Reactor* [7]

The characteristic of the artificial wastewater showed in **Table 2**.

Table 2. Formulas for artificial wastewater [2]

Components	Concentration (mg/L)	Components	Concentration (mg/L)
Starch (*grade* PA)	2,000	$NaHCO_3$	0.1571
Gelatin	3,000	$CdCl_26H2O$	0.00003
Oil - Grease	6,390	$MnCl_26H2O$	0.014
NH_4HCO_3	3.95	$ZnCl_26H2O$	0.0056
K_2HPO_4	0.6743	$CuCl_26H2O$	0.0047
$FeCL_36H2O$	0.5561	$CoCl_26H2O$	0.002
$MgCl_26H2O$	2	$CrCl_26H2O$	0.00078
$CaCl_26H2O$	1.721		

Anaerobic bacterial seeds comes from industrial palm oil wastewater ponds and cow's rumen with 1:1 ratio (%v/v). Bacterial enrichment is done in a media that comprised of glucose (20g/L) and *trace mineral* that consist of 448 mg/L K_2HPO_4; 2.256 mg/L NH_4HCO_3; 85mg/L $MgCl_2.6H_2O$; 4.83 mg/L $FeCl_3.6H_2O$; 0.444 mg/L $NiCl.6H_2O$; 0.402 $CoCl_2.6H_2O$ dan 0.036 mg/L $(NH_4)_6Mo_7O_2.4H_2O$. The research used organics artificial wastewater with characteristics that represents industrial palm oil wastewater based on Table 2.

The biomass utilized in this research has been acclimatized [2]. Biomass is kept in anaerobic reactor of 20 L volume. Acclimatization of microorganism is done through 3 stages of acclimatization with the amount of wastewater range to 30% and 100%. At the acclimatization stages, Volatile Suspended Solids (VSS) and Chemical Oxygen Demand (COD) was measured every 24 hours. The expected concentration of VSS is 2,000 – 4,000 mg/L with steady-state COD parameter showing the stability of biomass to adapt with artificial wastewater [9].

2.2 Experimental design

This research used three factor factorial design (n=3). During the research, the three factors used are heavy metals for enzyme cofactor such as Zn, Mn, and Co towards ethanol formation. In 2^3 factorial, those three heavy metals are given codes to be then put in experimental designs (other than controls without any metals addition). Table 3 and Table 4 shown the codes for each metal in order and the experimental design.

Tabel 3. Codes and concentrations of heavy metals [12]

Codes	Heavy Metals	Compounds	Concentrations (mg/L)
A	Zn	$ZnSO_4.7H_2O$	4
B	Mn	$MnSO_4.H_2O$	3
C	Co	$CoCl_2.6H_2O$	0.5

Tabel 4. Experimental Design

Variation	*Source*
1	I (Control)
2	A
3	B
4	AB
5	C
6	AC
7	BC
8	ABC

2.3 Reactor running

The reactor operational is done in *batch* condition at laboratory room temperature of 25-27^{o}C. The volume of fully-operational reactor is 3.5 L with ratio of artificial waste: biomass is 80 : 20. Before operational starts, nitrogen *flushing* flows through reactor to create anaerobic condition. The operational is done in 48 hours with grab sampling every t0 = 0, t1 = 12 hour, t2 = 24 hour, t3 = 36 hour, and t4 = 48 hour. For every variation, two reactors operational is utilized (duplication).

In this experiment there are six parameters measured for every sampling which is COD, pH, VSS, ethanol, TVA and DO.

2.4 Analytical statistics

In this experiment, data processing uses statistical method with three variance factor analysis (Zn, Mn, and Co metals). The purpose of factorial experiment is to determine the interaction among tested factors. The probability of interaction are positive response (synergize) or negative response. From this statistical analysis, it can be obtained the result to decide metal cofactor that affects ethanol forming in anaerobic POME wastewater treatment.

3 Results and Discussion

3.1 Seeding and acclimatization

The biomass used are those enriched by [2] and acclimatized. According to [9] the purpose of microorganism *seeding* is to multiply the amount of microorganism of experimental study by using VSS and COD parameter as a base. The result of *seeding* shows that VSS parameter has reach the level of 3,700-4,000 mg/L and decreasing of COD at 60% on day 6.

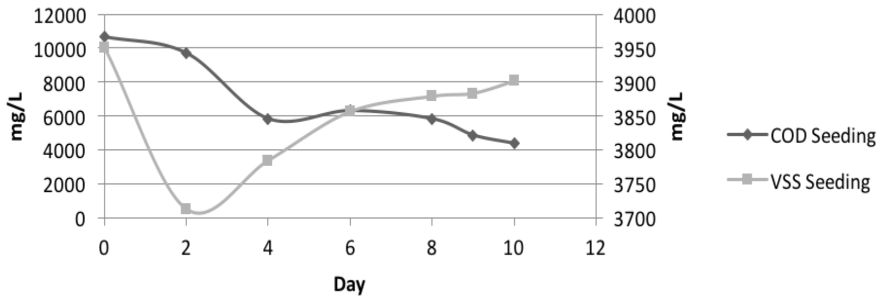

Figure 2. COD and VSS parameter during *seeding* process

The acclimatization phase is executed through 2 stages of acclimatization, which is 30% wastewater and 70% wastewater. Based on previous data of COD decrease which takes 6 days of time, every stage of acclimatization is done in 6 days accordingly. During the 6th day of every acclimatization phase, COD decreased in 56 - 60% amount until steady stage has been reached.

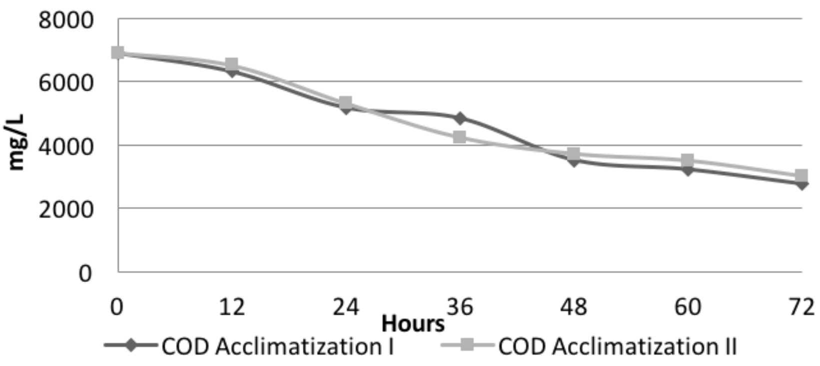

Figure 3. COD based on 2 acclimatization stage

Meanwhile, VSS parameter shows increasing value until day 6th with rate of increase is similar on every stage. The end result range of VSS is within 2,000 – 4,000 mg/L.

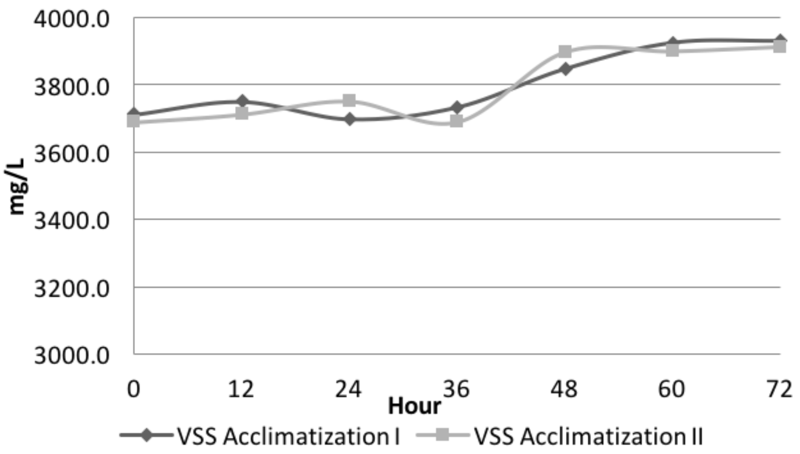

Figure 4. VSS based on 2 acclimatization stage

3.2 Reactor running

After biomass is ready to utilize, proceed to *running* preparation. The total volume that becomes system is 3.5 Litre, with ratio of artificial wastewater:

biomass equal 4:1 or 2.8 L:0.7 L. Beforehand, pH must be ensured to be inside the range of 6.2 – 7.6 because it is the optimum pH range for microorganism to degrade wastewater compound. If pH exceeds the limit which is 7.6, degradation still going but with lower efficiency of organic compound degradation, meanwhile pH below 6.2 will also lower the efficiency or organic compound degradation and produce acidic condition that blocks methanogen bacterial growth [13].

The system temperature is kept between room temperature, which is 24-27 ^{o}C. *Running* is done through duplication or two times of treatment, which are reactor A and reactor B. The total oxygen dissolved is below 0.9 mg/L, as for TVA increases until 36 hours and decreases until 48 hours. COD degradation varies from 27.3% to 90.91% the most efficient, while VSS increase during the start of 2,000-4,000 mg/L until the range of 6,000-8,000 mg/L on 48 hours. Meanwhile, ethanol measurement is fluctuating.

3.2.1 Heavy Metal Adition Effect Towards Formation of Total Volatile Acid

The 2^n statistical analysis is also used to assess the effect of metals addition towards TVA formation. This analysis is treated as *screening experiment* whereas the data obtained can be utilized as a basis for furthermore experiment. Factorial analysis aims to minimize the amount of experiment but still keeping the existing information for each factor. In this experiment, the hypothesis are following.

H_0: *the addition of X metals has no effect towards TVA formation*

H_1: *the addition of C metals has effect towards TVA formation*

As for zero or control condition (without addition of metals), the hypothesis is as follow.

H_0: *there is no TAV formation in the system without metals addition*

H_1: *there is TAV formation in the system without metals addition*

In this experiment, there are 3 factors being examined which are Co metals (C), Mn (B), and Zn (A), with each concentration is 0 and 0.5, 3, and 4 mg/L. There are 8 experiment variations based on 2^3 = 8 combinations.

Table 5. Treatments and TVA concentration

<table>
<tr><th colspan="3">Factor</th><th colspan="2">TVA concentration (mg/L)</th></tr>
<tr><th>Zn(A)</th><th>Mn (B)</th><th>Co (C)</th><th>RA</th><th>RB</th></tr>
<tr><td>0</td><td rowspan="2">0</td><td rowspan="3">0</td><td>960</td><td>960</td></tr>
<tr><td>4</td><td>2,304</td><td>2,304</td></tr>
<tr><td>0</td><td>3</td><td>1,344</td><td>1,344</td></tr>
</table>

Factor			TVA concentration (mg/L)	
4			1,920	1,920
0	0	0.5	1,536	1,920
4			1,728	2,304
0	3		960	768
4			960	1,344

Afterwards, RA and RB data is used to determined *Sum of Square* using *Table of Sign* [5] and *Yates* method [15]. The aims of these two different methods are to analyse whether there is or there is no error during calculation, based on whether the similarity of data obtained. From these two methods, it can be concluded that there is no difference found in *Sum of Square* values.

Table 6. Comparison result of TVA *Sum of Square* (SS)

SS Value	Methods		Remarks
	Sign Table	Yates	
SSA	2,076,672	2,076,672	Similar
SSB	995,328	995,328	Similar
SSAB	196,608	196,608	Similar
SSC	196,608	196,608	Similar
SSAC	602,112	602,112	Similar
SSBC	995,328	995,328	Similar
SSABC	196,608	196,608	Similar

Afterwards, F_{count} is calculated in each variation by using the significant value of 5% and 1%. The result is as shown in **Table 7**.

Table 7. Hypothesis testing towards TVA formation

Variation	df	SS	MS	Fcount	Ftable 5%	Ftable 1%	Remarks
1	1	50,331,648	25,165,824	809.09	5.32	11.26	Ho rejected
a	1	2,076,672	1,038,336	33.38	5.32	11.26	Ho rejected
b	1	995,328	497,664	16.00	5.32	11.26	Ho rejected
ab	1	196,608	98,304	3.16	5.32	11.26	Ho accepted
c	1	196,608	98,304	3.16	5.32	11.26	Ho accepted
ac	1	602,112	301,056	9.68	5.32	11.26	Ho accepted
bc	1	995,328	497,664	16.00	5.32	11.26	Ho rejected
abc	1	196,608	98,304	3.16	5.32	11.26	Ho accepted
Error	8	248,832	31,104	-	-	-	-
Total	15	-	-	-	-	-	-

Therefore, the conclusion of factorial statistics experiment is on following **Table 8**. Seeing from experiment results, it is observed that without any addition of metals, TVA formation happens. This is caused by the existing metals in artificial waste ingredients. The control experiment can be utilized as calibration control to see the effect of metals addition for higher amount of concentration. Meanwhile, it is observed that Zn metals, Mn metals, and combination of CoMn metals affect TVA formation. The highest TVA concentration observed is in addition of Zn metals with the value of 2,304 mg/L. In single addition, it is detected that Zn and Mn metals has effect statistically, but combination of both metals does not synergize to be classified as having an effect for TVA formation. The combination of Mn and Co metals also, where Co has no effect in single addition, affect TVA formation.

In order to see the correlations between metals cofactor screening towards ethanol formation, it has to be observed whether in this process *switching* happens. It is to see whether TVA formation has any effect towards ethanol formation. The basis can be referred using the *pathway* theory of anaerobic treatment, which consists by glycolysis stage, acidogenesis, and acetogenesis that becomes the focus of this experiment. The TVA that is measured in acetate has different pathway with ethanol formation.

Table 8. Hypothesis testing conclusions towards TVA formation

Metal Variations	Remarks	
1	Ho rejected	TVA exists in process without metals addition
A	Ho rejected	Zn metal affects TVA formation
B	Ho rejected	Mn affects TVA formation
AB	Ho accepted	ZnMn metals combination do not affect TVA forming
C	Ho accepted	Co metal does not affect TVA forming
AC	Ho accepted	ZnCo metals combination do not affect TVA forming
BC	Ho rejected	MnCo metals combination affect TVA formation
ABC	Ho accepted	ZnMnCo metals combination do not affect TVA forming

3.2.2 Heavy Metal Adition Effect Towards Formation Of Ethanol

The factorial analysis method on this experiment has some following hypothesis.

H_0: *the addition of X metals has no effect towards ethanol formation*

H_1: *the addition of C metals has effect towards ethanol formation*

As for zero or control condition (without addition of metals), the hypothesis is as follow.

H_0: *there is no ethanol formation in the system without metals addition*

H_1: *there is ethanol formation in the system without metals addition*

In this experiment, there are 3 factors being examined which are Co metals (C), Mn (B), and Zn (A), with each concentration is 0 and 0.5, 3, and 4 mg/L. There are 8 experiment variations based on 2^3 = 8 combinations.

Table 9. Treatment and ethanol concentration

Factor			Ethanol Concentration (mg/L)	
Zn (A)	**Mn (B)**	**Co (C)**	**RA**	**RB**
0	0	0	7,483.07	7,483.07
4			5,612.30	3,741.53
0	3		7,483.07	7,483.07
4			9,353.84	9,353.84
0	0	0.5	7,483.07	7,483.07
4			7,483.07	7,483.07
0	3		7,483.07	7,483.07
4			9,353.84	9,353.84

Afterwards, RA and RB data is used to determined *Sum of Square* using similar method. There is no difference found in *Sum of Square* values.

Table 10. Comparison between ethanol *Sum of Square* (SS)

SS Value	Method		Remarks
	Sign Table	**Yates**	
SSA	291,647.55	291,647.55	Similar
SSB	14,290,730.04	14,290,730.04	Similar
SSAB	14,290,730.04	14,290,730.04	Similar
SSC	2,624,827.97	2,624,827.97	Similar
SSAC	2,624,827.97	2,624,827.97	Similar
SSBC	2,624,827.97	2,624,827.97	Similar
SSABC	2,624,827.97	2,624,827.97	Similar

Afterwards, F_{count} is calculated in each variation by using the significant value of 5% and 1%. The result is as shown in **Table 11**.

Table 11. Hypothesis testing towards ethanol formation

Variation	df	SS	MS	Fcount	Ftable 5%	Ftable 1%	Remarks
1	1	1.232.210.907	616.105.453	3219.05	5.32	11.26	Ho rejected
a	1	291.647,552	145.823,776	0.76	5.32	11.26	Ho accepted
b	1	14.290.730,0	7.145.365,022	37.33	5.32	11.26	Ho rejected
ab	1	14.290.730,0	7.145.365,022	37.33	5.39	11.26	Ho rejected
c	1	2.624.827,97	1.312.413,984	6.86	5.39	11.26	Ho accepted
ac	1	2.624.827,97	1.312.413,984	6.86	5.39	11.26	Ho accepted
bc	1	2.624.827,97	1.312.413,984	6.86	5.39	11.26	Ho accepted
abc	1	2.624.827,97	1.312.413,984	6.86	5.39	11.26	Ho accepted
Error	7	1.531.149.65	191.393,7059	-	-	-	-
Total	15	-	-	-	-	-	-

Conclusion or remarks from factorial statistics experiment is shown in **Table 12** below. Remarks explains the meaning of hypothesis after proven by statistical calculations.

Tabel 12. Conclusion of hypothesis testing towards ethanol formation

Metals Variation	Remarks	
1	Ho rejected	Ethanol is present without any metal addition
A	Ho accepted	Zn metal does not affect ethanol formation
B	Ho rejected	Mn metal affects ethanol formation
AB	Ho rejected	ZnMn affects ethanol formation
C	Ho accepted	Co metal does not affect ethanol formation
AC	Ho accepted	ZnCo metals do not affect ethanol formation
BC	Ho accepted	MnCo metals do not affect ethanol formation
ABC	Ho accepted	ZnMnCo metals do not affect ethanol formation

Just like TVA testing, null variation turns out to affect ethanol formation. This means that every metal that exist in the artificial waste has affected ethanol formation on wastewater. This fact might be used as references for further experiment so that calibration values for metals that are found to affect ethanol formation, in experiments such as process performance and concentration variation.

According to experiment result, Manganese metal as well as ZnMn combination have affected ethanol formation with concentration of 9,353.84 mg/L. This statistical analysis gives a picture that in Mn addition individually, main effect is detected based on statistical approach, but undetected on Zn addition. Thus, Zn-Mn combination gives main effect that is detected statistically.

3.2.3 Switching on Pathway

From statistical analysis, it is obtained that metals that affect TAV formations and ethanol formations happen on either individual and double combination of metals. The data obtained, recapitulated, is as following.

Tabel 13. Metal screening result

<table>
<tr><th colspan="2">Screening of</th></tr>
<tr><th>TVA Formation</th><th>Ethanol Formation</th></tr>
<tr><td>Zn</td><td rowspan="2">Mn</td></tr>
<tr><td>Mn</td></tr>
<tr><td>CoMn</td><td>ZnMn</td></tr>
</table>

Addition of Zn metal individually affect TVA formation but not as for ethanol formation. This indicates the switching on process pathway, which is organic substance conversion, tends to form volatile acid rather than ethanol. This applies to for CoMn combination. Aside from TVA, pathway of reaction might have a tendency to form other byproducts, such as gasses.

As for Mn parameter, organic substances conversion tends to be effective for TVA and ethanol formation. Whereas, ZnMn parameter has organic substances conversion tendency to form ethanol. To know further about *switching* process on this anaerobic treatment, further experiment to analyze process performance on Zn, Mn, CoMn, and ZnMn metals is advised using the same condition.

4 Conclusion

This research is meant to determine statistically using *Circulating Bed Reactor* with main purpose to determine whether or not the effect of Zn, Mn, and Co metals towards ethanol formation on anaerobic process using 2^n factorial statistics, its effect towards TAV to analyse the presence of switching process, and to analyse the process based on measurement of parameter towards pathway.

These are the following conclusions.

1. Experiment using microorganism that has been through 2 stages of acclimatization with composition of artificial waste are 30%, and 70%. Wastewater used is artificial wastewater that has been adjusted to real wastewater characteristics. The purpose of using artificial wastewater other than suitable for screening is to maintain the equality on each test.
2. The use of 2^n factorial statistics aims to design for screening experiment. This analysis aims to lower the amount of experiment while maintaining the existing information on each factor. There are 3 factors being observed, which is Zn, Mn, and Co (n=3) with 2^3=8 variations.
3. Generally, pH fluctuations shows the coherence between anaerobic biological stages. Besides, the value of soluble COD that has gone lower and the value of VSS that has gone larger shows the presence of organics degradation in wastewater.
4. In the effect towards TVA formation, it is obtained that individual metal of Zn, Mn metal, and MnCo combination affect TVA formation. Combination of Mn and Co, where Co has no effect individually.
5. In the effect towards ethanol formation, it is obtained that individual metal of Zn and ZnMn metal combination affect ethanol formation, with ethanol concentration is detected 9,353.84 mg/L. The combination of Zn and Mn metals, where Mn has no effect individually.

The addition of Zn metal and MnCo metals combination tends to switch substances, which is organic material tends to form volatile acid rather than ethanol.

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Evaluation of Waste Transfer Operation at TPS Patrakomala Bandung City

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Abstract. For years Bandung City has problems in its municipal waste management, due to a limitation of service coverage and transfer station (TPS) facilities and its management. One of the government's efforts to solve the problems was by implementing a waste-free area program, known as Kawasan Bebas Sampah (KBS). One way to support the KBS program is by having a waste transfer station with reduce-reuse-recycle treatment facilities (TPS 3R). The purpose of this study was to identify the potential TPS to be functioned as TPS 3R and evaluate its transfer operation system. This study was conducted by selecting potential TPS, collecting its infrastructure data, supporting equipment, and waste vehicles by observation, interview, and physical measurements (for 8 days) to identificating its existing operational and evaluating its collection-transfer operation system according to Regulation of The Minister of Public Works No 03, 2013. The criteria selection was developed based on government regulations, stakeholder interview, and related policies. It was identified that TPS Patrakomala was the most potential TPS to be functioned as TPS 3R, but still operates without scheduled operation system. In TPS Patrakomala, the waste vehicles consisted of four conventional handcarts, eight motor bikes, and two pick-up cars per day, collecting waste respectively 1,4; 2,6; 3,6 m^3/trip, which were done 2 trips/day. At the end, a city dump truck will pick up the waste from TPS Patrakomala once or twice a day, with a capacity of either 10, 13 or 14 m^3. Even with the average waste transported were above the truck capacity (respectively 20; 22; 26 m^3/truck/trip) there were still some waste unstransported from TPS. In the near future, the result of this study will be used to design a TPS 3R which is expectedly contribute to the improvement of wast managementin Bandung City.

Keywords: *transfer station, TPS 3R, Kawasan Bebas Sampah, Bandung City, municipal waste, waste vehicles, waste collection, waste transfer.*

1 Introduction

Bandung City has problems in its municipal waste management, due to limitation of service coverage and transfer station (TPS) [4]. It is also spoken by the CEO of PD Kebersihan Kota Bandung, Dedi Nurdiana, acknowledged TPS in Bandung is minimal. This resulted waste piled up in some place. Ideally in every sub district at least have three TPS, while now still two. However, he said that parties difficult to build new TPS because of the constrained availability of land [11]. In addressing the issue of waste problems Bandung's Government has 3R (reduce, reuse, recycling) activities [10]. One of the most common indicator in evaluating the performance of 3R activities is the level of cleanliness which can be seen visually, although waste management syste effectiveness should be measured from operational handling and waste reduction. There are various ways in waste management with 3R activites, even this activities involves elements of society [10]. The clean environment is essentialy the goal of every urban waste management [1].

The current program that involved 3R activities and society is a Waste-Free Area known as Kawasan Bebas Sampah (KBS). Kawasan Bebas Sampah (KBS) is one of the many components of the medium-term development program (RPJMD) Bandung City. Kawasan Bebas Sampah is a collaboration program between Bandung's Government and Badan Pengelola Lingkungan Hidup (BPLH) Bandung, aiming at making 6 waste-free areas per year since 2013. The existence of waste-free area with well waste management actually has become the target of Bandung's Government [1]. The target in 5-year period of the reign of Mayor Ridwan Kamil, there should be developed 30 waste-free area throughout Bandung City at 2018 [1]. Within the last two years there are already 12 waste-free models, which are located scattered within 12 districts, namely Sukasari, Bojong Kaler, Rancasari, Lengkong, Bandung, Batununggal Kidul, Mandalajati, Sumur Bandung, Cibeunying Kaler, Regol and Sukajadi [9].

In order to support the running of KBS program, required the presence of waste reducing, reusing and recycling activities at the sources (community) and/or having a waste transfer station with reduce-reuse-recycle facilities (TPS 3R) to support the community [1]. As described above there are a few things which become the background the needed of TPS 3R, first the problem of waste that piled up due the limitiation of TPS, secondly it is difficult to make a new TPS due availability of the land, and third there is a program that running 3R activities in community and required a facilities to support them which is TPS 3R. Based on interviewed with KBS parties, the community become more motivated to do 3R if supported with well-condition of TPS. For example the community already sorting the waste at home, but when taken by waste collector is mixed up in the waste vehicles, so the waste is also mixed up in TPS.

Further, the presence of TPS 3R will facilitied the need of community, so that waste will be processed and reduced. This will work if it is supported by the existence of operational mangement system in TPS 3R. There are two main focuses in waste management in TPS 3R which are waste reduction (waste minimization) and waste handling.Waste minimization consist of the waste reuse, reduce, and recycle, so only residue that will transported to landfill. Waste handling consist of sorting, collecting, hauling and waste processing [6]. The result of this study will be used to design TPS 3R, covering both waste reduction and waste handling.

2 Methods

This study was conducted as described in Figure 1.

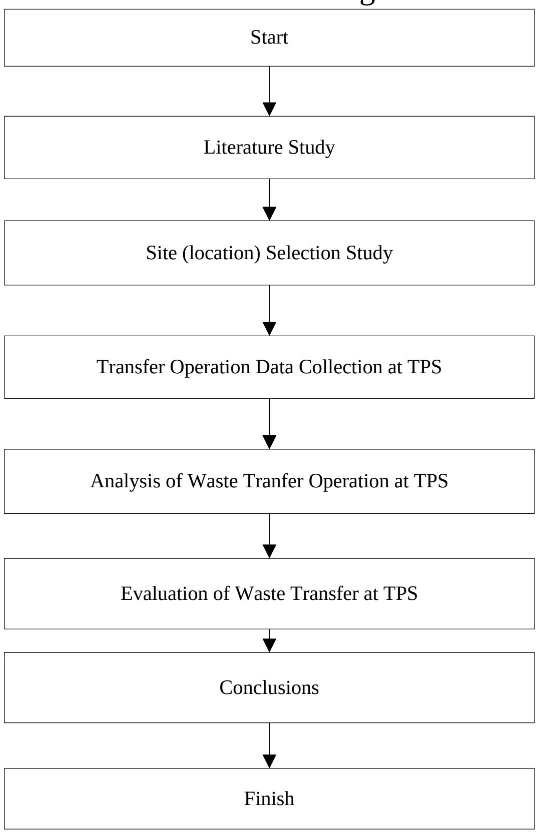

Figure 1 Method Flow Charts.

2.1 Site (location) Selection Study

Site selection study is important since the TPS 3R must meet the thecnical aspects of regulations and to ease the operational TPS 3R should be in KBS area [7]. To compile those requirement the selection was conducted using five criteria. The first and second criteria resulted from interviews and study on KBS program. The first criterion is to select TPS which are not a TPS 3R, TPS market, hospital, factory, commercial and/or institution. The second criterion, selects the location of TPS within KBS. The third criterion is to select land area > 200 m^2 as refered in the government regulation which is Regulation of The Minister of Public Works No 03, 2013 [5]. The forth criterion selects a TPS located in a land owned by Government of Bandung for the ease of operation. The fifth criterion selects a TPS that was priorites to be repaired but was still has to be done.

2.2 Transfer Operation Data Retrieval at TPS

At this stage the operational data collection aims to find out existing condition, waste collection and transport operation at TPS. Exsisting conditios are infrastructure, facilities and authority. Waste collection and transport are type, capacity, waste volume, time of the operation, activities of waste collection, and transport at selected TPS. Data-related to operation of waste collection are waste vehicle types, obtained through observation, measurement of waste vehicle capacity, and waste volume collected, operational time counting, and interview related activity of waste collection. Data-related operations of the waste transport are truck types obtained through observation, measurement of truck capacity, waste volume transported, operational time counting, and interview related activity of truck in TPS. Data collection was done for eight days.

2.3 Analysis & Evaluation of Waste Transfer Operation at TPS

In attempt to improved the TPS to TPS 3R became necessary to analysis and evaluate its existing conditions (infrastructure, facilities and authority) and operation system at TPS reffering to The Minister of Public Works No 03, 2013. There are several parameters that need to be evaluated such as land area and its capacity, availability of sorting and separate waste facilities, container, its operation should not interfere traffic and esthetic, do not pollute the environment and scheduled operation system.

According to Thecnical Guidance for the Realization of KBS Program [1] and Regulation of The Minister of Public Works No 03, 2013 [5] the data types, number, capacity, volume of waste collected, was used to find out suitability of collection operational in TPS and its analysis to sinchronized the transport operation which are type, number, capacity, volume of waste transported from TPS. The result of evaluation will be used to support operational of TPS 3R and other related data will be used to design or improve TPS 3R.

3 Analysis dan Evaluation

3.1 Site Selection

In the site (location) selection study, there were some result by using five criteria, described as follows:

1. Based on PD Kebersihan's data, in 2015 there are 159 TPS, comprise of 10 TPS 3R, 62 TPS markets, hospitals, factories, commercials and or institutions. Thus, from this first criterion. There are 87 TPS are eligible for this study.
2. Then with the second criterion, out of 87 eligble TPS, 45 of them are located in Kawasan Bebas Sampah (KBS) area.
3. Then, of the 43 TPS, 16 TPS meets the third criterion (land is owned by Bandung City Government) and 7 of them are the priorites to be repared namely TPS Komplek Sadang Serang, TPS Pasteur, TPS Kebun Binatang, TPS Patrakomala, TPS Ambon, TPS Gumuruh, and TPS Pagarsih.
4. The fourth criterion is the land must be greater than 200 m^2. There are 4 TPS which meets this criterion, namely TPS Komplek Sadang Serang, TPS Kebun Binatang, TPS Patrakomala, and TPS Pagarsih.
5. The fifth selects a TPS that was priorites to be repaired but was still has to be done, then produced TPS Patrakomala as the most potential location for this study.

Table 1 Potential TPS

No	Name	Location	Land Ownership (Pemkot)	Land Area > 200 m^2	Non Technical Aspect
1	TPS Komp. Sadang Serang	Jl Sadang Serang	√	√	
2	TPS Pasteur	Jl Dr Djunjunan	√		
3	TPS Kebun Binatang	Jl Tamansari	√	√	
4	TPS Patrakomala	Jl Patrakomala	√	√	√
5	TPS Ambon	Jl Ambon	√		
6	TPS Gumuruh	Jl Gumuruh	√		
7	TPS Pagarsih	Jl Pagarsih	√	√	

Based on the table above it can be concluded that TPS that meet the criteria to function to TPS 3R is TPS Patrakomala.

During the process of third stages site selection study, it was found that several TPS were already relocated or their functions have changed. It also can be analyzed that according to the Research and Development Division of PD Kebersihan, currently there is no formal authority responsible for updating data related to TPS. Consequently, in some cases written data owned by PD Kebersihan are not the same with the existing conditions.

3.2 Existing Conditions of TPS Patrakomala

TPS Patrakomala is located in Merdeka Sub-district, Sumur Bandung District. To the West it is bordered by the Merdeka District Office, to the North there is the Tongkeng Park, to the East is Jl. Tongkeng, and to the South is Jl. Patrakomala. Location of TPS Patrakomala can be seen in Figure 2 (in the picture TPS Patrakomala, also known as TPS Tongkeng).

Figure 2 Location of TPS Patrakomala

Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 [5], the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement. Currently the used area is 110 m^2 with a length of 11 m, width of 10 m, and a height of wall 2 m. The width of access road (Jl. Patrakomala) is 6 m. See Figure 3.

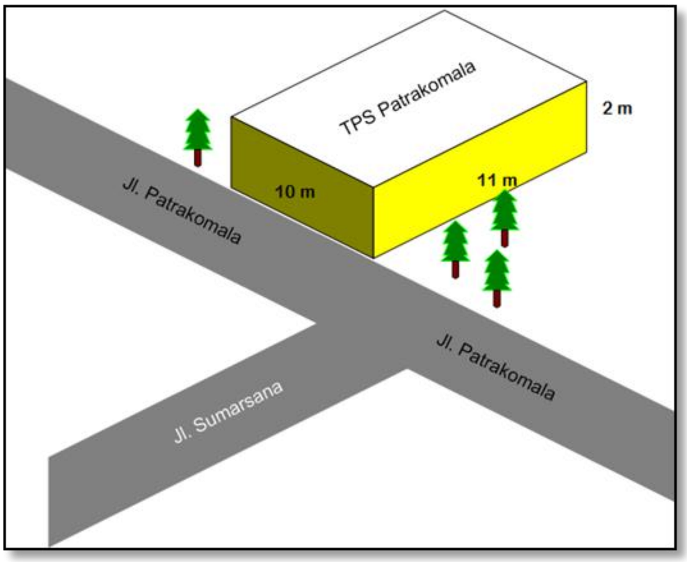

Figure 3 Currently Used Area 3D TPS Patrakomala

There was no waste container in TPS Patrakomala. According to statement of CEO PD Kebersihan, Dedi Nurdiana, he recommend that TPS should be equipped with a container, not only the walls [11]. It become a consideration in designing TPS 3R since it also require the needed of area or container for residue. Then in TPS Patrakomala there was no gate for waste vehicles and waste transport, so that vehicles can directly access TPS, as long as there is no other vehicles at the same time. If workers are doing the unloading; when the TPS is full, other vehicles had to wait in line. It can be analyzed if it too many vehicles are lining up, it will distrupt/interfere the traffic, this is contrary to the regulation, refered to Regulation of The Minister of Public Works No 03, 2013 [5] the activites of TPS should not interfere the traffic. The limitation in some facilities will need an improvement to run as TPS 3R.

3.3 Waste Tranfer Operational System

3.3.1 Waste Collection

During the 8 days of observations there were 32 waste vehicles. For the ease of observation vehicles are being labelled, and it was found to be 11 conventional handcarts, 16 motor bikes, and 5 pick-up cars. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] for area with relatively flat topography (slope < 5%) were able to use non-collecting machine such as traditional handcarts, whereas for the topography with the slope > 5% can use motorbikes. So for this area with relative flat topography was able to traditional handcarts.

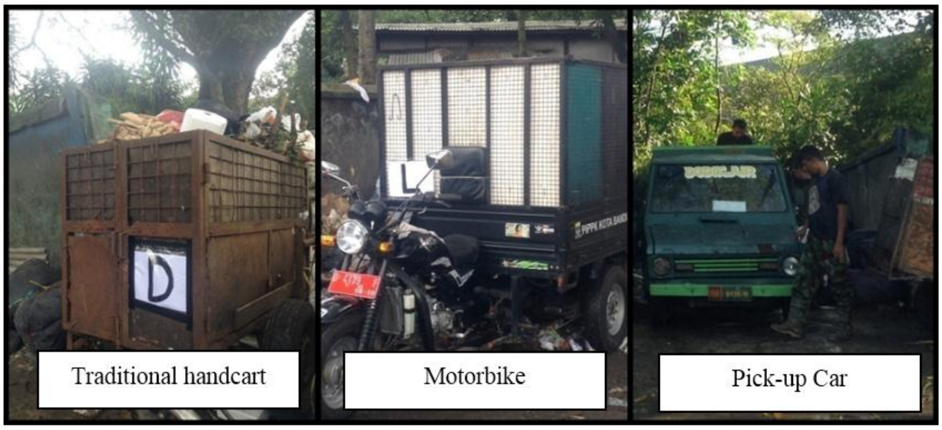

Figure 4 Types of Waste Vehicles

The entire waste vehicles did not operate everyday, therefore data of the average number of waste vehicles per day need to be counted. The average number of waste vehicles per day can be seen in Table 2.

Table 2 Number of Waste Vehicles

Types	Day								Average number per day
	1	2	3	4	5	6	7	8	
Traditional handcarts	3	7	8	3	3	3	2	2	4
Motor bikes	5	11	7	8	9	8	7	6	8
Pick-up cars	0	4	2	2	1	3	0	0	2
Average									14

From the table above the average number of waste vehicles were found to be 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day. It also can be seen compare to total number of each waste vehicles, motorbikes is the most operated everyday. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] waste collection need to be done by 1-4 trip/day. Based on observation the average of waste collection were 2 trip/day.

The dimensions and capacity measured can be seen in Table 3.

Table 3 Dimensions and Capacity of Waste Vehicles

Types	Dimensions P (m) x L (m) x T (m)		Capacity(m^3)	
	Minimum	Maximum	Minimum	Maximum
Traditional handcarts	1,50 x 0,75 x 0,90	1,55 x 1,25 x 1,20	1,01	2,33
Motor bikes	1,50 x 0,75 x 1,00	1,60 x 1,10 x 1,42	1,13	2,5
Pick-up cars	2,00 x 0,75 x 1,00	4,30 x 1,90 x 0,60	1,5	4,9

Based on the table above it can be concluded that pick-up car can carry or collect more waste as compared to other waste vehicles. The waste volumes carried or collected can then be calculated based on the dimension of the vehicles as follows:

$$\frac{(length\,cm\ x\ width\,cm\ x\ average\,waste\ height\,cm)}{10^6} \quad (1)$$

Then the waste volume from each waste vehicles can be seen on the Table 4.

Table 4 Waste Volumes Collected

Types	**Waste Volumes (m^3/trip)**
Traditional handcarts	1,4
Motor bikes	2,6
Pick-up cars	3,6

Based on the table above it can be concluded that the waste volume carried or collected by a pick-up is higher as compared to other waste vehicles. Further, its will become a consideration in operational of TPS 3R since motorbikes found to be the most operated also can carry more waste.

From the Table 2 and 4, the average that collected to TPS Patrakomala from 4 handcarts with average vaste volume collected 1,4 m^3/trip, from 8 motorbikes with average vaste volume collected 2,6 m^3/trip and from 2 pick-up cars with average vaste volume collected 1,4 m^3/trip, and the average of either waste collection were 2 trip/day it calculated that the average waste collected is 67,2 m^3/day.

3.3.2 Activities & Operational Time of Waste Collection at TPS

Based on the interview with waste collectors at the TPS, activities of waste collection start from 6 AM until 5 PM. Because TPS operated with unscheduled operation system, then the waste collector adjusted their collection time by itself. The TPS has no gate and also an authority might caused the existence of waste collector that enter to TPS after 5 PM. Therefore there will be waste staying overnight in TPS Patrakomala. Operational schedule and officer is required to adjust activities of waste collector and trucks that will pick up waste. The objective is to prefent waste for staying overnight in TPS. The average time to collect the waste for each waste vehicle in their service can be seen in Table 5.

Table 5 Waste Collection Times per

Day	Handcarts (hour:minute)	Motorbikes (hour:minute)	Pick-Up Car (hour:minute)
1	1:06	1:24	-
2	2:08	1:55	1:40
3	1:04	1:28	1:37
4	1:10	2:05	6:20
5	2:09	1:25	2:15
6	2:46	1:29	4:04
7	0:59	1:41	-
8	1:05	1:34	-
Average	1:33	1:37	3:11
Maximum	2:46	2:05	6:20
Minimum	0:59	1:24	1:37

From the table above it can be seen that the average time for handcarts and motorbikes to collect waste was faster than pick-up cars. It was due to the volume of waste collected and the ability of the waste collector itself. Since motorbikes operated faster, even from Table 4 the waste that collected using motorbikes almost twice as waste collected from using handcarts, the average collection time relatively same. Therefore the waste volume collected using handcarts is not as much as collected by motorbikes and pick-up cars, it also stated in the Table 4. Those were the reason why waste collector who use handcarts can have faster time in waste collection than pick-up cars.

Unloading and loading activities counted at TPS Patrakomala can be seen in Figure 6.

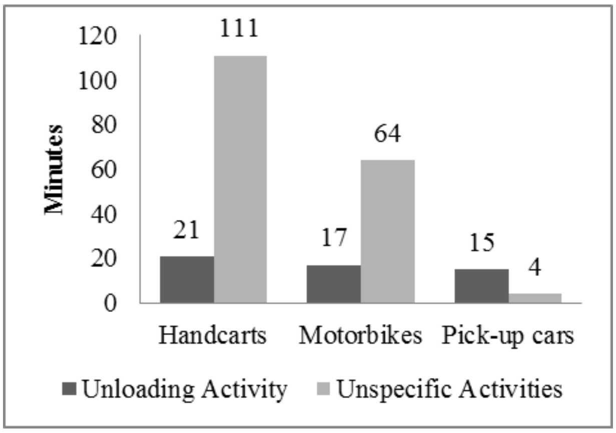

Figure 5 Average Time of Waste Collector-Waste Vehicles Activities at TPS

The average time needed to unloaded for waste collector who used handcarts, motorbikes and pick-up cars were respectively 21, 17, and 15 minutes. There are other unspecific activitessuch as queuing time for unloading, cleaning the certain vehicles, and resting. Queuing time occurs when TPS was full of waste so other waste collectors have to wait until the waste in TPS picked up by trucks. The average time for irrelevant (unspecific) activities of a waste collector who used handcarts, motorbikes and pick-up cars are respectively 111, 64, and 4 minutes. The waste collector using handcarts need a longer time to rest than the others, because they have to walk from sources to TPS. Data on time needed by waste collectors will be adjusted for recommendation of operational activity scheduling of waste collector, so there are no queues that could interfere the access of dump truck to enter the TPS, so the waste that already collected in TPS can be immediately picked up by dump truck.

3.3.3 Waste Transportation

Waste transported done by dump trucks, to transport waste from TPS Patrakomala to Sarimukti Landfill was conducted 1-2 trips/day. The capacity of a dump truck and the waste volume transported to the landfill can be seen in Table 6.

Table 6 Truck Capacity and Waste Volume Transported

No	Date	Types	Truck Capacity (m^3)	License	Waste Volume Transported (m^3)
1	17-Apr-16	*Dump truck*	14	R 1780 AB	26
2	18-Apr-16	*Dump truck*	14	R 1780 AB	27

No	Date	Types	Truck Capacity (m^3)	License	Waste Volume Transported (m^3)
	18-Apr-16	*Dump truck*	14	R 1780 AB	26
3	19-Apr-16	*Dump truck*	14	R 1780 AB	26
	19-Apr-16	*Dump truck*	14	R 1780 AB	26
4	20-Apr-16	*Dump truck*	10	D 8253 C	20
5	21-Apr-16	*Dump truck*	14	R 1780 AB	26
6	22-Apr-16	*Dump truck*	13	F 9179 AA	22
7	23-Apr-16	*Dump truck*	14	R 1780 AB	26
	23-Apr-16	*Dump truck*	14	R 1780 AB	26
8	24-Apr-16	*Dump truck*	14	R 1780 AB	26

From the table above we can analyzed that to maximize the amount of waste transported to the landfill, the truck driver fills the container twice as its normal capacity. The truck capacity is either 10, 13 or 14 m^3, whilst the average of waste transported to landfill were respectively 20, 22 and 26 m^3/truck/trip. Refered to the average waste collected was 67,2 m^3/day, it can be analyzed even the average of waste trandported to landfill as mentioned above, there were still some waste unstransported from TPS.

The waste in truck container was fully compacted its also raises problem such as dripping of leachate from the sides of truck and odor pollution, since the waste are mostly garbage [3].

The dimensions of truck measured can be seen in Table 7.

Table 7 Dump Truck Dimension

Longest				Shortest			
Dump truck	**L**	**W**	**H**	***Dump truck***	**L**	**W**	**H**
	4 m	2,2 m	3,05 m		3,5 m	2 m	2,7 cm

Based on observation and refered to Table 3 and 7, with the existing length of TPS metre, ideally only 2 waste vehicles that can unload the waste at the same time as the truck which arrived to fill the container. Further, data from Table 3 and 7 will be used and adjusted to design a loading and unloading space at TPS 3R.

3.3.4 Activities & Operational Time of Truck at TPS

Currently, in TPS Patrakomala waste is transported to landfill once or twice per day. Truck arrival time and activities of waste filling can be seen in Table 8.

Table 8 Activities & Operational of Truck at TPS

No	Date	Type	License	Arrival Time	Departure Time from TPS	Filling Process (hours)
1	17-Apr-16	*Dump truck*	R 1780 AB	6:30	8:40	2:10
2	18-Apr-16	*Dump truck*	R 1780 AB	5:00	7:47	2:47
	18-Apr-16	*Dump truck*	R 1780 AB	12:05	14:23	2:18
3	19-Apr-16	*Dump truck*	R 1780 AB	5:00	7:45	2:45
	19-Apr-16	*Dump truck*	R 1780 AB	12:32	14:41	2:09
4	20-Apr-16	*Dump truck*	D 8253 C	11:08	13:57	2:49
5	21-Apr-16	*Dump truck*	R 1780 AB	11:50	14:10	2:20
6	22-Apr-16	*Dump truck*	F 9179 AA	8:01	9:30	1:29
7	23-Apr-16	*Dump truck*	R 1780 AB	5:00	7:30	2:30
	23-Apr-16	*Dump truck*	R 1780 AB	13:45	15:26	1:41
8	24-Apr-16	*Dump truck*	R 1780 AB	5:30	8:10	2:40

As mentioned above time of arrival and departure when the waste transported once a day the truck will come in 5:30 AM then will depart at 8:10 PM or come at 11:50 PM and depart at 14:10 PM. time of arrival of the truck. Time of arrival and departure when the waste transported twice a day the truck will come in 5 AM and depart at 7:45 AM, then the truck came again at 12 PM and leave around 3 PM at the most. From the table 6 and 8 it also can be analyzed that the trucks arrive in TPS with empty container, and it requires approximately 1,5 - 2 hours to fill the container.

The quality of waste collection with dump truck are significantly depent on TPS which essentially consist of haul time and waiting time at the site [8]. Hence, scheduling is required so the waiting time that may accur in TPS can be minimized. Since TPS Patrakomala operated with unscheduled operation system, there is a time when dump truck and waste vehicles went to TPS at the same time, which cause either waste vehicles or dump truck need to wait each other performed. Another problem is there are collectors that unload the waste in TPS after the final truck transported to the landfill. Consequently, some amount of waste stays overnight in TPS Patrakomala. Therefore, operational schedule is required to adjust activities of waste collector and trucks hauling, which at the end avoiding the waste unloaded in TPS Patrakomala for staying overnight to prefent there is wating time in TPS.

4 Conclusions

Several important conclusions can be drawn as follows:

1. TPS Patrakomala was identified as the most potential TPS to function as TPS 3R, based on several criteria. The limitation in some facilities will need an improvement to run as TPS 3R.
2. Currently TPS Patrakomalaoperated with unscheduled activities, there was no waste container and gate in TPS Patrakomala.
3. Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement.
4. The operating waste vehicles were 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day, with waste volumes respectively 1,4; 2,6; 3,6 m^3/trip. The average of waste collection is 2 trip/waste vehicle/day.
5. The dump truck to collect waste from TPS Patrakomala operated 1-2 trip/day, with capacities either 10; 13; 14 m^3, but the average of waste volume transported were respectively 20; 22; 26 m3/truck/trip which meant above its capacity there were still some waste unstransported from TPS.
6. Operational schedule is required to adjust activities of waste collector and truck, which at the end avoiding the waste unloaded in TPS Patrakomala for staying overnight or untransported to the landfill and waiting time in TPS.
7. Further, the presence of TPS 3R will facilitied the need of community, so the waste will be processed and reduced, supported by the the existence of operational management system.
8. The result of this study will be used to support operational of TPS 3R and other related data will be used to design TPS 3R, which is expectedly contribute to the improvement of waste management system in Bandung City

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Assessment the Level of Readiness of the Waste Bank Development into a City Scale Waste Bank

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Abstract. Waste Bank is one of the strategies used to implement waste reduction at the source. Bandung city is one of the cities that implemented this program, either through government or NGO. This study aims to assess the level of readiness of the waste bank development into a city-scale waste bank. That method by waste bank indicator development, through descriptive analysis approach, referring to the integration of laws and guidelines of waste bank. That there are three components in the assessment of readiness of development of city-scale waste bank, they are quality of building construction, management system, and operational system, where each component have weight, they are 33%, 33%, and 34%. This indicator used to assess the implementation of Resik Waste Bank of PD Kebersihan to be developed into a city-scale waste bank. Assessment for each indicator used the ordinal and Guttman scale. The result of the assessment showed that Resik Waste Bank is ready to be developed into a city-scale waste bank with a value of 77,09.

Keywords: *waste bank, waste, assessment.*

1 Introduction

One of the basic implementation of the Undang-Undang No. 18, 2008 was Reduce, Reuse and Recycle (3R) activity at the source. The same strategy can be applied through waste bank program. This program potentially to improve waste separation by the community and can provide economic benefits [4]. To get the maximum benefit from the waste, the city scale waste bank are needed [7].

With the city scale waste bank, it is expected that the reduction of waste generation can be measured, recorded, and well controlled. As well as the implementation of waste banks can increase the benefits, both for the community, environment, and government.

Bandung city is one of the cities that implemented this program, either through government or NGO. Resik Waste Bank of PD Kebersihan is one of the waste bank built by the government of Bandung City and potentially to be developed into city-scale waste bank view in terms of institutional, management, financing, and business development, as well as integration with municipal waste management [3]. This study aims to assess the level of readiness of the Resik Waste Bank development into a city-scale waste bank by waste bank indicator development.

2 Materials and Methods

The method of this research was a descriptive analytical approach, by the data analyzed either from the literature or the results of the previous research [9]. The flow diagram of this research can be seen in Figure 1.

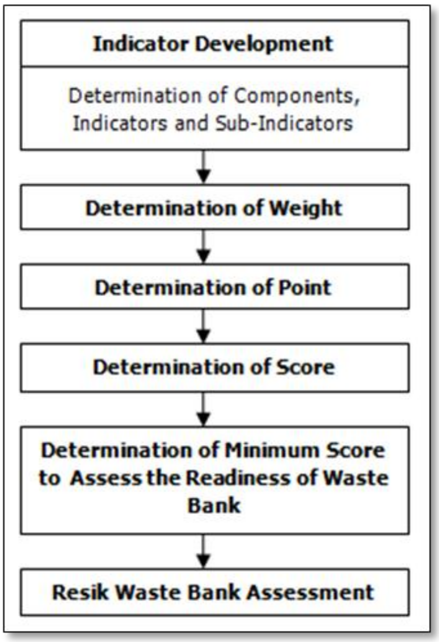

Figure 1 Flow Diagram of Research

There are secondary data used as reference, i.e. technical requirements of transfer station (TPS 3R) in Appendix II PerMenPU No. 03/2013, PerMenLH No. 13/2012 about the Guideline Implementation of 3R through Waste Bank, and City Scale Waste Bank Concept Book published by the Deutsche Internatioale Gesellschaft für Zusammenarbeit (GIZ) GmbH.

In Appendix II PerMenPU No. 03/2013, there are technical requirements of TPS 3R,i.e. area, supporting facilities, recycling activity, composting, bio gas, and TPS placement provisions.

In PerMenLH No. 13/2012, mentioned there are four aspects in the implementation of the waste bank, i.e. the construction requirements, management system, work mechanism, and implementation of waste bank, where there are several components in each aspect. Aspects and components required in PerMenLH No. 13/2012 can be seen in Table 1.

Table 1 Aspects and Components in PerMenLH No.13/2012

Aspect	Component
1. Construction Requirement	1. Floor
	2. Wall
	3. Ventilation
	4. Roof
	5. Ceiling
	6. Door
	7. Waste bank area
	a. Gate
	b. Yard
	c. Garden
	d. Parking
	8. Drainage
	9. Space savers/ customers
2. Management System	1. Savers/ customers
	2. Officer
	3. Recycling industry
	4. Waste management
	5. The role of officer
3. Work Mechanism	1. Waste separation
	2. Waste submission to waste bank
	3. Waste weighing
	4. Recording
	5. Waste sales result submitted put into saving book
	6. For results
4. Implementation	1. Determination of working hours
	2. Withdrawal of savings
	3. Borrowing money
	4. Savings book

Aspect	Component
	5. Pick-up service
	6. Kind of savings
	7. Kind of waste
	8. Pricing
	9. Waste condition
	10. Minimum weight
	11. Waste bins
	12. System for results
	13. Salary

In construction component for floor, walls, vents, roof, ceilings, and doors, were not mentioned the kind of the building, whether it's an office, warehouse, or both. In management system were described in general. As well as in mechanism work aspect, which has not been described each of its components. Components in implementation of waste bank aspect were as already clear.

In the City Scale Waste Bank Concept Book [7], mentioned there are five components that became the concept of waste bank development, i.e. the establishment of the Organization, the management of the city waste bank, management, financing and business development, as well as integration with the municipal waste management. Indicators required in City Scale Waste Bank Concept Book [7] can be seen in Table 2.

Table 2 Indicators in City Scale Waste Bank Concept Book

Components	Indicators
1. Establishment	a. Has a legal basis as a condition of legal
	b. Has the kind of institution
	c. An alternative type of institution : BLUD, BUMD, fungtional cooperative, foundation
	d. Area
	e. Building
	f. Equipments and tools
	g. Manager/ officer
	h. Capital basic
2. City Scale Waste Bank Organization	a. Executive board
	b. Savers/ Customers

Components	Indicators
	c. Institutional structure
3. Management	a. Coordination of City Government
	b. Operational standard
	c. Quality assurance
	d. Operational method
4. Financing and Business Development	a. Capital
	b. Partnership
	c. Dissemination and Promotion
	d. Increasing the role of community
5. Integration with Municipal Solid Waste Management	a. The existence of the Government's authorized in waste management
	b. The Government should craft a district/ city waste management planning

2.1 Indicator Development

Scheme integration of existing indicators can be seen in Figure 2. Area requirements, supporting facilities, and TPS placement provisions can be integrated with the requirements of building construction, to be in the component quality of waste bank construction. Based on PerMenPU No. 03/2013, it is mentioned that the meaning of TPS 3R is place for the collecting and sorting waste that have economic value. Based on this, the waste bank can be interpreted as the place for the implementation of 3R activities, as mentioned in PerMenLH No. 13/2012. So the quality of existing construction in the waste bank should be able to support the 3R activities in it. However, in terms of quality of construction of waste bank buildings also need to consider the location of the determination of garbage bank, which is related to clear land ownership, as well as violation or not of the building to the Spatial Plan (RTRW). Thus, in the quality component of building construction added indicator of the location of the building of the waste bank.

The requirements of the management system can be integrated with the components of establishment, organization management, financing and business development, as well as integration with municipal waste management, to be within the components of the management system. In this component added job description indicator from the waste bank management. This is useful for assessing whether any officer of waste bank has done its own work or not.

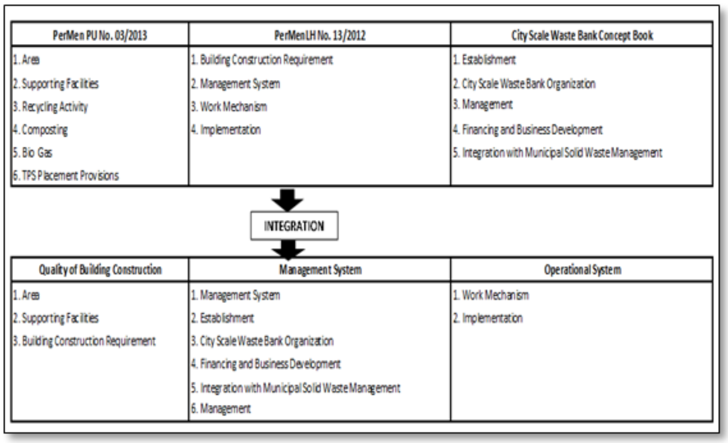

Figure 2 Scheme Integration of Existing Indicators

The requirements of work mechanism and implementation of waste bank can be integrated with the management component, to be within the operational system components. In this component added indicator Health and Safety. This becomes important to avoid the presence of diseases caused by solid waste and / or accidents due to operational activities conducted in waste banks.

In addition to being considered to facilitate the assessment, development or addition of this indicator is also considered important in the implementation of city-scale waste banks later, because the indicators have been developed will be used to assess the readiness of a waste bank to be developed into a waste bank operating on a city scale. Based on the results of development, the illustration of indicators can be seen in Table 3, while the complete structure of the City Scale Waste Bank indicator can be seen in Table 4.

2.2 Determination of Weight

The third component of the next elected given the weight value, where the weighting given to the components of the quality of building construction, system management, and operational system, each amounting to 33%, 33%, and 34% of the total value of 100. So if all the indicators and indicator are met, then the bank trash that votes will have a value of 100. Operating system components are given weights a little bit larger than the other two aspects due to the operational system is considered as an aspect of the implementation of what has been planned on the quality of Imperial construction and building management systems.

Each indicator and sub indicator that exist within each component are also given weight to the value of each indicator and indicator. The granting of the weighting is based on a scale of interests of any indicators or indicators, so that the indicator or indicators that are considered more important will earn a percentage of the value. In addition, the size of the percentage also determined based on the difficulty of the arranged.

For example the warehouse building is considered more important than acreage residue buildup. This is because the warehouse was the location for storage of the product until demand is big enough to carry out its distribution[2], where storage is considered necessary to adapt the product to the needs of the consumer. In addition, the warehouse can also be defined as a place that bears the duty to save the items that will be used in the production of the goods is requested, until the appropriate production schedule [1]. So the sub indicator warehouse has a larger percentage than the sub indicator acreage buildup of residue.

Table 3 Illustration of City Scale Waste Bank Indicators

Component	Indicator	Point	Sub Indicator	Score
Component 1	Indicator 1		Sub Indicator 1.1	
			Sub Indicator 1.2	
	Indicator 2		Sub Indicator 2.1	
			Sub Indicator 2.2	
			Sub Indicator 2.n	
	Indicator 3			
	Indicator 4			
	Indicator 5			
Component 2	Indicator 1			
	Indicator 2			
	Indicator n			
Component 3	Indicator 1			
	Indicator 2			
	Indicator n			

Table 4 City Scale Waste Bank Indicators

Component	Indicator		Point
I. Quality of Building Costruction (CS) (33%)	CS 1	Location of Waste Bank (20%)	6.6
	CS 2	Building (20%)	6.6
	CS 3	Building Area (30%)	9.9
	CS 4	Warehouse (15%)	4.95
	CS 5	Office (15%)	4.95
II. Management System (MS) (33%)	MS 1	Institutional (20%)	6.6
	MS 2	Capital (20%)	6.6
	MS 3	Institutional Structure (10%)	3.3
	MS 4	Job Description of Officer (5%)	1.65
	MS 5	Human Resources (5%)	1.65
	MS 6	Partnership (10%)	3.3
	MS 7	Dessimination and Promotion (10%)	3.3
	MS 8	Integration with Municipal Solid Waste Management (20%)	6.6
III. Operational System (OS) (34%)	OP 1	Savers/ Customers (15%)	5.1
	OP 2	Kind of Waste (15%)	5.1
	OP 3	Operational Facilities (15%)	5.1
	OP 4	Waste Collecting and Management (12.5%)	4.25
	OP 5	Weighing and Recording (12.5%)	4.25
	OP 6	Health and Safety (15%)	5.1
	OP 7	Monitoring and Evaluation System (15%)	5.1

2.3 Determination of Point

Points is the result between the percentage weighting of indicators with the percentage weighting of components, or as in the following equation :

$$Point \quad = \% \text{ weighting indicator } x \text{ } (\% \text{ weighting component } x \text{ } 100) \qquad (1)$$

2.4 Determination of Score

The value is the result of times between the percentage weighting of indicators with sub points, or as shown in the following equation:

$$Score = \% \text{ weighting sub indicator } x \text{ point} \qquad (2)$$

2.5 Minimum Score to See the Readiness of Waste Bank

Within each component, determined the magnitude of the minimum score that must be met by a waste bank to be developed into a city scale waste bank. The minimum score is later used as the minimum score to determine whether a waste bank is ready or not to be developed into a city scale waste bank. The minimum score is determined based on the accumulation of points is greatest in each component.

The minimum score on the quality of building construction component of 9.90 and at least must have a supporting building with sufficient area, particularly the warehouse waste bank. The magnitude of the minimum value in the component management system is of 19.80 and and at least must have institutional capital, must be, and integration with the municipal waste management. The magnitude of the minimum score on the component operational system is of 25.50 and at least must have a component of customer, the kind of waste, operational facilities, health and safety, as well as monitoring and evaluation. The minimum score of each component is further added, and obtained the value of 55.20. So a waste bank is said to be "ready" to be developed into a city scale waste bank when it has a score of > 55.20-100, and said to be "not ready" when it has a score of 0 - ≤ 55.20.

The assessment for each of the sub indicator of City Scale Waste Bank Indicators using the ordinal and Guttman scale. Ordinal scale is a scale of value classification and order or there is the sequence [8]. While the Guttman scale is classified as a single-dimensional, i.e. the scale that generates cumulative answers because grains are associated with each other [10]. With a scale of assessments that are done are Guttman firmly, i.e. "-no" or "Yes-No". So that the given value is 1 if present or Yes, and 0 if not. Self-assessment may be conducted through interviews, secondary data analysis, and observations. Here is a sample calculation of a waste bank readiness assessment to be developed into a city scale waste bank, namely:

1.) Score of sub indicator (example : sub indicator on indicator location of waste bank)

First sub indicator (Location not violate RTRW) :
Answer "violate" = 0
Answer "not violate" = 1 x score
= 1 x (%weighting sub indicator x point)
= 1 x 50% x 6,60
= 3,30

Second sub indicator (Land ownership clearly)
Answer "not clear" = 0
Answer "yes" = 1 x score
= 1 x (%weighting sub indicator x point)
= 1 x 50% x 6,60
= 3,30

2.) Score of indicator (example : indicator location of waste bank)

Score of indicator = Amount of score of sub indicator
= score of first sub indicator + score of second sub indicator
= 3,30 + 3,30 = 6,60

3.) Score of component (example : component quality of building construction)

Score of component = Amount of score of indicator
= score of indicator 1 + score of indicator 2 + score of indicator 3 + score of indicator 4 + score of indicator 5
= 6,60 + 6,60 + 9,90 + 4,95 + 4,95 = 33

4.) Total score
Total score = Amount of point of component
= 33 + 33 + 34 = 100

3 Results and Discussion

Recapitulation of Resik Waste Bank assessment can be seen in Table 5.

Resik Waste Bank achieved the point up to 23.37 for the buiding construction quality component, which means have a warehouse of waste bank. For the management system component, Resik Waste Bank achieved the point up to 28.38. However, in terms of institutional has not met the points required, because was financial management has not conducted independently, because Resik Waste Bank is under the Project Development Business Unit of PD Kebersihan, then in the process of drafting the budget plan costs (RAB) still spring hinge with the unit. And for the operational system component, Resik Waste Bank achieved the point up to 25.34. However, in terms of the kind of waste, health and safety, as well as monitoring and evaluation has not met the points required. Related kind of waste, there is no customers save the organic waste to Resik Waste Bank, and because kind of waste can be saved in Resik Waste Bank just inorganic waste. Related health and safety, there is no guideline or rules about it. Because the reason for felt discomfort, officer of separation, hauling and packaging did not use protective tools themselves. As well as the absence of a procedure for the implementation of the emergency condition. Related monitoring and evaluation, was implementationed with frequency of time over the past three months.

Based on the assessment, the result showed that Resik Waste Bank has a point of 77.09 supported by adequate buildings and operational facilities. However, it is necessary to have independent financial management, related regulations of health and safety, and monitoring evaluation conducted at least once a month.

Table 5 Recapitulation of Resik Wste Bank Assessment

Component	Indicator		Point
I.Quality of Building Costruction (CS) (33%)	CS 1	Location of Waste Bank (20%)	6.6
	CS 2	Building (20%)	6.6
	CS 3	Building Area (30%)	0
	CS 4	Warehouse (15%)	3.47
	CS 5	Office (15%)	6.7
II. Management System (MS) (33%)	MS 1	Institutional (20%)	5.78
	MS 2	Capital (20%)	6.6
	MS 3	Institutional Structure (10%)	2.64
	MS 4	Job Description of Officer (5%)	1.32
	MS 5	Human Resources (5%)	0.17
	MS 6	Partnership (10%)	1.98
	MS 7	Dessimination and Promotion (10%)	3.3
	MS 8	Integration with Municipal Solid Waste Management (20%)	6.6
III. Operational System (OS) (34%)	OP 1	Savers/ Customers (15%)	5.1
	OP 2	Kind of Waste (15%)	2.13
	OP 3	Operational Facilities (15%)	5.1
	OP 4	Waste Collecting and Management (12.5%)	4.25
	OP 5	Weighing and Recording (12.5%)	4.25
	OP 6	Health and Safety (15%)	1.28
	OP 7	Monitoring and Evaluation System (15%)	3.19
		Total	**77.09**

4 Conclusion

Conclusion that can be drawn, namely Resik Waste Bank is ready to be developed into a city-scale waste bank with a value of 77.09.

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OCEAN AND MARITIME ENGINEERING

Adaptive Port Planning for Phase II of New Priok Development in Indonesia

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Abstract. The initial masterplan of New Priok in the Port of Tanjung Priok was developed in 2012 is being updated to cater to new developments and new demands. In the new masterplan (2017), Phase II of development will start from 2035-onwards, depending on the future conditions. This study is about creating a robust masterplan for Phase II, which will remain functional under future uncertainties.

The methodology being applied in this study is scenario-based planning in the framework of Adaptive Port Planning (APP). Scenario-based planning helps to open up the perspective of the future as a horizon of possibilities. The scenarios are built around two major uncertainties in a 2x2 matrix approach. The two major uncertainties for New Priok port are economics and sustainability awareness. The outcome is four plausible scenarios: Green Port, Business As Usual, Moderate Expansion, and No Expansion. Terminal needs in each scenario are analyzed through traffic analysis and identifying the key cargos and commodities.
In conclusion, this study gives the wide perspective for Port of Tanjung Priok for the planning Phase II of the development. The port has to realize that uncertainties persevere and are very likely to influence the decision making as to the future layouts. Instead of ignoring uncertainty, the port needs to make the action plans to deal with these uncertainties.

Keywords: *Indonesian ports; port's design; port planning; scenario-based planning.*

1 New Priok Development: Background

The masterplan of Tanjung Priok of 2012 has been evaluated and updated to deal with future (unpredictable) challenges. In the latest update of the masterplan, the focus of the planning will be on Phase I of development to optimize all the terminals. Phase I is divided into three subphases, see **Figure 1**, and correspond to following time periods:

1. Short term: 2016-2020. Land reclamation for all container terminals (CT I, CT II and CT III), deepening of inner basin, and dredging waterways to -16 m LWS.

2. Middle term: 2020-2025. Land reclamation for product terminals and deepening of outer basin and waterways to -20.5 m LWS.
3. Long term: 2025-2035. Dredging of inner waterways to -20 m LWS.

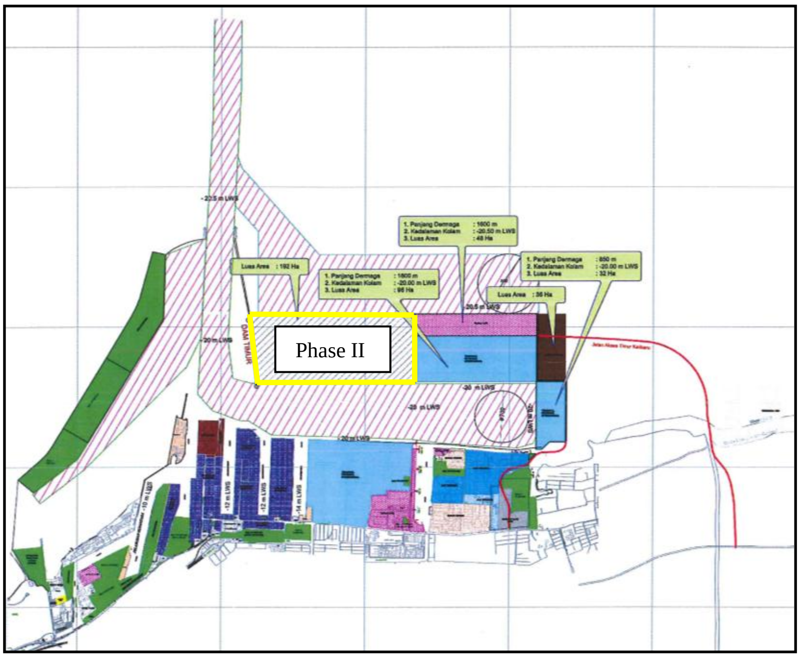


Figure 1 Long-term planning of New Priok Development (2025-2035) (IPC, 2017)

Phase II (2035-onwards) is intentionally left untouched due to a large number of uncertainties in the future. It had been designed four container terminals for phase II in the prior masterplan (PM38, 2012), however, it was seemingly too optimistic to be implemented.

1.1 Problem Description and Proposed Solution

1.1.1 Problem Description

Study the existing masterplan of New Priok Development and make it robust masterplan for Phase II of development.

1.1.2 Proposed Solution

In order to a create robust masterplan, scenario-based planning in the framework of Adaptive Port Planning (APP) is applied. This takes major future uncertainties confronting by the Port of Tanjung Priok. These frameworks are combination of

Assumption-Based Planning and Adaptive Policy Making methods which produce an adaptive masterplan by assuming that the future is unknown.

1.2 Adaptive Port Planning (APP) Frameworks

Ports are beset with many uncertainties about their futures. They are confronted with new demands in terms of functions and scales, new external constraints, and changed expectations, and yet must ensure functionality, capacity and service quality during their design lifetime (Taneja, 2013). The inability to do so can mean costly adaptations for a port or loss of cargo and competitive position. Thus, planning ideally needs to anticipate on unexpected future developments and to ascertain that the infrastructure, once built, continues to function well.

The Traditional Masterplanning does not take any uncertainties into account beyond those included in the scenarios that form the basis of the forecasts. The layouts are prepared for the middle scenario and when the actual development deviates from this scenario, the port is often able to accommodate this by postponing or accelerating the next phase. However, this does not work in case of very drastic changes, such as for instance a strong reduction of coal imports due to the closure of coal-fired power plants.

A new planning approach is required that aims at developing plans that take uncertainties more explicitly into account, and allow for change, learning, and adaptation over time-based on new knowledge and changing circumstances. Such flexible or adaptable plans allow the port to be altered or employed differently, so as to be functional under new, different, or changing requirements in a cost-effective manner. Adaptive Port Planning (APP) aims to achieve this by bridging the gaps in the traditional practices of port planning by incorporating uncertainty and flexibility considerations (Taneja, 2013).

It provides a framework for the planner to generate plausible alternatives in the context of the planning objectives; identify critical uncertainties (vulnerabilities and opportunities); and then, to explore, value, and incorporate flexibilities for handling these uncertainties. Subsequently, actions can be taken in the planning stage, or actions can be prepared in advance and taken as events occur. Next, the planner evaluates the alternatives and makes a selection (the value of flexibility is included in the evaluation). During the implementation phase, actions are taken in response to triggers from a monitoring system set up for the selected alternative. Such a monitoring system scans the external environment for new developments and alerts planners of the need to modify or reassess the plan (Taneja, 2013). The various steps as illustrated in **Figure 2** are explained below.

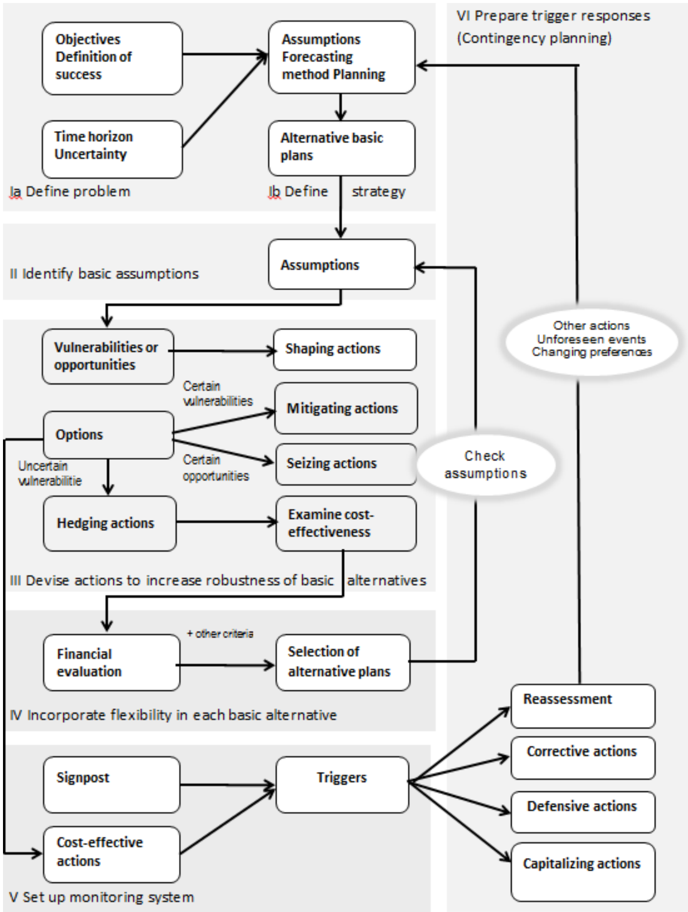


Figure 2 Steps in APP (Taneja, 2013)

Step Ia Define the problem/project

This first step involves studying the objectives of the organization and the needs of the stakeholders in order to formulate the goals of the project. Based on this, a definition of success can be given, in terms of the specification of desired outcomes. The various constraints or boundary conditions, the available choices, and the underlying assumptions are identified next. An *assumption* is an assertion about some characteristic condition that underlies the current plan.

Step Ib Define strategy and formulate alternatives

The strategy includes selecting a forecasting method, planning techniques and tools, as well as a (financial) evaluation method. The planning time horizon (short, middle or long) determines the choice of strategy. In case of port projects, these can relate to the various port layouts, infrastructure designs or the complete Masterplan.

Step II Identify vulnerable assumptions underlying each alternative plan
Identifying vulnerable assumptions in the plan requires an assessment of the consequences of failure of an assumption. It involves thinking about the future, for plausible developments that could occur in the lifetime of a plan and cause the plan to fail. If the development is favorable for the plan, it is called an opportunity. Otherwise, the development is called a vulnerability.

Step III Increasing the flexibility and robustness of each alternative
In the third step of the process, the robustness of each alternative is increased. This step is based on specifying actions to be taken in response to the vulnerabilities and opportunities identified in Step II. There are two basic ways of preparing a plan for vulnerabilities and opportunities, either by taking actions now (in the planning and design phase) or by preparing actions in advance that can be taken in the future, if necessary.

Step IV Evaluate and select alternative
After actions to make the plan robust have been identified and incorporated in each alternative, the alternatives must be compared. This comparison of alternatives requires determining the effects of the alternative based on pre-defined criteria. Financial, economic or cost-benefit analysis are commonly carried out.

Step V Set up monitoring system for the selected alternative
Even with actions taken in advance, there is still the need to monitor the performance of the selected alternative and take action if some of the assumptions are failing. This requires an identification of signposts. Signposts specify information that should be tracked in order to determine whether the plan is on course to achieving its success.

Step VI Contingency planning (preparing trigger responses) for the selected alternative
In this step, the plan, based on the selected alternative, is further enhanced by including adaptive elements. A contingency plan is a provision in the plan that specifies how a vulnerability will be handled, in case events or changes cause the vulnerability to appear. These actions are prepared for in advance. Once the basic plan and additional actions are agreed upon, the final step involves implementing the entire plan.

The scenario-based approach is one of tool/technique in Adaptive Port Planning, besides brainstorm session which is also used as an initial action in the study, probabilistic approaches and Explanatory Modeling and Analysis (EMA) (Taneja, 2013). The scenario approach is about creating stories about plausible future and preparing for the uncertainties of the future. Scenarios are a set of reasonably plausible, but structurally different futures (Heijden, 2005). Scenarios help to open up the future as a space of possibilities and give the port authority and the port planners a wide-view of the range and impact of uncertainties.

The benefits from using scenarios in long-term planning are threefolds. First, it helps to deal with situations in which there are many sources of uncertainty. Second, it allows examining the `what ifs' related to scenarios. Third, scenarios provide a way to explore the implications of uncertainty by identifying possible future problems and identifying (static) robust strategies for dealing with the problems (Walker, 2012). By successfully identifying the possible scenario of the future, an organization can prepare early the strategic forces to tackle the problem.

1.3 Steps of Applying APP Frameworks for Phase II New Priok

An appropriate and suitable framework for the case study in this research is Adaptive Port Planning (APP) scenario-based planning. In these frameworks, some steps in the working flow are not being used, which are step III and step IV. The (simple version) frameworks of scenario-based planning are depicted in **Figure 3**.

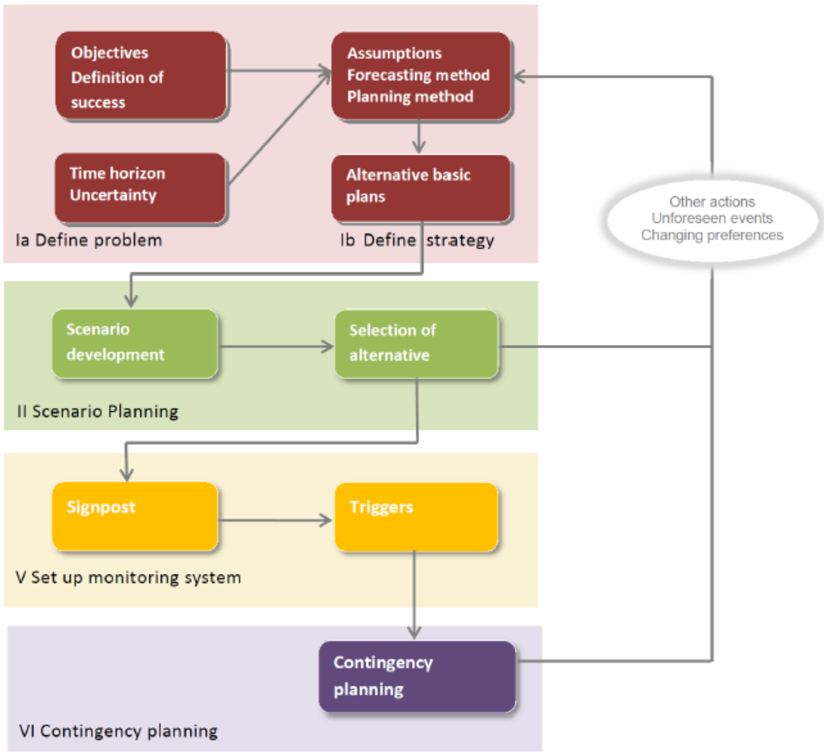


Figure 3 Adaptive Port Planning (APP) scenario-based planning (Taneja, 2013)

1.3.1 Step I Define Problem

1.3.1.1 Objectives, Definition of Success, and Time Horizon

The objective of this study is to find a robust solution for Phase II planning of New Priok Development. The definition of the success of the development is completing the construction of New Priok, integrating its hinterland, and encouraging the growth of the port in order to improve logistic performance index[1] of Indonesia (third wave of IPC wave's reformation, 2016). The time horizon of this planning related to Phase II, is from 2035-onwards.

1.3.1.2 Uncertainty Analysis

The major unknown parameters related to port planning and design are possible crisis in global demand, trade and finances, changes in global production patterns,

[1] Currently, Logistic Performance Index (LPI) of Indonesia is 2.98, in the rank 63 out of 160 countries (World Bank, 2016).

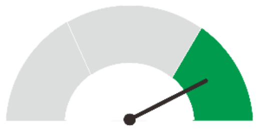
availability and uses of natural resources, shift of economic influence to developing regions, demographic distribution, population aging and population growth in emerging countries, scarcity of land, transport-related technological innovations, climate change and natural disasters, environmental preservation, energy costs, and sustainability growth (Arecco P, 2015).

Phase II of New Priok Development in 2035 will face unknown future states. The ten major global and regional trends (uncertainties) that will probably affect the planning of Port of Tanjung Priok are listed in **Table 1**. Those factors are analyzed from various corporate's and government's documents (port's masterplan PM42, MP3EI, IEO, feasibility study of CBL canal) and independent institution's reports (McKinsey).

The factors are categorized on the basis of three speeds related to the intention of the government or corporation to address the problems based on current condition, which are:

1. Moving slowly. Categorized as very low willingness to adapt. Sometimes it could be due to lack of information about the factors.
2. Moving steadily. Categorized as relatively stay the same of the current condition. This could be seen by extrapolating recorded information from the past until present circumstance, which they stay look-alike.
3. Moving quickly. Categorized as very high willingness/actions to approach it which are confirmed through the formal programs or documents of related stakeholders.

Table 1 Summary of uncertainty analysis

No	Trends	Rate of change
1	**National Connectivity Will** • MP3EI document (political willingness of connectivity and investment planning in ports)	
2	**Adapting to Global and Regional Economy** • Increasing international trades • New Priok Project	 Moving quickly
3	**Adapting to GDP and Cargo Growth** • GDP growth amplifies cargo growth • New Priok Project	
4	**Adapting to Mega Ship Development** • New Priok Project → deepening of basins	
5	**Hinterland Connection** • Feasibility study of CBL canal	
6	**Sustainability Regulation (PPP)** • Partially implemented	 Moving steadily
7	**Bonus Demography Welcoming** • Realize in the MP3EI • No specific programs prepared	
8	**Adapting to Future Energy Demand** • Low implementation of renewable energy • The masterplan of Phase I was highly allocated for fossil resources	
9	**Adapting to Advanced Technology of Transport** • Low implementation of transparency in logistic • Lack information of future handling technology	 Moving slowly
10	**Adapting to Climate Change** • No specific government body or programs to anticipate • Lack knowledge of climate change	

1.3.2 Step Ib Define Strategy

The strategy for New Priok to cope with future uncertainties is to carry out scenario-based planning. It is not possible to define the future as one picture, several alternatives/scenarios are needed. Each scenario tells a story of how various elements might interact under uncertain condition.

1.3.3 Step II Scenario Planning

1.3.3.1 Scenario Development

The critical uncertainties with regard to the future port of Tanjung Priok are economic growth and environmental and sustainability required by the society. These are placed on 2 main axes to create a 2x2 matrix.

Based on those critical uncertainties, four scenarios that might be related to the development o f New Priok Project for the long period are proposed, shown in **Figure 4**. These are:

1. **Scenario 1, Green Port**. In this scenario, society and government are well-aware to sustainability matters and economy grows significantly. This scenario is also projected the high investment in every infrastructure sector, including port development. The development of the port project, especially New Priok Project, has to be very friendly to environment and society, besides profit oriented.

2. **Scenario 2, Business as Usual (BaU).** This scenario seemingly represents the existing condition of Indonesia, specifically of Port of Tanjung Priok. One axis shows the promising growth of economic and container sectors and another axis displays sustainable issue still lag behind.

3. **Scenario 3, Moderate Expansion.** In this scenario, the economic growth is still positive but with the small value. This will impact the low investment on port infrastructure in Indonesia. People will really aware of sustainability and environment issue, apparently, there will be a specific government body and regulation to control it.

4. **Scenario 4, No Expansion.** In the future, people tend to put aside the sustainable issues and the economic condition is not really supportive of doing development. Probably there is no need to expand container terminals. Optimizing the existing container terminals in Phase I and old port in the land would be a rational answer to the small growth of containers.

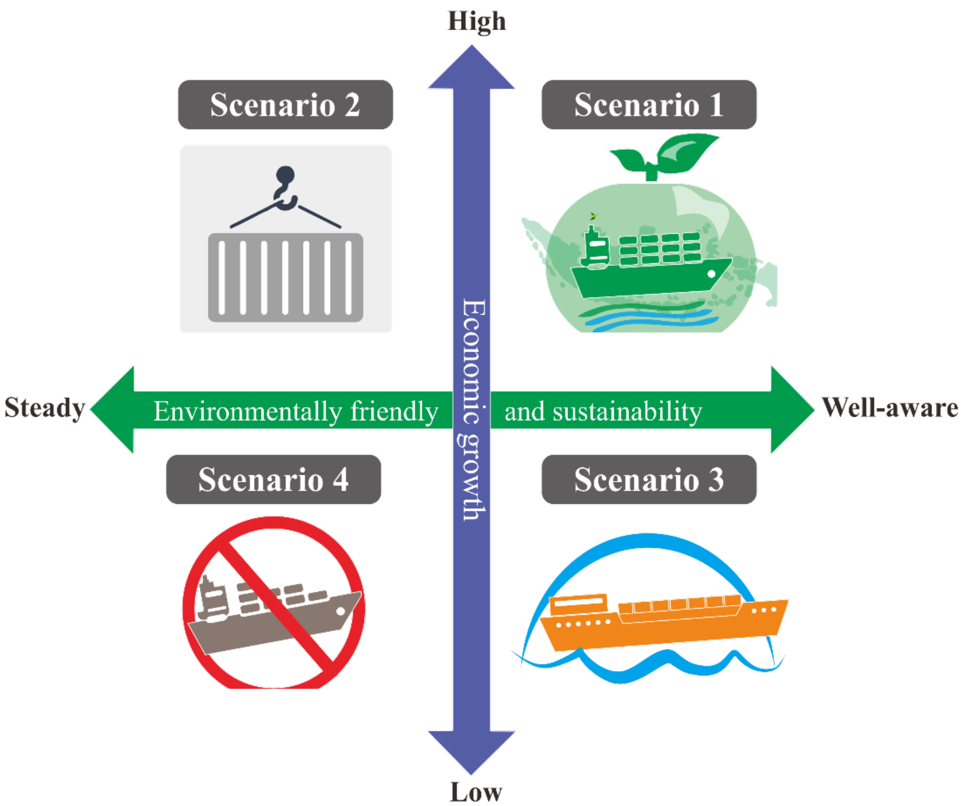


Figure 4 Scenario of Phase II

The features of each scenario are characterized in **Table 2**. The first two features in column one represent the economic performance of the future. The four features after are sustainability of the future. The last two features are about future energy terminals which are correlated with economic and sustainability.

These characteristic will determine the terminal needs in the last part of the analysis. Fundamentally, four components are assessd to be characteristics of each scenario: economic performance, environmental and sustainability discourses, modal shifting, and future energy.

Table 2 Scenario characteristics

	Scen. 1	Scen. 2	Scen. 3	Scen. 4
Containers growth	High	High	Medium-Low	Low
Investment in port	High	High	Medium-Low	Low
Environmental awareness	High	Medium-Low	Medium	Low
Sustainability discussion	High	Medium-Low	Medium	Low
Needs of modal shifting	Yes	No	Yes	No
CBL Canal needs	Yes	No	Yes	No
Energy mix	Renewable + Fossil	Fossil	Fossil + renewable	Fossil

1.3.3.2 Scenario Selection

Selection of the alternatives will be very relative to what are going to be observed in the future. However, the type of each scenario can be characterized by doing SWOT (Strength, Weakness, Opportunities, and Threats) analysis as shown in **Table 3**.

Table 3 SWOT analysis

	Scen. 1	Scen. 2	Scen. 3	Scen. 4
Strength	• Future change adaptation • Environment friendly • Reduce congestion	• Economically attractive • Business as usual • Less discussion on adaptation	High attention to environment and sustainability	• Cost effective
Weaknesses	• Massive change • Risky on investment • Rejection of the trucking players	• Harming environment • Heavy congestion, pollution	Risk on low investment	Port will not improve
Opportu nities	• Future change • global player, competitive port	• Containerized port • fossil fuel demand high	Green port	Financially safe
Threats	The future will remain the same	The changing of future to the green issues	Money and investment	Abrupt market change

Table 4 shows the promising commodities in each scenario. The robustness of the industry is assessed using an index with scale 1-5 (the higher the number, the most promising that particular industry in each scenario). In order to compare the industries within the scenario, they have also been evaluated using -, 0, +, and ++ (indicating lower to higher performance). The fulfillment of this evaluation is adjusted from related government's/corporate's institution reports and has been confirmed by IPC (Indonesia Port Corporation).

It is clearly displayed in the evaluation that container is the highly promising industries among others, followed liquid bulk, and renewable energy (port is proposed to be the center of handling/storage area for windmills and bioenergy[2]).

[2] Indonesia is the largest of palm oil producers in the world (FAOStat, 2014)

Table 4 Evaluation of promising commodities

Alternative cargo sectors		Green Port 		BaU 		Moderate Expans. 		No Expans. 		Total
Containers		++	5	++	5	+	3	0	2	15
Liquid bulk	Oil	+	3	++	4	+	3	0	2	12
	Gas	+	3	++	4	+	3	0	2	12
Renewable energy	Bioenergy	++	4	0	2	++	4	0	2	12
	Windmill	++	4	0	2	+	3	0	2	11
Others	General Cargo	+	3	+	3	0	2	0	2	10
	Solar	0	2	+	3	0	2	0	2	9

1.3.4 Step V and VI Monitoring Phase

Having identified possible scenarios, monitoring the signpost and trigger to the system have to be identified in order to make the scenario plausible. Some useful signposts are trade pattern in South East Asia and Asia-Pacific, politic and economic stability of Indonesia, the new convention/masterplan/regulation of government and port of authority that change cargo and energy demand, sustainable discourse in the national level, etc. In addition, global oil prices and energy-used shifting could influence product terminals looks in the future.

Step VI involving contingency planning for the selected alternative is not discussed here. It is suggested that just before going over to implementation of the plan, a reassessment of the existing uncertainties has to be carried out, and suitable actions prepared.

2 Development of Alternative Layouts Based On Scenario Planning

The possible design terminals of Phase II considering the scenarios and promising industries, the terminal needs are shown in **Table 5** and **Figure 5-Figure 7** together with the dedicated terminals area. The terminal area has been determined based on promising commidities and the projection of future containers in Port of Tanjung Priok.

Table 5 Terminal design in Phase II based on scenario planning approach

No	Scenario	Terminals	Dedicated area
1	**Scenario 1**	Container Terminal 4	64 ha
		Container Terminal 5	48 ha
		Container Terminal 6	48 ha
		Product Terminal 4	31 ha
		Renewable Energy Terminal	31 ha
2	**Scenario 2**	Container Terminal 4	64 ha
		Container Terminal 5	48 ha
		Container Terminal 6	48 ha
		Product Terminal 4	31 ha
		Product Terminal 5	31 ha
3	**Scenario 3**	Container Terminal 4	64 ha
		Renewable Energy Terminal	31 ha
4	**Scenario 4**	No Additional Terminals	

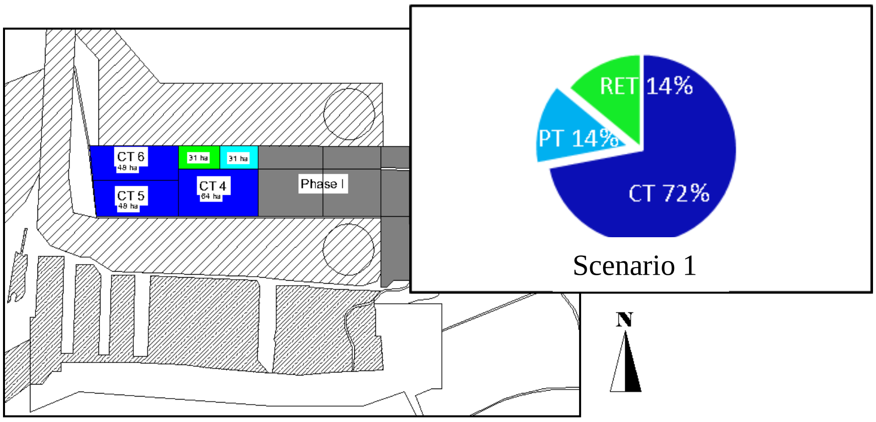


Figure 5 Proposed New Priok Phase II layouts based on scenario 1

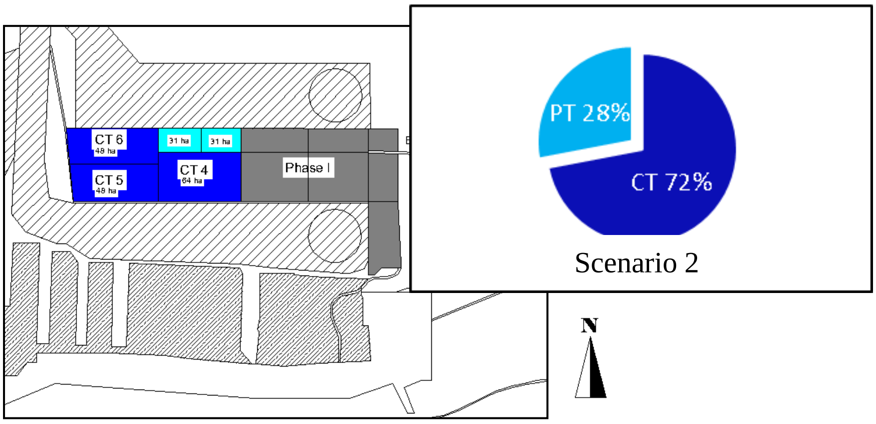


Figure 6 Proposed New Priok Phase II layouts based on scenario 2

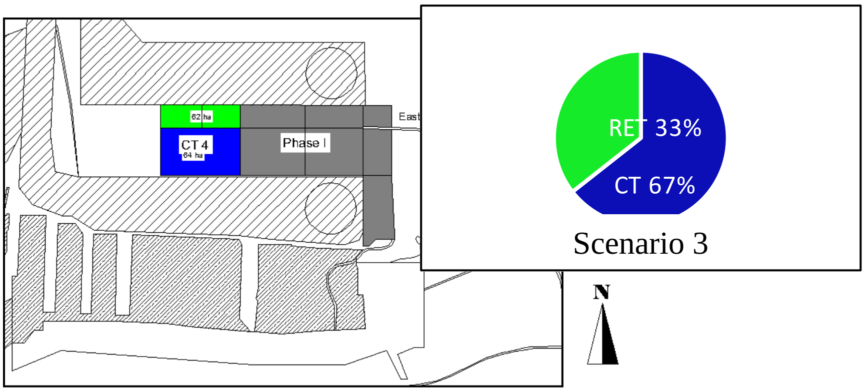


Figure 7 Proposed New Priok Phase II layouts based on scenario 3

3 Conclusion

This study is about planning and design of New Priok Development Project under uncertain future condition. In order to do so, Adaptive Port Planning (scenario-based planning) is implemented.There are ten major uncertainties confronting the port in the future, related to economic activities and sustainability issues.

Containers and energy demand are expected to be grow in the future. There is a possibility to implement generation of renewable energy in Java Island (where Tanjung Priok is operated), especially bioenergy and wind energy. The hinterland conditions of Tanjung Priok are heavily congested by trucks distributing the cargos. Therefore, finding alternative ways to shift the road traffic is critical for the port.

There are four proposed alternative layouts (one layout with no additional terminals) to cope with uncertainties. The selection of an alternative will depend on future condition (and management decision making) through monitoring of the uncertainties.

Nomenclature

APP	= Adaptive Port Planning
BaU	= Business as Usual
CBL	= *Cikarang Bekasi Laut* Canal
CT	= Container Terminal
FAOStat	= Food and Agriculture Organization Statistics
GDP	= Gross Domestic Product
IEO	= Indonesia Energy Outlook
IPC	= Indonesia Port Coperation
LWS	= Low Water Spring
MP3EI	= *Masterplan Percepatan Pembangunan Ekonomi Indonesia* (masterplan of acceleration of economic development of Indonesia)
Pelindo	= Pelabuhan Indonesia
PT	= Product Terminal
PT PPI	= *PT Pengembangan Pelabuhan Indonesia*/Port Developer
RET	= Renewable Energy Terminal
Scen.	= Scenario
TEUs	= Twenty-foot Equivalent Units

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Model of Fluid Flow and Pressure Distribution around Rectangular Shape using Laplace, Vorticity-Transport and Poisson Equation

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Abstract. The influence of fluid dynamic is crucial to the continuation of ocean structure operation. The main parameters for the analysis of fluid dynamic effects to objects are the flow pattern, the value of the fluid velocity and pressure distribution around the object. For doing such analysis require the modeling of motion of fluids passing through the object. In this project, the modeling is performed with finite difference numerical methods and software MATLAB, with some fluid conditions namely steady and incompressible fluid flow. The analysis of modeling results includes the verification of the results with the Bernoulli principle, and comparisons between models of ideal fluid (potential flow) with viscous fluid. From the results of the modeling, the pattern of fluid flow around objects in potential flow case and viscous fluid case (with a low Reynolds number) generate a laminar flow pattern.

Keywords: *bernoulli principle, low reynold number, navier-stokes equation, viscous flow*

1 Introduction

All the ocean infrastructure in the sea cannot be separated from its interaction with fluid. For example, fluid passing through the pile of offshore structures or fluid surrounding the subsea pipeline. The study limitation of fluid dynamics by experimental and theoretical studies make numerical analysis very beneficial. The movement of the fluid can be predicted by solving mathematical equations describing the fluid transport processes by numerical methods. The computation method advantage is that it will complement the results of experimental and theoretical study besides reducing effort required to perform laboratory experiments. Computational fluid dynamics will also provide an interesting graphic visualization.

2 Theoritical Background and Methodology

The case study used here is a fluid passing through the subsea pipeline simplified to a rectangular object, with properties shown in Figure 1.

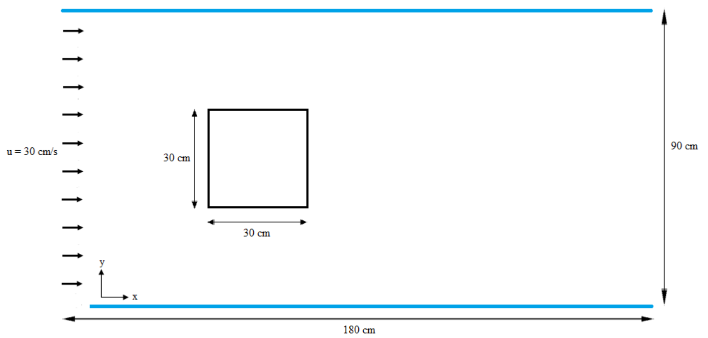

Figure 1 case study

This modeling is done for two separate cases, namely the motion modeling of inviscous fluid and viscous fluid. The inviscous fluid modeling use Laplace governing equation (Equation 1), whereas the viscous fluid modeling use couple governing equation, namely Vorticity Transport Equation (Equation 2) and Poisson Equation for ψ (Equation 3) where the two are a couple equation being solved simultaneously. All governing equations are discritized with the finite difference equations.

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}=0 \qquad (1)$$

$$\left(\frac{\partial^2\omega}{\partial x^2}+\frac{\partial^2\omega}{\partial y^2}\right)=\frac{1}{\mathrm{Re}}\left(u\frac{\partial\omega}{\partial x}+v\frac{\partial\omega}{\partial y}\right)$$

(2)

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}=-\omega$$

(3)

The value of pressure around objects obtained by solving Bernoulli equation (Equation 4) for the inviscous fluid and Navier-Stokes equation (Equation 5) for the viscous fluid.

$$\rho\frac{V^2}{2}+p+\rho gz=cons$$
(4)

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{\partial p}{\partial x}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right) \quad (5a)$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{\partial p}{\partial y}+\frac{1}{\mathrm{Re}}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right) \quad (5b)$$

In solving the Navier-Stokes equations to obtain the pressure value requires a governing equation which links the evolution of the pressure on the entire domain to the velocity value. The link is obtained by merging the Navier-Stokes equations in Equations 5a and 5b, and the result is Poisson equation for pressure (Equation 6).

$$\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}=\frac{1}{\mathrm{Re}}\left\{\frac{\partial}{\partial x}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\frac{\partial}{\partial y}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)\right\}$$
$$-\left\{\begin{array}{l}\left(\frac{\partial u}{\partial x}\right)^2+\frac{\partial u}{\partial y}\frac{\partial v}{\partial x}+u\frac{\partial^2 u}{\partial x^2}+u\frac{\partial^2 v}{\partial x\partial y}+\\ \frac{\partial v}{\partial x}\frac{\partial u}{\partial y}+\left(\frac{\partial v}{\partial y}\right)^2+v\frac{\partial^2 u}{\partial x\partial y}+v\frac{\partial^2 v}{\partial y^2}\end{array}\right\}$$
(6)

The algorithms for the modelling of inviscous fluid, viscous fluid, and the algorithm for solving the Navier-Stokes equation for pressure solution are shown in Figure 2, Figure 3, and Figure 4.

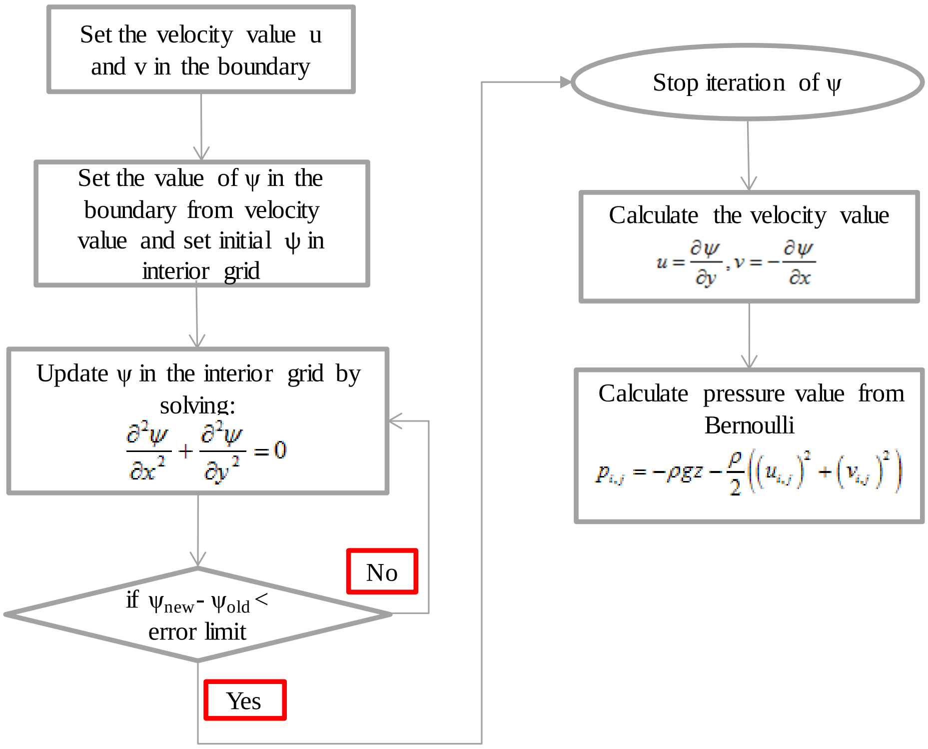

Figure 2 Algorithm for Inviscid irrotational flow modeling

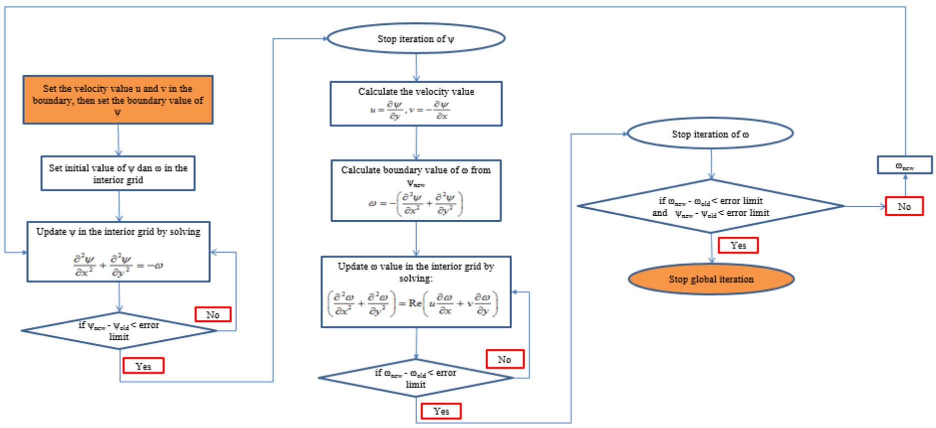

Figure 3 Algorithm for viscous flow modeling

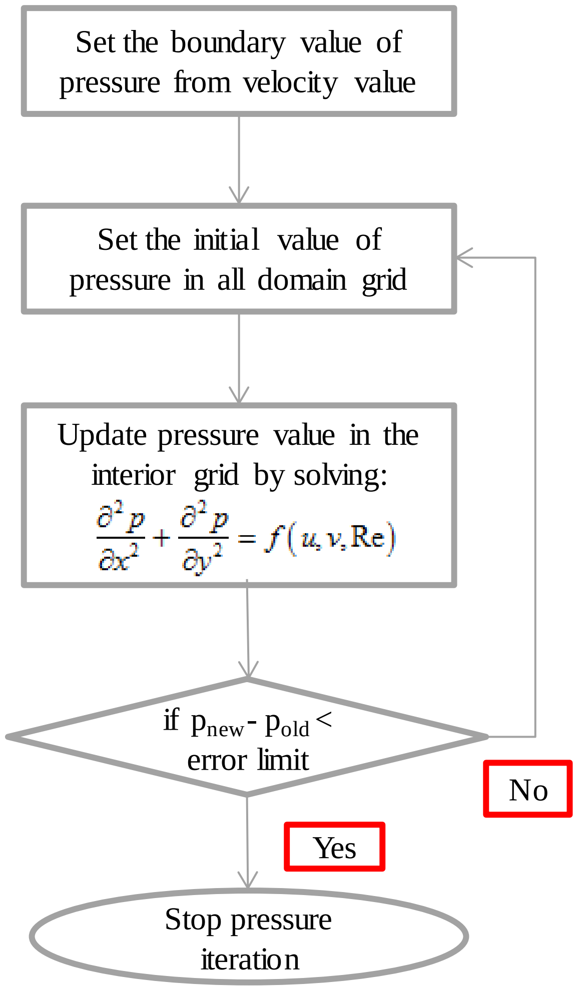

Figure 4 Algorithm for pressure solution in viscous fluid

3 Result and Analysis/Discussion

From the modeling of inviscous fluid by solving Laplace equation with the grid $\Delta x = \Delta y = 3$ cm, the number of grid nx = 61 and ny = 31, and the error limit for the iteration process is 1E-7, the results obtained are the flow patterns (the streamline) as shown in Figure 5, the velocity vector as shown in Figure 6, and the kinematic pressure from the Bernoulli equation as shown in Figure 7.

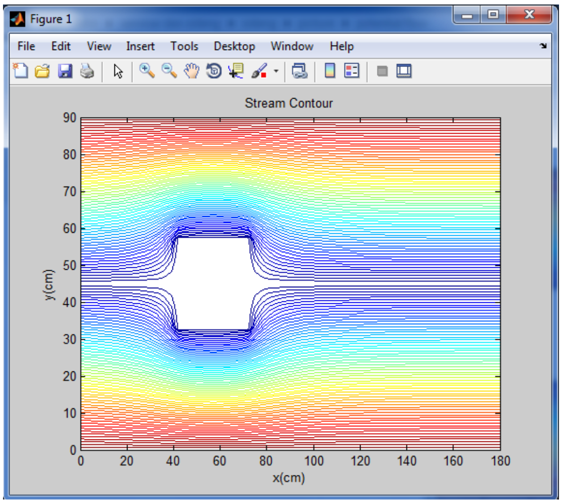

Figure 5 Streamline in inviscous fluid

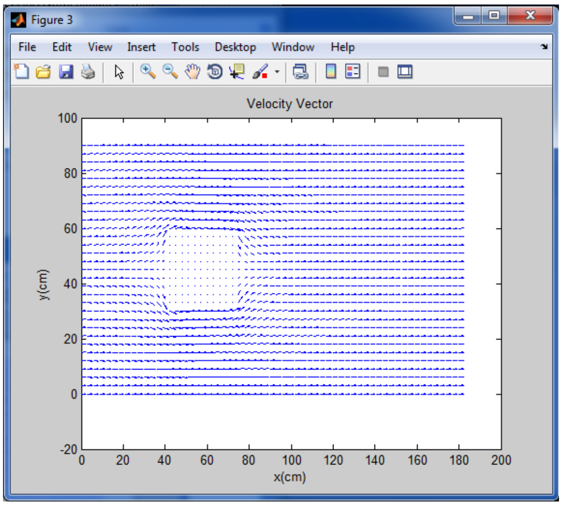

Figure 6 Fluid velocity vector in inviscous fluid

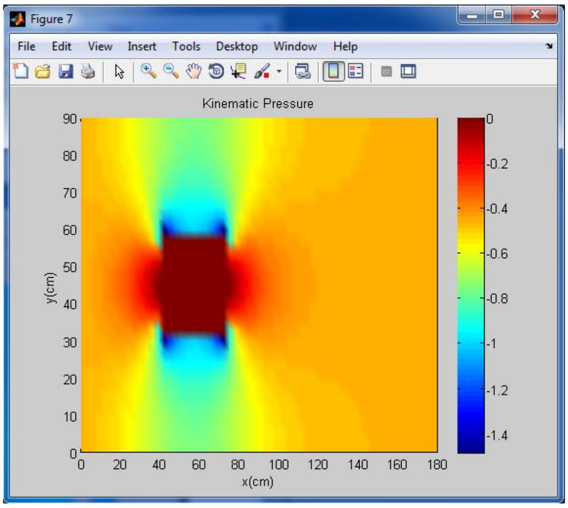

Figure 7 Fluid kinematic pressure in inviscous fluid

From the modeling of viscous fluid by solving Vorticity Transport Equation with Reynold numbers = 10, grid $\Delta x = \Delta y = 3$ cm, the number of grid nx = ny = 61 and 31, the error limit for the iteration process is 1E-7, velocity scale 1:30, length scale 1:15, the results obtained are the streamline as shown in Figure 8, the velocity vector as shown in Figure 9, the contours of vorticity as shown in Figure 10, and the pressure by solving the Navier-Stokes equation as shown in Figure 11 (the pressure value obtained is unstable or are dependent on the initial condition due to numerical problems).

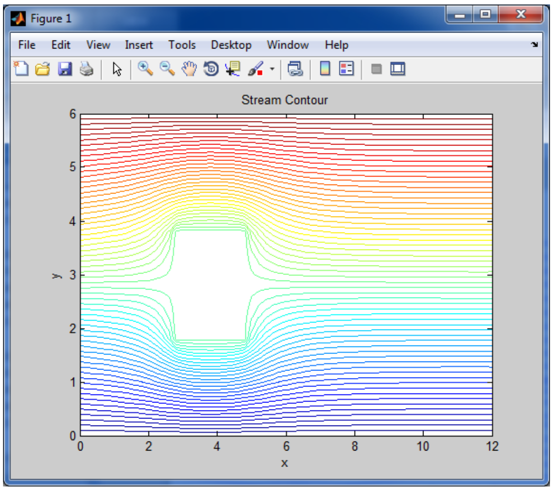

Figure 8 Streamline in viscous fluid

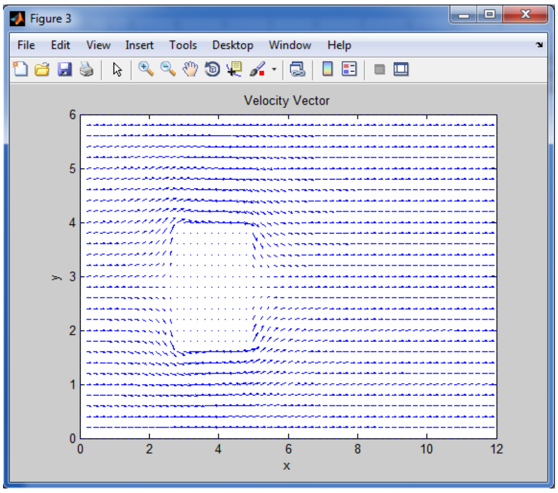

Figure 9 Velocity vector in inviscous fluid

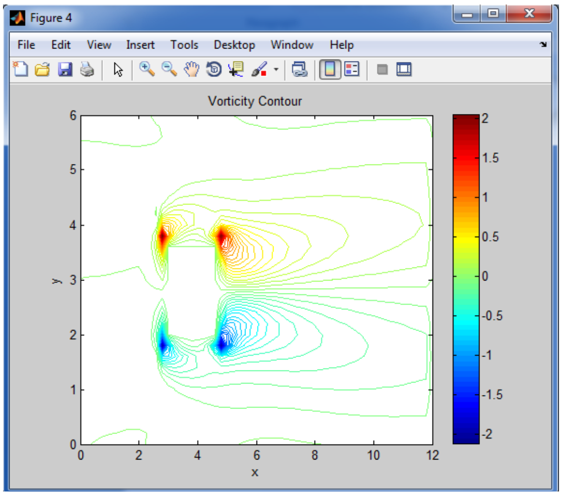

Figure 10 Vorticity contour in viscous fluid

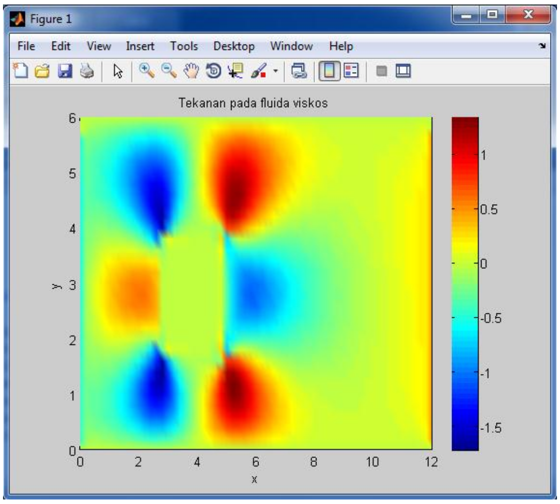

Figure 11 Fluid pressure in viscous fluid by solving Navier-Stokes equation

For Re = 10 is still a small Reynold Numbers, the Bernoulli equation can be used to obtain the pressure around the object as shown in Figure 12.

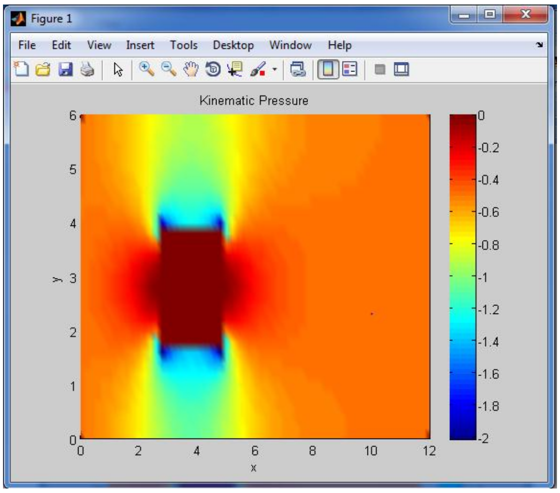

Figure 12 Fluid kinematic pressure in viscous fluid by solving Bernoulli Equation

The comparison of velocity value in inviscous and viscous fluid modeling shown by the graph in Figure 14 and Figure 15 around the position of objects number 1 to 12 (see Figure 13) describes that the effect of viscosity provides modeling result with bigger velocity value than if the effect of viscosity is ignored. On the contrary, graph in Figure 16 shows that the pressure value on the modeling results including the viscosity is smaller than the pressure value without fluid viscosity inclusion in the modeling.

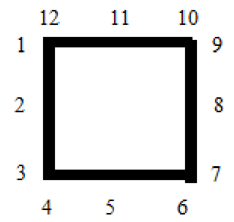

Figure 13 Position at the body/object

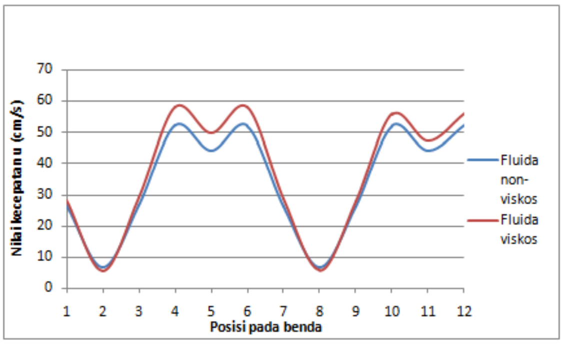

Figure 14 Graph of u velocity component value between inviscous and viscous fluid modeling

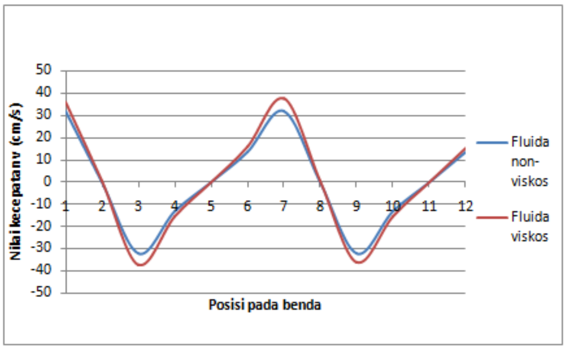

Figure 15 Graph of v velocity component value between inviscous and viscous fluid modeling

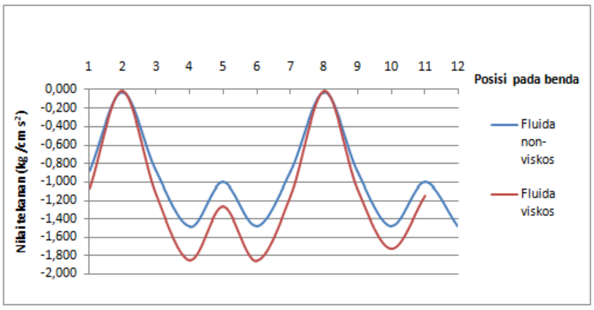

Figure 16 Graph of kinematic pressure value between inviscous and viscous fluid modeling

4 Conclusions and Recommendations

Conclusion of the fluid flow modeling:

1. The result of fluid flow modeling around the object in the case of potential flow resemble the flow pattern in the case of a viscous fluid with a low Reynolds number values (laminar flow).
2. The pressure solution in the fluid flow modeling in the case of potential flow fulfill the Bernoulli law, while the pressure solution on the viscous fluid modeling result is still unstable (depending on initial condition) due to numerical limitations, boundary conditions, and the programming language limitations.
3. The results of numerical modeling by finite difference method is highly dependent on the size of the grid.
4. Software MATLAB can be used as a good tool in modeling fluid dynamic, but it has limitations such as, for a small grid size, iteration process can take a long time to finish.

Suggestion for further research:

1. Numerical modeling by finite difference method is more appropriate for cases that are less complex.
2. Solving viscous fluid problem by Navier-Stokes equations requires complex boundary conditions (boundary condition), especially for the pressure variable.
3. Solution of fluid dynamic problem around objects should use a coordinate system that adapts to the objects geometry. For example, modeling a subsea pipeline is better by using polar coordinates.

4. Solving fluid problems with a high Reynolds numbers value and with the finite difference method require adequate numerical concepts comprehension and MATLAB skills.
5. Further calculation of the forces imposed to the object is needed so that it can be useful in technical applications.
6. The fluid dynamic modeling by numerical methods requires high patience and high accuracy.

5 Nomenclature

P	=	Pressure
u	=	Horizontal velocity
v	=	Vertical velocity
Re	=	Reynold number
x	=	Horizontal coordinate
y	=	vertical coordinate
ρ	=	Density
ψ	=	Potential Velocity
ω	=	Potential Vorticity

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CONSTRUCTION MANAGEMENT

Communication & Conflict Management to Improve Succes Rate of Design & Build Team Collaboration In Indonesia

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Abstract. Modern world of construction promotes efficiency as an important factor for competitiveness. Concept of lean construction, Design and Build (DB) contract and all the things that promote efficiency in construction are expected to improve the conventional contracting systems. As the complexity of construction management develops, the answer of that phenomenon i collaboration. Although if a collaboration is not managed properly, it will have a negative impact on the success of the collaboration itself. This study aims to examine the management of communication & conflict factors in the collaboration of the DB team to improve the collaboration of the DB team in Indonesia. In this study the authors hypothesize that communication and conflict factors are greatly affect the success of the project team collaboration. With questionnaire method involving 127 respondents who are divided from building and infrastructure project, the authors collect data which then analyzed using SPSS and SEM PLS 3.0. From the analysis of the data, it was found that (1) the indicators of seeking agreement (conflict variable) and (2) communication planning indicator (communication variable) proved to have direct and significant influence on the success of collaboration, and need to be managed properly since procurement phase to increase succes rate collaboration in DB team. The results of this study are aimed at assisting other projects in developing communication and conflict management for success on their project team collaboration.

Keywords: *Project collaboration; conflict in project; project communication.*

1 Introduction

To embrace the modern era of project development, where competition is getting tighter, technological developments are accelerating, so little difference will have a great impact, lean construction concepts, design and build contracts systems and other things that promote efficiency in construction are expected to address deficiencies which may occur in conventional contract systems. As the construction world develops, the greater the scope of work to be fulfilled, the more complex the problems encountered and the need to involve a large amount of expertise, it is clear that no single entity has all the knowledge and ability to complete the project itself [1]. The answer to this phenomenon is to collaborate between the parties on the construction project, to be able to handle the greater, and increasingly complex project level. Collaboration is a process of participation of several people or groups of organizations to work together to achieve certain results [3]. In the process of design and build project, from the initiation phase to the closing stage, it will involve collaboration of various parties to achieve the final goal of the project. The parties involved in a project will collaborate to achieve the final goal of the project, but they has various background related to experties, interests, goals, point of view, experience and many other differentiating factors. In the process of project, if not well managed, these distinguishing factors often cause problems that impede performance on collaboration [4]. These factors must be managed in order to support the success of the collaborative process itself. In this paper the author will discuss the factors of communication and conflict as a determinant of the success of collaboration on the design and build project team.

Communication is the process of conveying ideas, hopes, messages conveyed through certain symbols that are meaningful, done by messengers & addressed to message recipients with the intention of achieving togetherness (commonness) [5]. Lack of communication with either significantly will have a negative effect on the quality of work coordination [6]. Even in the research of construction projects in Jabotabek, the lack of communication among workers due to the presence of distinctive cultural diversity - each can be a work constraint that can affect the implementation performance and productivity that is a decrease in performance time up to 69.61% [7].

Conflict is a process whereby one party perceives that his interests are opposed or negatively influenced by others [8]. Poor communication quality is one of the causes of conflict. The resolution of the conflict itself must involve an advanced communication process to reach the best agreement for all parties. Therefore, from various potential project problems that may be experienced, this study aims to examine the management of communication & conflict in the design build project team collaboration in order to improve the success of design build project team collaboration, by identifying communication and conflict factors that significantly affect the success of collaboration, and how to improve effective communication and conflict management to resulting the positive impact at the level of success of design and build team collaboration in Indonesia.

2 Theoretical Review

2.1 Collaboration Concepts

The 21st century is considered to be a good time for Project performance is largely determined by the level of efficiency of collaboration [9]. Collaboration allows participants to have the capacity to complete work that can not be done by one party [10]. The benefits gained from good collaboration will vary according to the type of business or company, but the benefits may include: increasing profits through sharing skills across business units or companies; Cost reduction through best practice; Improve decision making through deep vision and knowledge sharing; Innovation through sharing ideas; Improve the ability to pursue goals that include the distribution of units or companies.

If the construction industry wants to stay competitive and succeeds in meeting the demands of an increasingly demanding client, then we have to start thinking of working collaboratively. [11] To achieve this advantage, however, the organization must consciously see that there are potential losses and barriers to collaboration, In order to manage them. Thus a good collaborative work between the Owner and the Project Manager of the design contractor is required.

Before beginning to collaborate, the parties involved should understand areas critical for the sustainability of collaboration [12]:

1. Vision, all members of the collaboration must agree with the purpose of collaboration tsb

2. Stakeholder Engagement, Collaborative leaders must ensure that all key stakeholders communicate with each other during the collaboration

3. Trust, Members of the collaboration must build a trusting relationship

4. Communication, All members must be well communicated

5. Processes, It should be explained how the collaboration will run until day by day

Technology, Must be approved what technology method daat most easy to use for collaboration can be done and awake.

2.2 Collaboration Process

After the parties agree to collaborate with each other, the first and most important component of the collaborative process is to create the process itself. This involves creating important guidelines that serve as a framework of how collaborating parties will work together throughout the project phase. This can be done with an independent facilitator or with members of one of the collaborating parties and is considered capable of acting as a facilitator. A good way, it is the early stages of all parties determining the collaborative process to succeed [13]. The process of collaboration is described by Giesen as follows:

1. Preparation (stage one) Pre-Deliberation
2. Seeking Agreement (stage two) Deliberation
3. After Agreement (stage three) End-Deliberation

2.3 Communication

To generate effective communication in the framework of successful collaboration, it is necessary to have a communication plan in which the Project Improvement Team develops communication plans such as communication planning through asking the following questions:

• Who needs what information?

• When do they need information?

• Who gives information?

• How will the information be provided?

2.4 Conflict

Basically, conflict management is only divided into 2 stages, namely how to avoid conflict, and how to solve the conflict that already happened. A project manager must be active and focused in avoiding and preventing conflicts, if not properly handled conflict will develop into claims, and should promptly resolve claims to prevent them from developing into disputes and legal matters [14].

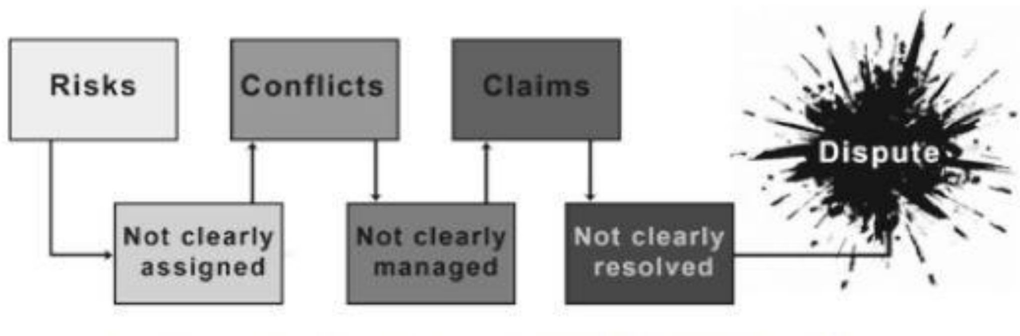

Figure 1 Risk,Conflict,Claim, and dispute continum model

Source: Archarya and Lee (2006)

In the early stages, if the conflict is not successful to mitigate, alternative methods of conflict resolution can be resolved without involving others. For conflict resolution can refer to several alternatives, among others: avoid, compete, cooperative, accommodative, and the most commonly used is a compromise. The most common and inexpensive form of conflict resolution in construction, where the control of the conflict process is still held by the parties involved. To achieve a good solution to the conflict, four characteristics must be met: justice, efficiency, wisdom and stability. The figure below shows the five common conflict management styles that can be found in alternative conflict resolution processes, in relation to individual relationships or shared satisfaction [15].

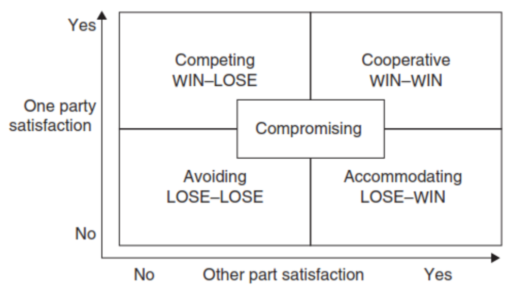

Figure 2 Negotiation Model

Source : (Rex, 1981)

2.5 RESEARCH METHODS

In the stage of finding answers to the problems that have been formulated in the previous chapter, at first a study of related literature are conducted and the formulation of the problem is divided into points of research question (RQ). In this study 2 research question are set, which each expected to be answered through the stage of the research process. Furthermore, research will be conducted with appropriate methods to answer the research objectives that have been set. In conducting this research is prepared in advance stages of research that will be done. The following stages of the research are:

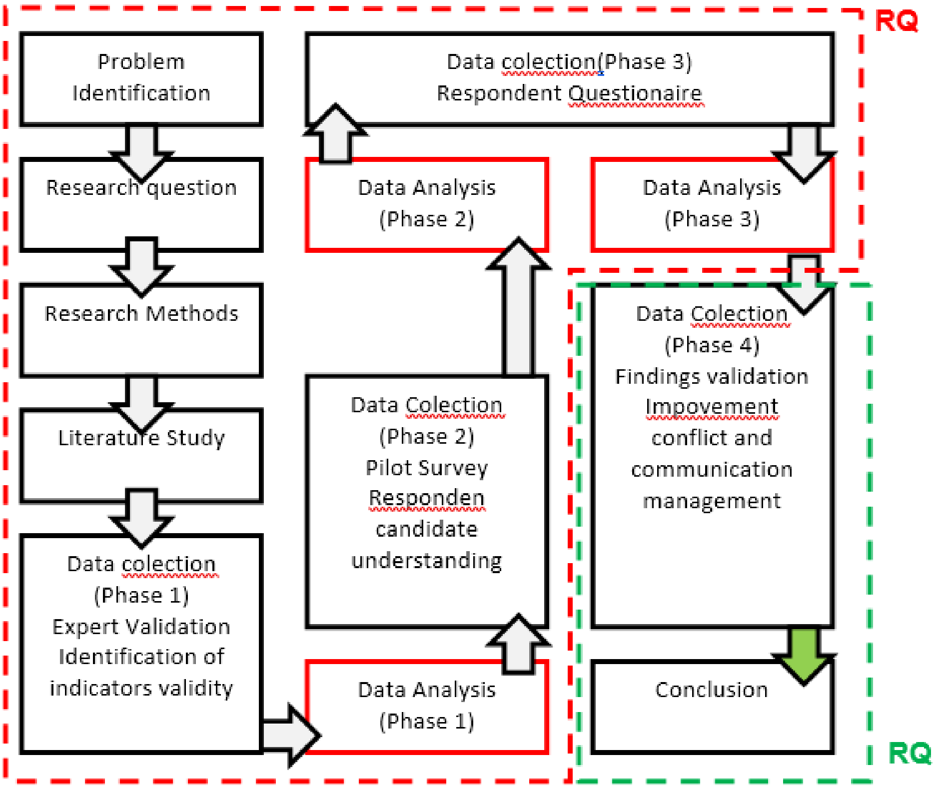

Figure 3 Research flowchart

Source: Authors, 2017

2.5.1 Research Variables / Indicators

Table 1. Research Independet Variables(K)

Indicator	
Conflict	
$K_{1.1}$	Work organization
$K_{1.2}$	Seeking Agreement
$K_{1.3}$	Produce choices
$K_{1.4}$	Human Interaction
$K_{1.5}$	Open Negotiation
$K_{1.6}$	Human Resources
Communication	
$K_{2.1}$	Communication Plan
$K_{2.2}$	Information Distribution
$K_{2.3}$	Component Identification
$K_{2.4}$	Stakeholder Management
$K_{2.5}$	Communication aproach

Source: Authors, 2017

Table 2. Research dependent variables (M)

Indicator	
Collaboration Success	
$M_{5.1}$	Well known team member
$M_{5.2}$	Want to trust and to be trusted by other team member
$M_{5.3}$	Able to communicate well to other team member
$M_{5.4}$	Will to contribute in problem solving discussion in project meeting
$M_{5.5}$	Have a solid team
$M_{5.6}$	Have high flexibility through the dynamic of the project
$M_{5.7}$	Produce innovative products or methods from a high innovation team.
$M_{5.8}$	Sharing knowledge & experience, experties, and togetherness

Source: Authors, 2017

2.5.2 DATA COLLECTION

The data collection for the research includes the collection of primary data and secondary data which is divided into three stages as follows:

1. Conduct questionnaires and interviews with experts involved in the construction project implementation process of at least three similar projects to identify the influence of communication and conflict variables on successful collaboration of design teams. Respondents at this stage are 6 experts with the following criteria:

    - Have a minimum of S1 and have mastery on Project Manager on Design project Build.

    - Involved directly in the implementation of the Design and Build project and is the core personnel in the implementation of the Designed Build project and has been experienced in construction projects for at least 5 years.

Experts are asked to provide an assessment of the effect of communication and conflict variables on successful collaboration on project design teams. The questionnaire survey was conducted to reduce the indicators that have been obtained from the literature. Respondents at this stage are 6 experts with the following criteria

2. Conducting questionnaire pilot survey of respondents for variables K1, variable K2, and variable M obtained from the results of literature study and interview results. The respondents were asked to provide an assessment for understanding the substance and ease in filling out the questionnaire. This questionnaire survey was conducted with the aim that the collection of data can then be understood well by the respondents, and can produce valid data. Respondents at this stage are 10 respondents with the following criteria:

- Have a minimum of S1 and have experience in team collaboration on design and build projects.
- Engage directly in the implementation of the design and build project and be the core personnel of the project implementation and has been in the construction project for at least 3 years.

3. After the survey is completed and the validated K1, K2, and M variables are then carried out a questionnaire survey of the core design and build project team that has been directly involved in the construction project implementation and a minimum of more than 5 years experience. Respondents were asked to provide an assessment of the effect of communication and conflict variables on the success of collaboration on the design team and the improvement of their management on the design project based on their experience. Respondents at this stage have the following criteria:

- Have minimum education S1
- Engage directly in the implementation of the design and build project and be the core personnel of the project implementation and has been in the construction project for at least 5 years.

2.5.3 DATA ANALYSIS

After the results obtained from the data collection, the data were analyzed by SPSS application to determine the level of homogenity. Then the data is processed again using SMARTPLS 3.0 to be able to know the significance of its effect on the success of collaboration and relationship pattern among variables and indicators.

With the three variables already have their own way of assessment, then the analysis of data that has been collected and assessed. The data that have been collected will be analyzed in the following way:

1. Data in input to SPSS to be tested homogeneity based on work experience, position, and last education.

2. To determine the level of validity and reliability of data, then made a model on SEMPLS 3.0 then in the input data of the questionnaire to each indicator and tested its validity and reliability by performing calculations PLS Algoritm and seen the results of composite reliability and AVE.

3. Then run the process of calculating the bootstrapping to determine the level of significance of the influence of each indicator by looking at the amount of outer loading results, in this process can be seen which variables / indicators which have the greatest influence on the success of design and build team collaboration.

4. Then from the bootstrapping process is also seen the path coefisient which is the level of significance of relationships between variables / indicators, from this process can be seen where the relationship between variables / indicators dominant and the level of significance.

5. Then from the results can be ranked to be a finding that will then be improved by re-validating the findings and improvements to the experts.

2.5.4 RESEARCH RESULT

Based on data collection from literature and previous research, there are 52 indicators from 3 variables (K1, K2, M5) which are considered to have an effect on the success of collaboration on the design and build team in Indonesia. This initial validation was carried out by 6 experts. All of 52 indicators are received approval from experts and furthermore 52 of these indicators will be used for the development of pilot survey and respondent questionnaires.

After the pilot survey to 10 candidates of respondents, the questionnaires were distributed to 200 prospective respondents. The result of this questionnaire was obtained by 127 respondents who gave answer, which was divided from 63 respondents with building project background, and 64 respondents with background of infrastructure project. Furthermore on the data of the respondents are tested statistic test homogeneity with the result there is no difference understanding of respondents related to background position, work experience, and last education on each indicator proposed. After the homogenity test on the indicator, then performed the calculation process using SEM PLS 3.0 to test the validity, reliability, and get the level of significance of influence and relationship patterns between variables and indicators. Development of models based on listed indicators is as follows:

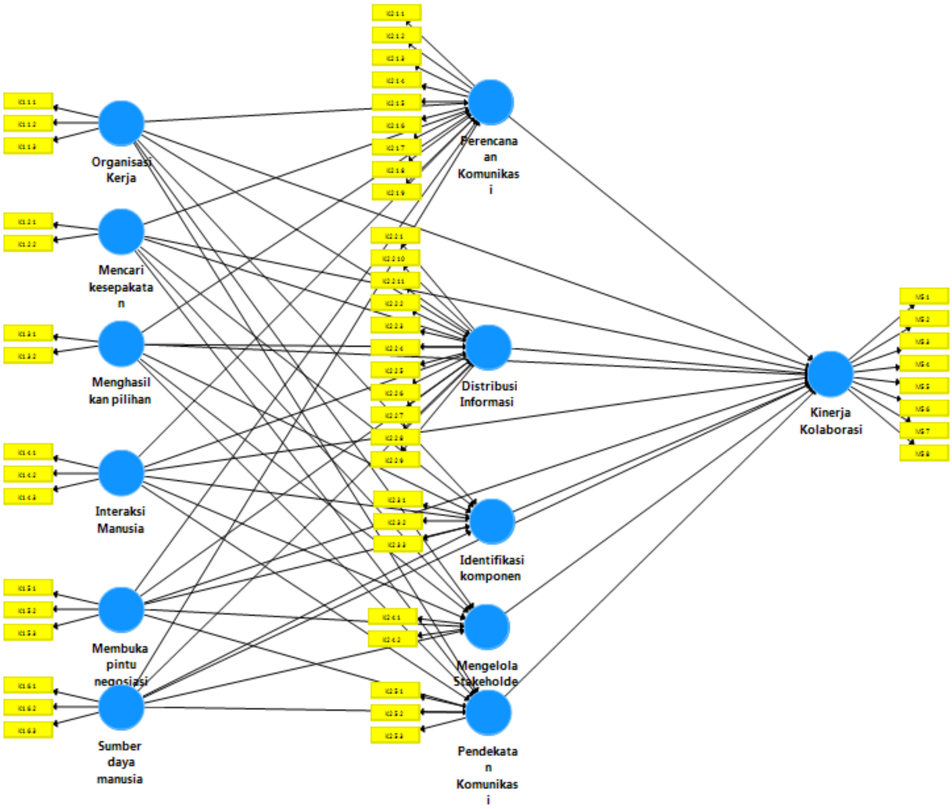

Figure 4 SEM PLS Model (Variable K1,K2, and M5)

Source: Authors, 2017

From variable, indicator and sub indicator model of all variables that have been made (figure 2), calculation procedure is done by using PLS Algoritm and Bootstrapping tool on a SEM PLS 3.0. To obtain the desired results in this study, which is about finding indicators that directly and significant impact on the success of design and build team collaboration, then the procedure should be run is bootstrapping, followed by ranking the results of the path coefisient on the bootstrapping menu, and identified indicators Which is directly related to the success of the collaboration, and has a sufficient level of significance.

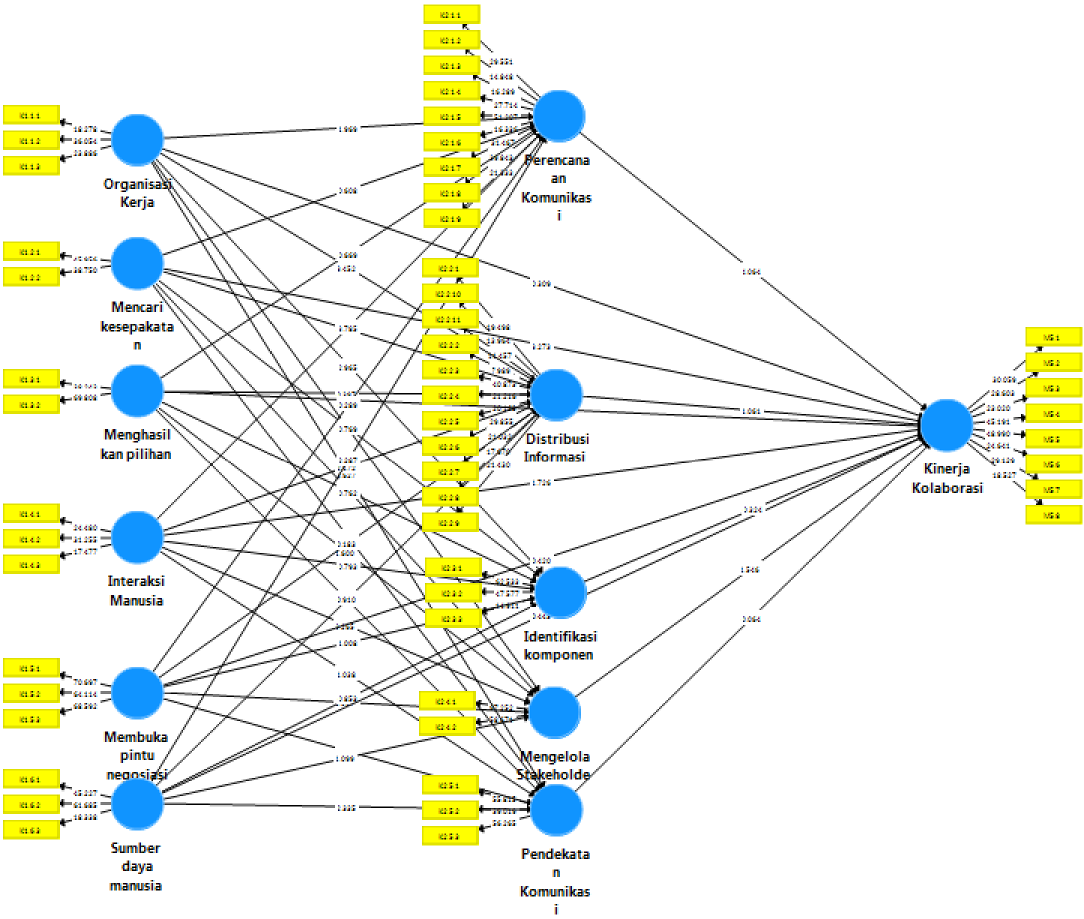

Figure 5 Bootstrapping procedure result

Source: Authors, 2017

Table 3. Rank result of significant path coeffisient procedure on bootstrapping

No	Indicators Relationship	T Statistics (|O/STDEV|)
1	Work Organization -> Stakeholder Management	5,051
2	Communication Planning -> Collaboration Sucess	4,028
3	Human Interaction -> Communication Planning	3,656
4	Work Organization -> Information Distribution	3,423
5	Work Organization -> Comunication Aproach	3,379
6	Work Organization -> Component Identification	3,179
7	Seeking Agreement -> Collaboration Sucess	3,087
8	Human Resource -> Comunication Aproach	2,472
9	Human Interaction -> Stakeholder Management	2,469
10	Membuka pintu negosiasi -> Pendekatan Komunikasi	2,317
11	Mencari kesepakatan -> Comunication Aproach	2,244
12	Human Interaction -> Information Distribution	2,132
13	Human Resource -> Communication Planning	2,050
14	Work Organization -> Communication Planning	1,988

Source: Authors, 2017

From the ranking result of the significance level of relationship pattern according to the direction in the expert validation stage in the previous chapter, the following findings are produced:

A. H1: **Communication Planning** from communication variable affects the succes of team collaboration is accepted by showing significant relation with T statistic = 4,028 (> 1,96) it shows that Communication planning strongly influence the success of team collaboration. The 1.96 number limit indicates the level of significance of the relationship between variables where if the statistic T value is less than 1.96 the relationship between the variables is not significant or less influential [16].

B. H1: **Seeking agreement** from conflict variable affects the success of team collaboration is accepted by showing a significant relationship with T statistic = 3,087 (> 1,96) it shows that Seeking the deal affects the success of the collaboration. The 1.96 number limit indicates the level of significance of the relationship between variables where if the statistic T value is smaller than 1.96 the relationship between the variables is not significant or less influential [17].

Pattern of relationships between Indicators that have a direct and significant impact on the success of the collaboration:

In the relationship between communications and conflict indicators, there are 41 (forty-one) relationships, of which 14 (fourteen) relationships are significant with statistical T values above 1.96, and 2 significant lancers are found to be significant to success Collaborations identified through calculations using the SmartPLS 3.0 application, which are:

1. **Communication Planning** affects the success of team collaboration is accepted by showing a significant relationship with T statistic = 4,028 (> 1,96) it shows that communication planning greatly affects the success of team collaboration. In previous research it has been found that communication planning is very important because one of the main causes of conflict in team collaboration is poor communication between team members [21] [22].

2. **Seeking agreement** affects the success of team collaboration is accepted by showing significant relationship with T statistic = 3.087 (> 1,96) it shows that Seeking agreement affects the success of collaboration. In previous research it has been found that conflicts that hamper collaboration will only occur if the parties find no agreement in determining the rules governing the rights and obligations of the parties [23]

3 CONCLUSION

The conclusions of this study include:

1. Answering RQ 1, the factors in communication and conflict management that affect the success of design team collaboration are:

   - Indicators generating choice of conflict variables should be given attention so that the project proceeds safely as it is the most influential indicator with statistical T = 76,940.

   - The indicator opens the door to the negotiation of conflict variables from deserving attention and is an indicator that affects with statistical T = 73,609

   - Human resource indicators of the conflict variable also deserve attention because it is an influential indicator with T statistic = 64,519

Pattern of relationships between Indicators that have a significant effect on the success of the collaboration:

- Planning Communication proved to influence the success of team collaboration by showing the value of T statistic test results path coefisient bootstrapping SEM PLS 3.0 = 4,028 (> 1,96)

- Seeking agreement proved to affect the success of team collaboration is accepted by showing the value of T statistic test result path bootstrapping coefisient SEM PLS 3.0 = 3.087 (> 1,96)

2. Answering RQ2, in its role of enhancing collaborative success, How to improve communication and conflict management of research findings that have direct and significant impacts:

   The result of identification of significance factor of success of collaboration which yield 2 significant indicator and direct influence on success of collaboration, that is

   1. Communication planning (var.Communication)

   2. Seeking agreement (var Conflict)

   Based on the communication management and conflict management stages and findings above, the appropriate assessments are done by better analyzing the parties to be invited to cooperate in the collaboration team, the analysis is carried out thoroughly, from the earliest stage of procurement, Only to technical and administrative matters, but this research suggests an analysis of other factors, especially on the understanding and scheme of the party's communication plan if it is believed to handle the project, and that party's views on the conflict and the experience of the party in seeking a conflict resolution agreement, Negative impacts and miss communication in the project can be avoided, so that collaboration can work well.

3. Hypothesis in chapter 2, which states that communication and conflict factors affect the success of team collaboration significantly successfully proven through the results of processing and data analysis.

4 SUGGESTION

The suggestions of this research are:

1. The scope of this research has not been possible to analyze the risk approach, hence the need for further research on collaboration with risk approach so that the result of risk analysis can be the basis of reference to the development of supporting theory of success of further collaboration.

2. Conflicts and communications are interrelated and significantly affect the success of collaboration, so the authors suggest that communication and conflict management has begun since the earliest stages of planning and recruitment of collaboration teams, more easily when in addition to technical factors often the primary valuation factor, communication management factors and Conflicts can also be one of the hiring criteria to be considered.

3. The results of the research can be used as a reference in developing conflict management and communication in the design project.

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Integrating Standard Operating Procedures for Basement Work Area

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Abstract. Excavation work area for basement construction, is one of hazardous area. Work accident could be occur due to unsafe condition such as buried by landslides, falling from the edge, falling material, and so on. In attempt of preventive of unsafe condition, thus needed to create a Standard Operating Procedure (SOP) in the form of practical and obvious guideline which can be understood as well as rules commonly. The objective of this study is to provide the recommendation of integrated occupational safety SOP. Based on this case study, there has been no research on integrated occupational safety SOP with basement work area.

This studies done by interviewing the safety officers to determine dangerous area at the building construction in order to be identified regarding to unsafe conditions. Based on previous studies and the interview result along the approval form safety officers, then excavation work area for basement construction review was made more distantly related to unsafe conditions. So that the excavation work area for basement construction was identified for 17 types of risk.

The result provides a recommendation of integrating SOP. This SOP has been through validation process by the safety officers. The recommendation consist of the form of flowchart described in detail on the description of the unsafe condition, risk of harm, and preventive action which is then visualized by sketch of site management to safe condition at excavation work area for basement construction. Thus by following this SOP then it supposed to be zero accident.

Keywords*:* *excavation work, basement, unsafe condition, occupational safety*

1 Introduction

One of the efforts to implement safety characteristics is to do everything according to the standard operating procedures. Currently, foreign companies are very concerned about safety, most of them implement zero tolerance to the SOP.

A Good corporate is required to uphold the occupational safety. Most successful construction companies have recognized that safety and health management is a critical strategic issue and have developed comprehensive company safety and health programs Schaufelberger and Lin [1]. Therefore a good construction company certainly has a system know as SHE / HSE (Health and Safety Environment). At construction sites, the system can be derived in the form of an integrated workflow system to realize the discipline of work as a facility. In this system commitment and responsibility are indispensable for addressing and reducing the risk of work accidents.

A construction company implements the occupational safety by referring to the national standards such as SNI and SMK3 and also the international standards such as OSHA and OSHA 18001. We know that oftentimes those standards are hard to understand. Not all Management in the company has a practical and clear guidelines that are convenient to implement. And we know that every management is required to provide a safe working system in the form of guidance so that it can be as a rule even by ordinary people, so that the determination of safety risk allocation in a construction project can be realized in the form of management system descriptively in a work process package with standardized steps and must be followed for the purpose of project can be reach.

Related to the risk of occupational safety, in the construction industry occupational safety risks are caused by two things as explained by Schaufelberger and Lin (2014), about the cause of the accident as follows. “Why do accidents occur on construction project sites? They may result from an unsafe act by the worker or from unsafe job conditions or both”. “Research into why construction accident occur has shown that about 90% are due to unsafe behavior and about 10% are due to unsafe job conditions”. Based on the statement of the accident can be caused by two factors, internal factors arise due to a negligence of workers who are not adherent to safety procedures that have been provided by the company. Some of the statements can be concluded that the percentage of accidents is mostly caused by unsafe actions compared to unsafe conditions, but it is undeniable that sometimes the cause of unsafe acts is because of unsafe conditions as well.

The literature study conducted in this study is to review further about unsafe condition and unsafe action related to the area of construction sites in order to create a working procedure. For that purpose accordingly, we conducted an interview with the safety officer about unsafe conditions in the multi-storey building. Results from interviews about the work areas of accidents in construction projects among other are the areas of the roof, excavation, and fabrication.

Excavation to be the case chosen in this study because it is based from previous articles and research on cases of occupational accidents occurring in the basement work area. Wirahadikusumah [2] has studied One of the study says that from various activities in construction projects, excavation work is one type of hazardous work, where the accident occur tend to be serious even lead to fatality.

2 Literature Review

2.1 Construction Accidents Figure

Isafetyadmiral [3] claims based on data from Provider of Social Services in Indonesia at 2016 the number of accident in construction sector constantly at 32% competing the manufacture at 31%. Health and Safety Executive [4] has recorded the fatal injuries arising from accidents at work in Great Britain by the headline results of 2016/2017 can be seen at Figure 1,2.

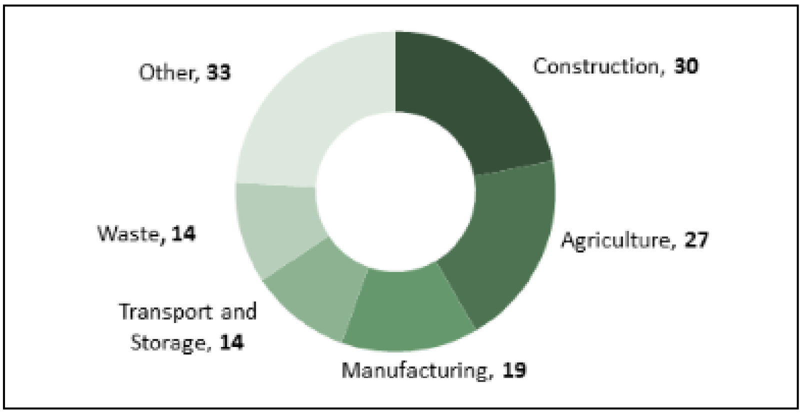


Figure 1 Fatal Injuries to workers by main industry

Source : www.hse.uk

Figure 1 showed that construction industry has biggest contribution to fatal injuries. Every accidents that has been showed statistically by Figure 2, could be occur at construction sites included the basement excavation.

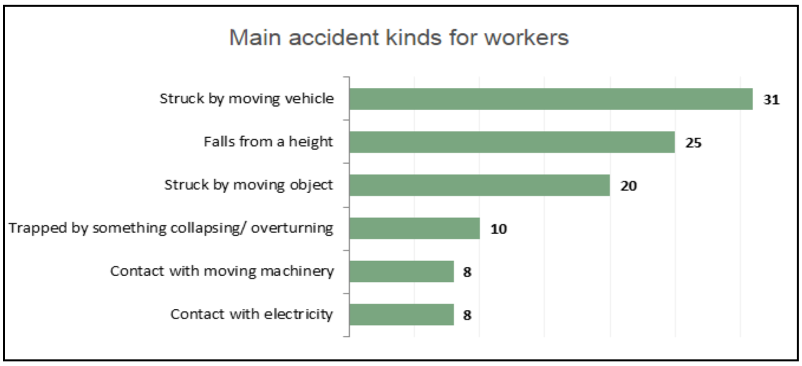


Figure 2 Main accidents kind for workers

Source : *www.hse.uk*

2.2 Domino Theory

Nugraheni [5] has studied the "Domino Theory" Heinrich developed the first theory of accident causation by picturing this accident sequence as a series of five dominoes standing on edge. It has become known as the Domino Theory accident causation.

Abdelhamid in Nugraheni [5] has studied the Domino Theory postulates as the first domino is toppled over, it will knock down the other four dominoes, unless at some point a domino has been remove to stop the sequence. This model suggested that through inherited or acquire undesirable traits, people may commit unsafe acts or cause the existence of mechanical or physical hazards, which in turn cause injurious accidents.

By the explanation of Nugraheni [5] about the "*Heinrich's Domino Theory*", then concluded as follows:

First domino: Ancestry and social environment. If people are born with and/or are socialized to developed faulty personal characteristic such as recklessness, stubbornness, avariciousness, etc.

Then

Second domino: Fault a person: Result either inherited or acquire, such as recklessness, violent temper, nervousness, excitability, inconsiderateness. Ignorance of unsafe practices, and these are proximate reason for committing unsafe acts or for the existence of mechanical or physical hazards.

And

Third domino: Unsafe conditions such as wet or muddy conditions of soil, landslides and unstable soil conditions for heavy equipment, physical environmental factors, no barricade at excavation pit, etc.

Resulting directly in

Fourth domino: *Accidents* that are even such as falls of persons, striking of persons by flying objects, etc.

And

Fifth domino: It will cause an *injury,* such as fractures, lacerations, etc.

Taking the third domino, then if the first and second dominoes fall in a row then it will not fall on the fourth and fifth dominoes. It has been likened to third domino is "unsafe act and unsafe conditions". By taking one of the dominoes can be interpreted as a form of action to mitigate risk. Risk mitigation could be done in anyway. In this study risk are mitigated by recommending a construction site management that is claimed to be a preventive acts.

2.3 Regulation Used

The regulation are designed to minimize the possibility of an unsafe actions or conditions arising. Many different standard safety regulations have been issued by various organizations, and the following were used as reference for this study as follows:

1. The Occupational Safety and Health Act (OSHA) passed by Congress in 1970, this act established mandatory safety and health procedures to be followed by all firms in interstate commerce. One of the article of OSHA used for this study is Personal Protective Equipment (PPE) Regulation. OSHA Requires that many categories of PPE meet or be equivalent to standards developed by the American National Standards Institute (ANSI). ANSI has prepared safety standards since the 1920s, when the first safety standard was approved to protect the heads of industrial workers (www.osha.gov)

2. OHSAS (Occupational Health and Safety Management Systems) : 18001, about the safety management. The most common standard is widely adopted (referenced) by many companies (organizations) in carrying out the implementation of Safety Management System and Occupational Health in the management of the organization (company) is concerned.

3. Regulation of the minister of labor (Permenaker 05/MEN/1996).

4. Quality Management System ISO (International Standard Organization) 9000:2000.

In this study ISO 9000 used as well as reference to confirm the standard operating procedures which integrate between occupational safety and construction sites with implementation method to prevent the unsafe condition as part of quality.

3 Results

Based on the formulation of the problem is obtained, the main purpose of this research is to be create a structured system of the standard operating procedures integrated for basement work area. The problem formulation in this study that is not yet found a structured system that integrates between the safety of work with quality and implementation methods reviewed from the construction sites.

Data collection was conducted using interviews supported by literature study on the regional/international regulation of safety and quality management. Data was analyze by compare the interview results and adjusted with the occupational safety standard either the national or the international. Draft SOP in this study is in the form of workflow made by Microsoft visio software, and accompanied by the simple modelling visualizations of construction sites, reviewed by the safe conditions sketch by sketch up software. In the process of validation, the expert attach the assessment and suggestion to complete the draft. If the draft is not approved it would be revised, and reversely when the draft is approved then it can continue to the discussion according to the study series. The discussion contains explanation about the quality management and the assumptions were used in this study.

The result of this study is processed by descriptive and systematic as presented by output framework (Figure 3) as follow.

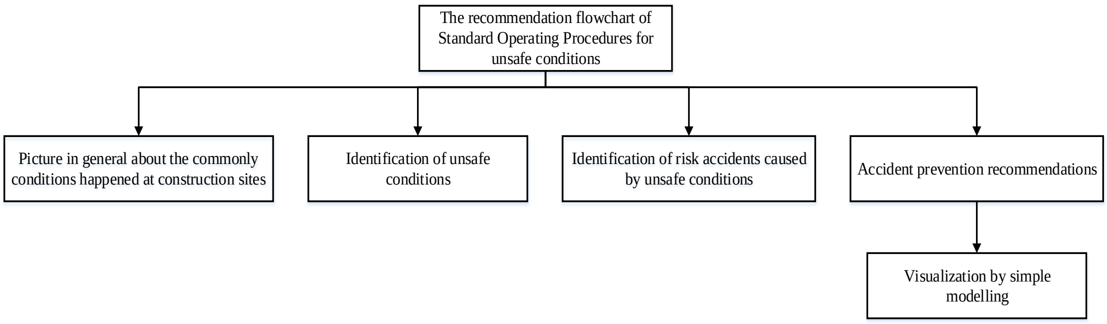


Figure 3 Study output framework

The results of this study is the standard operating procedure in the form of descriptive and flowchart accompanied by simple modelling of visualization. To obtain the output of this research, study series and result as explained as follows.

3.1 Interview Result

Based on the interview result it can be concluded that the cause of unsafe condition not just from nature, or the situation at construction sites, but also from the unsafe actions of workforce were involved during the process of construction. The unsafe actions the compounded by the environment of construction sites, so those thing are causing the accident.

Hazardous area (frequent of accident) mentioned by the source ie; roof building construction, excavation, and fabrication. On the interview, excavation more elaborated than other construction areas, so that the excavation area of the land was selected as the location reviewed on its unsafe condition.

3.2 Result Output

Output of this research is a series of working standard operating procedures (SOP) recommended for construction service provides in Indonesia. In this standard operating procedures there have been identified 17 kinds of risk of harm caused by unsafe conditions caused by nature or the field situation caused by unsafe acts of labor involved during the execution of excavation for basement. These are 17 kinds of risk were identified as follows:

1. Unrepresentative soil investigation.
2. Landslides and unstable soil conditions for heavy equipment.
3. Wet/muddy conditions of soil.
4. Physical environmental factors.
5. Inadequate lighting.
6. No barricade at excavation pit.

7. No warning signs or alarms.
8. Toxic gas and limited oxygen levels.
9. The active electricity and underground pipes.
10. Scattered materials.
11. No supervisions.
12. Uncontrolled maneuver of heavy equipment.
13. Natural disasters.
14. Excavation conditions after work cut off more than a day.
15. Bad weather.
16. Installation and removal of retaining wall.
17. Defective materials and equipment.

3.3 Recommendations of Standard Operating Procedures Flowchart for Unsafe Conditions at Excavation Work of Basement Multi-Storey Building

Previously note that from 17 risks were identified not all of them frequently happened at excavations work. There are some unsafe conditions rarely happened or frequently happened but can be anticipated. As example presented at Figure 4, *flowchart* below is 1 From 17 Kinds of Recommendations Flowchart Working Procedures for Unsafe Conditions At Excavation For Basement Construction About Access for The Heavy Equipment In Unstable Excavation Areas As An Example Of The Rarely Happened Risk At Excavations.

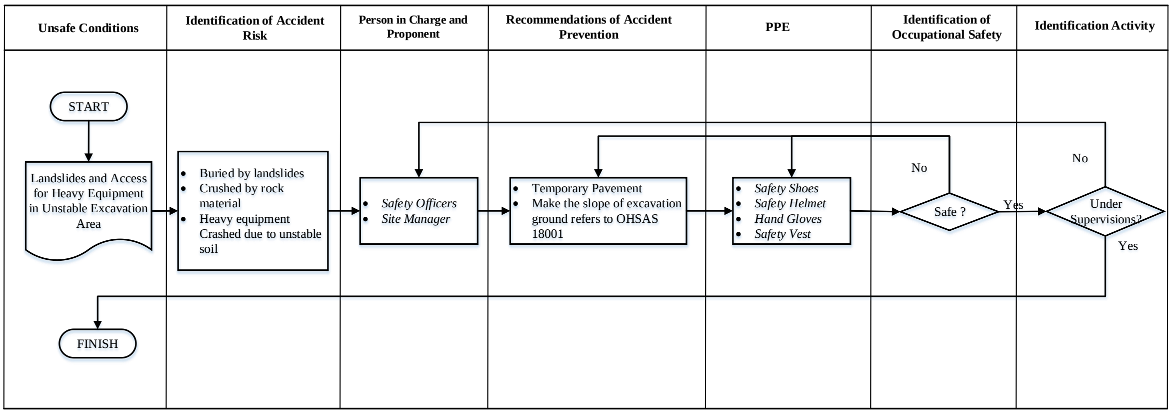


Figure 4 Flowchart of prevention actions for landslides and access for heavy equipment in unstable excavation area

The flowchart explained about the conditions where the access for heavy equipment in unstable excavation areas. In the implementation, if no hazard is identified due to hard soil/rock/rocky nature, then accident prevention efforts (environmental conditioning to be safe) are not necessary. However, personal protective equipment (PPE) is recommended to remain worn even identified as zero accident.

For unsafe conditions frequently happen presented at Figure 5 about the wet/muddy conditions of soil. This flowchart below is another 1 from 17 kinds of recommendations flowchart working procedures for unsafe conditions at excavation for basement construction on the risk of wet or muddy soil conditions as an example of the exact risk that occurs when excavation.

When the drilling, tip of bore pile would osculate the ground water level. The water would perfuse and fill the excavation then it becomes muddy. Such conditions must occur as an impact from the implementation method by bore pile and its kind. Thus, the standard operating procedure for unsafe conditions at excavation (wet/muddy conditions) is recommended to do as the procedure as well. The procedure begin with recognize the type unsafe conditions.

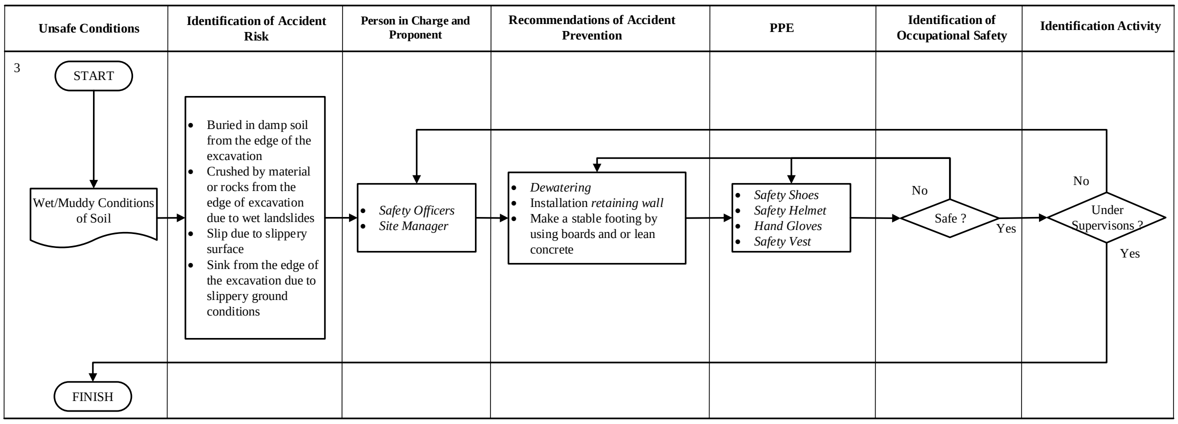


Figure 5 Flowchart of Wet/Muddy Conditions of Soil

Person in charge and the proponent must be aware and select the accident prevention acts properly, they have to ensure that worker used suitable PPE according to their field of work. Work could be execute on permission of the person in charge and the proponent, and they are responsible to supervise the work.

3.4 Description and Identification of Accident Risk of Unsafe Conditions at Excavation for Basement Construction

Description and identification of accident risk of unsafe conditions is taken based on frequent event and or experienced events by workforce from interview to safety officer. In addition, the description also improved by seeing the opportunities from the conditions or situations and possibility to inflict the accidents which is seen from the perspective of researcher as a commoner.

As an example can be seen at Table 1 Access for the heavy equipment in unstable excavation areas. At the third risk identification, several times have happened. The sand or clay conditions are very possible that type of soil unable to sustain the heavy equipment with a load exceeding the bearing capacity of the soil, thus causing landslides and heavy equipment to be overturned and fall on the workforce who was unaware around it.

For the fourth risk identification are rare to found caused not necessarily when rolled heavy equipment is burning and exploding. The identification of this case is very rare, but that doesn't it cannot happen.

Table 1 Description working procedures for landslides and the access for the heavy equipment in unstable excavation areas

Excavation Area of Basement Work		
Unsafe Conditions	**Description**	**Identification of Risk Accidents**
Landslides and the access for the heavy equipment in unstable excavation areas	The landslides in the soil excavation are due to pushing force at the edge of the soil excavation is greater than the retaining force. The retaining force is affected by the strength and density of the soil. While the driving force is influenced by: 1. The level of rainfall 2. Tilt slope 3. Geological structure 4. Earthquake intensity In addition, heavy equipment access is also a point that often occurs area of work accident. Access to skip heavy equipment (excavator, scrapper, back hoe, clam shell, dragline) in the excavation work area of	1. Buried landslides 2. Wrapped by rock material along the landslide 3. Crushed by heavy equipment falling due to unstable ground collapse. 4. Burns caused by explosion of the rolled heavy equipment.

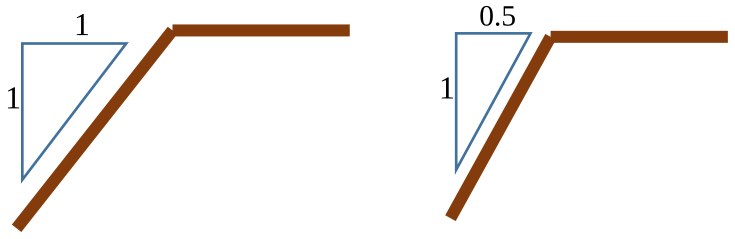
Excavation Area of Basement Work		
Unsafe Conditions	Description	Identification of Risk Accidents
	the soil is usually a downhill road with a certain slope. In a construction of a construction project (basement), this access may be temporary, or permanent (direct pavement). If this access is temporary then the possibility of access is not equal to the permanent road carrying capacity. However, permanent access is also reserved for passenger cars, so the strength (carrying capacity) of such access may not be able to withstand the load from the machine under certain conditions.	

3.5 Recommendation of Accident Prevention Efforts

Conditioning is done by arranging/managing the site/work area of excavation in such a way, among others by recommending the method of the construction implementation, equipping PPE (Personal Protective Equipment), arranging the layout of minerals, and so on. This is done to reach the goal of “zero accident”.

The results of this study are recommendations, so not all accident prevention efforts should be applied. There are several recommendations of prevention efforts that can be done if necessary, depending on the condition, situation, project characteristic, location of development, even the character of the workforce.

Table 2 Recommendations of prevention efforts for landslides and the access for the heavy equipment in unstable excavation areas

Excavation Area of Basement Work	
Unsafe Conditions	**Recommendations of Prevention Efforts**
Landslides and the access for the heavy equipment in unstable excavation areas	Factors that affect the stability of soil excavation include overloading, inadequate shoring, soil degradation, cracks of soil, pipes/other materials damaged in the soil, earthquake-induced vibrations, or vibrations caused by heavy equipment such as bore pile, franki pile, jack in pile, and dump truck traffic. The conditioning of the working environment is carried out as follows: 1. Retaining wall is installed before digging the soil. Retaining wall method such a sheet pile, soldier pile, soil nailing, so forth. 2. Conditions of soil with a very large crumbling field the retaining wall can be reinforced with bracing. 3. If the protection system is made by soil slope method, the slope can be made with a slope angle not steeper than 1-0.5 horizontal to vertical (34 degrees measured from horizontal) as seen at Figure 3.3 but if it is not possible then it can be given a retaining wall that is temporary. 4. At heavy equipment access in the excavation area the ground is made not too steep or access is made with temporary pavement to withstand heavy loads. 5. Wearing general personal protective equipment (safety shoes, safety helmet, hands gloves, safety vest)  **Figure 6** Illustration of Slope Recommendations for Stability by *Regulatory Review Of* 29 CFR 1926 *Subpart P*: *Excavation* OHSAS 18001:2007 [6]

3.6 Simple Visualizations of Site Management Recommendation at Excavation for Basement Construction

To be easily understandable some recommendations require explanations in the form of visual form of drawings/sketches, so described in the form model. Following among others.

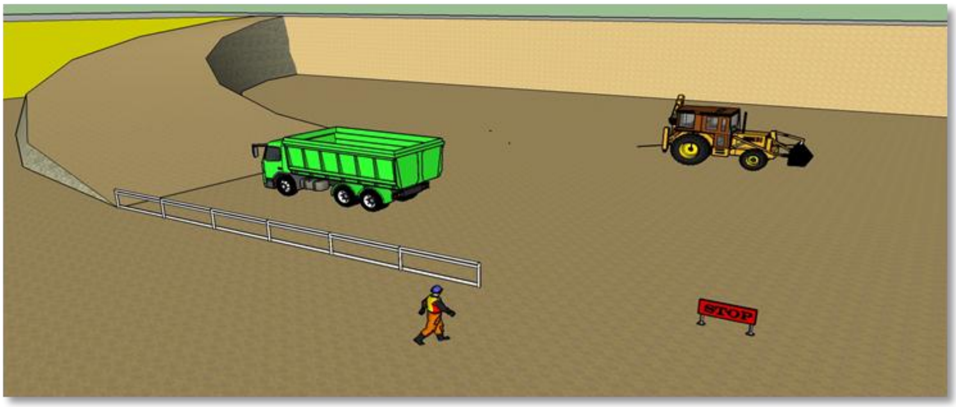


Figure 7 Prevention efforts for heavy equipment in unstable excavation areas and uncontrolled maneuver of heavy equipment by visualization.

It can be seen in the figure that the access of soil excavation is made of sirtu (hard rock), and heavy equipment is given its own space to operate which is limited by railing and signs. The example of another risk that frequently occurred at excavation is falling from the verge. The risk is occur mostly cause by unavailable barricades and signs. Figure 6 is one the recommendation by visualization of prevention effort for falling protection from the verge. We recommend to Railing made of iron with a height of 1-1.5 m with toe boards as high as 14 cm. Railing is full of dug soil, with certain sides for access in and out of excavation area. The outlet area is closed by using a detachable chain as a door.

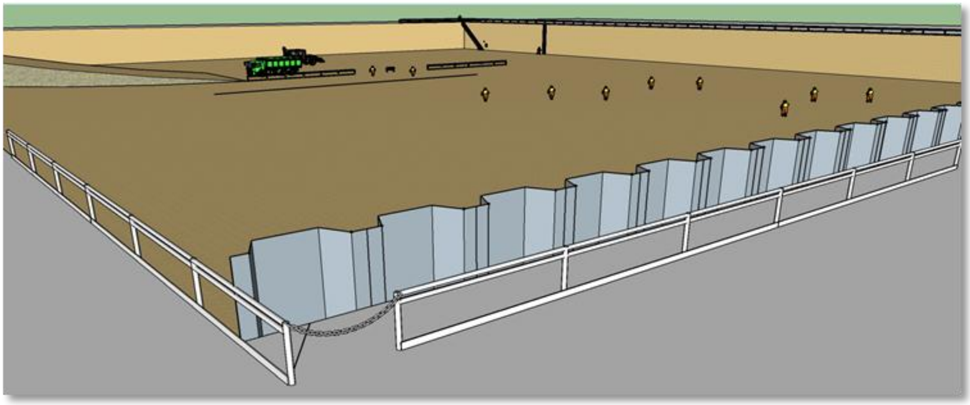


Figure 8 Prevention efforts for falling from elevation

4 Discussion

The result of this study is refers to regulations and standard. Here are the regulations and standards were used along with its role in this research.

1. PERMENAKER 05/MEN/1996
   Used to prepare the standard operating procedures recommendation document in this study which consists of integration, document control, and rules on hazard identification, risk assessment and control. So the requirement to make the document has been fulfilled in this research.
   Although this regulation is an old rule, but still applied in some contractor companies. A several sources related to this study said that, it is not easy to apply new rules to old habits. Special preparations such as periodic training and workshops are required companies in Indonesia

2. The joint decree of the Minister of manpower and the Minister of public works no. Kep-17/men/1986 No.104/KPTS/1986 on occupational safety and health at construction sites.
   The working procedure recommendation for unsafe condition in this study was improvised based on several articles in CHAPTER X DECISIONS of Joint Decree no. Kep-174 / men / 1986 No. 104 / KPTS / 1986.
   The articles CHAPTER X DESCRIPTIONS used as reference in this study are selected based on causal relationships of unsafe conditions, descriptive unsafe conditions, risk identification, and accident prevention efforts. The selected articles are subsequently implemented using other related articles.

3. OHSAS 18001:2007 Article 4.3.1 Hazard Identification, Risk Assessment, and Control Determination.
   In addition to using the national standard reference, in order to strengthen the results of the standard operating procedures recommendations in this study, it also uses the reference from the international standard that is OHSAS 18001: 2007

4. OHSAS Regulatory Review of 29 CFR 1926, Subpart P: Excavation.
   OHSAS 18001: 2007 provides special requirements on excavation, which is listed in the Regulatory Review of 29 CFR 1926 Subpart P: Excavation. In this study Regulatory Review of 29 CFR 1926 Subpart P: Excavation contributes to the identification of accident risk and on the recommendation of accident prevention efforts.
   Identify the risk of injury and prevention efforts in terms of Section 1.4 of the Requirements of Excavation Standards. In the subpart it has been explained that OSHA has published a number of documents that describe the standard excavation requirements for contractor companies. The standard consists of 10 standards for open excavation on earth.
   Six of the ten standards have been selected as a reference of risk identification and accident prevention efforts due to unsafe conditions.

Unsafe conditions that cause accidents to labor are not only caused by situations and or conditions, but are also supported by unsafe acts committed by the workforce, whether they are in action, or their actions after and or before implementation. As has been explained that the percentage of causes of occupational accidents comprises 10% due to unsafe conditions and 90% due to unsafe actions. So no matter how high the level of security measures performed by the workforce, it will still be a risk of harm if it is not supported by safe conditioning in the construction project environment.

The work procedure recommendation in this study consisted of description of unsafe condition, identification of risk of injury, and accident prevention efforts. Although the main focus of this study is unsafe conditions, the results of this study still involve unsafe actions. This means that there is a causal relationship by both though indirectly.

Occupational safety in this study not only protects the physical and life of workers from the risk of injury and death, but also to keep the mindset of the worker in order to work comfortably. A comfortable thinking can indirectly increase productivity, which affects the quality of implementation and results (correlation of occupational safety, quality and environment).

5 Conclusion

1. Standard operating procedure recommendations are prepared using a flow chart described in detail on unsafe conditions, identifying the risk of injury to workers, and workplace accident prevention efforts in hazard areas in construction projects (basement soil dredging areas) based on National and international standards on excavation. To create a recommendation of working procedures, the guidelines used as a reference is PERMENAKER 05 / MEN / 1996.

2. In the work area of soil excavation for basement construction identified 17 kinds of risks. The identification of these risks is derived from interviews developed based on previous literature and research studies on workplace accident risks on construction excavations, as well as national and international standards:
   a. Joint Decree No. Kep-174 / men / 1986 No. 104 / KPTS / 1986, on CHAPTER X DECISIONS of Joint Decree No. Kep-174 / men / 1986 No. 104 / KPTS / 1986.
   b. OHSAS 18001: 2007, at Regulatory Review of 29 CFR 1926 Subpart P: Excavation.

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Comparing the Environmental Impacts of Concrete Works: In-situ Method and Prefabricated Construction Method

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Abstract. Increased construction activities due to infrastructure development have raised environmental concerns. The environmental impact from the processes to construct is assumed to be fairly minor compared to those from the operation of infrastructure facilities. However, the construction processes are significant activities; thus, estimating the energy use and greenhouse gas (GHG) emissions is important for contractors in implementing more responsible practices, e.g., selecting greener materials and methods. A study has been conducted to observe the environmental impacts of two different methods in constructing reinforced concrete floor: in-situ method and prefabricated method. This study investigated the concrete flooring of 28,244 square meter as part of a plant in Jakarta area. This study compared energy consumptions and CO2 emissions for both methods. The use of different tools and equipment of all activities were closely examined to estimate the amount of gasoline consumptions. The emissions were estimated based on references/literatures. The results showed that the in-situ method consumed 6,887.40 MJ per cubic meter of concrete, and produced 719.39 kg CO2 per cubic meter of concrete. The activities related to producing fresh concrete consumed the most energy (37.36%); the activities related to installing reinforced steels generated the most CO2 emissions (41.51%). Concrete floor construction with prefabrication method, while it was faster, the environment impacts was higher than the traditional in-situ method. The prefabrication method consumed 15,079.12 MJ per cubic meter of concrete and produced 1,911.52 kg CO2 per cubic meter of concrete.

Keywords: *emissions, energy consumption, concrete, in-situ, prefabrication, contractors.*

1 Introduction

Indonesia as a developing country that contributes to global climate change through their industrial activities is committed to reduce greenhouse gas emissions as evidenced by Indonesia's commitment to reduce emissions by 26% on their own and 41% with international support in 2020 compared to business as usual scenario, with growth of 7% per year. One focus of attention Indonesia is the environmental sustainability of this latter on the reduction of CO2 emissions. The energy sector, especially the activities of the burning of fossil fuels (coal, petroleum, natural gas) is the largest contributor to greenhouse gas emissions (especially carbon dioxide, CO2). From the Indonesia Second National Communication report is also known that carbon dioxide emissions from fossil fuels throughout the years 2000 - 2005 increased by 6.4% per year. One of the contributors is increased development activity in the construction sector.

These emission reductions are largely mitigated by the reduction of energy consumption in construction industry project. Although the environmental impact of the structure is not solely determined by the CO2 emissions and energy consumption, but it is one parameter that is often discussed.

Data from Asosiasi Semen Indonesia (ASI) on the 1st Semester of 2012 suggest that the total cement consumption in Indonesia reached 25.89 million tons, up 15.1% over the same period in 2011 amounted to 22.49 million tons. That figure has reached 48% of the target consumption in Indonesia by 54 million tons. Other materials like steel is also a growing need along with the development of the construction industry. National consumption of steel products in the second semester / 2011 is expected to increase about 5% over the first half / 2011 amounted to 3.58 million tons (Ministry of Industry, 2012).

A goal to get estimates of energy consumption and CO2 emissions generated by construction activities in Indonesia. However, due to the existing limitations, the estimates of activities must be carried out by the smallest events in advance, as the parts contained in a building for example, energy consumption and CO2 emissions generated by the work to produce a slab in a unit volume.

In this study, the estimation of energy consumption and CO2 emissions is done on the work of reinforced concrete slabs which is carried out using two methods namely insitu method and prefabricated method during concrete production and construction process. This also examine the biggest factor influencing CO2 emission and energy consumption in the activity so that it can be used as a reference and description for the perpetrators of the construction industry in maintaining environmental sustainability through activities to reduce energy consumption and CO2 emissions in this case related to the reinforced concrete construction process through the selection of methods undertaken.

2 Insitu Method vs. Prefabricated Method

In the construction of structures with concrete materials known two common development methods, namely Insitu method and prefabricated method.

2.1 Insitu Method

Insitu method is casted concrete directly on the location of the planned structural elements. According to Ervianto (2006), insitu method or conventional method is a major component of most structures within a building. A column structure is designed to withstand an axial load of press. Conventional method in its construction planned in advance, all the concreting work is done manually by assembling the reinforcement of the building are made. Basically, this method also requires some prefabricated elements such as formwork, reinforcement, and wood used as workshop floor. However, only limited discussion of this research in any construction methods so that the elements mentioned above are not included in the discussion.

The advantages of conventional method, among others: easy and common in working in the field; easily formed in various cross sections; calculation is relatively easy and common; connection beams, columns and floor plate is monolithic (fully bonded).

While conventional concrete has weaknesses as follows: required more labor; relatively more expensive; the use of formwork is relatively more; employment in the construction of a rather long because the process is sequential interdependence with other work; affected by the weather, if it rains casting processing cannot be done.

Insitu method begins with the work of bearing material for the floor plate work using several tools, among others dumper, skid loaders and excavators, where the work done is the removal of the formwork and reinforcement. After the formwork is installed then do the work of bearing reinforcement. Beam and plate job done manually after the formwork work carried out in the order in which the formwork job.

After the reinforcement phase is completed, the next stage is the preparation of casting is done to ascertain the location of the casting completely clean of dirt in order to avoid damage to the concrete. Casting is done by using a mixer truck which is connected by pipeline to the process of pouring concrete to the location. Pouring concrete is done gradually to avoid segregation which can reduce the quality of concrete. During the casting process took place, was also taken concrete compaction using a vibrator to eliminate air cavities and achieve maximum density concrete. Vibrational activity in this case study requires special attention due to the need for the quality of the concrete itself designated as the placement of large machines used in the plant. After the concrete hardens, formwork demolition ± 7 days after casting is completed. To maintain the quality of the concrete after the concrete casting implemented remains to be watered 2 to 3 times a day in accordance with weather during the week.

2.2 Prefabricated Method

Prefabricated method is a construction method that does casting components in a specific place (fabrication), and then brought to the site (transport) to be arranged into a structure intact (erection).

Prefabrication method in which components are manufactured in assembled inside the building with the help of cranes and lifting equipment and other handling. Prefabricated structural components made of concrete with precast units or precast elements (print unit) depends on the alternative consumer, printing is well controlled, given time to hardening and achieve certain desirable strength before raised and brought to the construction site for the actual construction.

Precast concrete production stage at the factory starting from the dry bed to clean up the remnants of concrete from a previous job, followed by the manufacturing of wiring by inserting a PC Wire detensioning end by one hole and hook on the barrel and then drag it to the area stressing end and insert it into the wedge. PC Wire further cut in the area detensioning end. Continued activities by stressing process, the process of withdrawal of wire using clamping hours. Stressing process is done one by one on a wire from one side to the other side where every PC Wire drawn ± 2 times the voltage required to be fulfilled. Once everything is ready, the operator informs the concrete parts supply (PLC) to send concrete using a concrete bucket that works automatically to shed a concrete mixture into the molding machine (slide former). The activities continued with the sizing process tailored to the needs on the ground, followed by the cutting process using a cutting machine. The next step is making the hole joint shear connector and column followed by curing until the concrete dries. After completion of all of these activities, prefabricated concrete ready to do the final process is finishing. While the power source a driving force at the plant uses electricity.

In the post production stage, there are several steps done, which is handling, storage, stacking, shipping (transport), and the installation of concrete in the field. After the stage of material processing in Plant A, the next stage is a prefabricated concrete transport to the project site. The transport process using a dump truck transporting prefabricated concrete directly into the project.

Some of the advantages of prefabricated construction in the building industry are:

- Faster construction time, since the work on the structure of the site, construction of foundation and erection of prefabricated components

- The use of optimum materials as well as good quality material
- Production of precast units on a large scale to make it more practical to use the machine so as to reduce the amount of labor
- Construction work can be carried out without depending on weather conditions.
- More economical due to the use of concrete molds are not a lot of variety and is used repeatedly
- Broadly speaking, reduce costs due to reductions in the use of supporting tools, such as scaffolding and others
- The resulting quality is better as a result of plant processes are always under careful monitoring and strict
- Produced prefabricated elements always through laboratory testing in the factory to get a structure that meets the requirements, both in terms of strength and in terms of efficiency
- The need for the workforce can be tailored to the needs of production

Problems in the prefabricated construction are:
- Transportation of components from the factory to the field
- The difficulty in handling in the field, especially in the erection (establishment), lifting (removal) and connecting (splicing) at the time of finalization of the construction
- The need for energy in the factory prefabrication methods to be larger than the in-situ method because it requires more engine power
- Requires land for manufacturing and stockpiling (stock yard)

3 Data Collection and Data Analysis

3.1 Results of Data Collection

The case studies were observed reinforced concrete work on construction projects PT. Astra Honda Motor undertaken by a contractor A is in the process of work the concrete floor, the building uses two types of methods in a building that is part of the flooring using the method of insitu the use of ready mix concrete comes from the batching plant A and parts using prefabricated using elements prefabrication of prefabricated factory engaged in manufacturing precast concrete.

The data collection consists of two parts. The first part is the observation field with a floor plate-making process on the project in situ method PT. AHM who use ready mix concrete from the batching plant A that supplies ready mix for the project with a production capacity of 60 m^3/h and the second part is the observation of the concrete work with the method of prefabricated carried out in the factory A concrete elements will also be used in most of the floor plate PT. Astra Honda Motor.

Work insitu concrete with onsite method uses quality K-300 mixed concrete from the batching plant as well as some kind of reinforcement is D16 and D13, the volume of concrete it takes as much as ± 3150 m^3. While the floor plate takes on the job of prefabricated concrete methods of ± 9302 m^2 and comes from the factory prefabricated type of hollow core concrete floors with each width of 1.2 m and a length of 6 m. Here is a picture detail pieces insitu method floor plate and the floor plate prefabrication method.

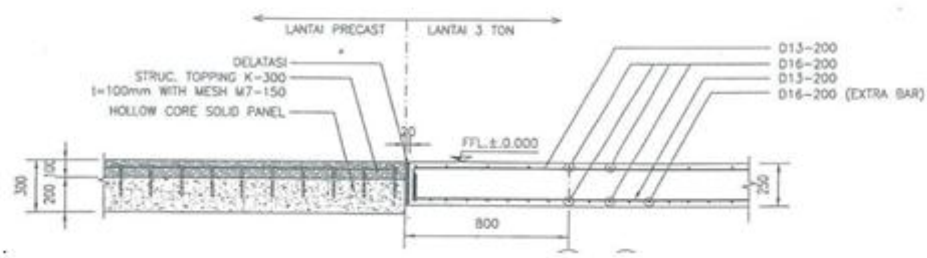

Figure 1 Cross Section Floor Plate Insitu Concrete

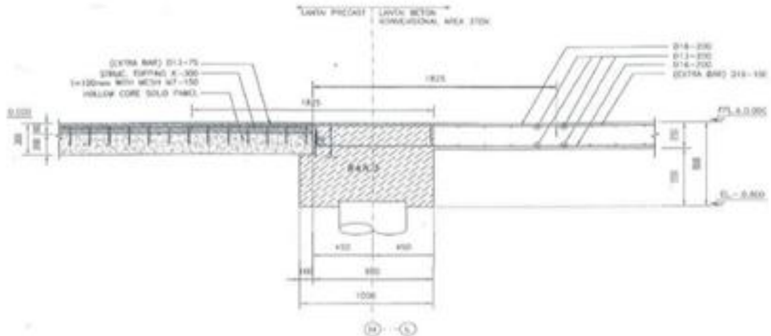

Figure 2 Cross Section Floor Plate Prefabrication Concrete

In Table 1 below show the kinds of tools and specifications used in performing work activities of the floor plate with two kinds of methods.

Table 1 Type and Specification Tool

Stage	**Process**	**Driver Process**	**Equipment specifications**	**Type of Fuel**
Insitu Method				
Transportation of Materials	Transportation of cement	Truck Carrier Cement	Capacity 30 Ton	diesel fuel
	Freight aggregate rude	Dump Truck	Dump Truck HINO, Capacity 25 Ton	diesel fuel
	Freight aggregate smooth	Dump Truck	Dump Truck HINO, Capacity 25 Ton	diesel fuel
	Transporting fly ash	Truck	Toyoto Dyna 300 SWB, 36.7 mpg (15.6 km/ltr)	diesel fuel
	Transportation Admix. Sikament	Truck	Toyoto Dyna 300 SWB, 36.7 mpg (15.6 km/ltr)	diesel fuel
Stirring Concrete	Freight aggregate crude and refined from bin to	Belt Conveyor	Sicoma, capacity 60 m3 / h (480 V) | Generator Set (350 KVA)	diesel fuel
	stirring material	Mixer		
Transportation	transporting concrete	Truck Mixer	Truck Mixer Hino, HMM H-700, Capacity Max. 7 m^3	diesel fuel
Transportation Reinforcement	Flat Bed		Hino Ditro, Capacity 7.5-8 ton	diesel fuel
Transportation Formwork	Truck		Toyoto Dyna 300 SWB, 36.7 mpg (15.6 km/ltr)	diesel fuel
Work Reinforcement	Bar Bender Bar Cutter	Takeda Machinery, 3.7 KW Toyo C33, 2.2 KW	150 KVA Generator Set	electricity
casting process	Truck Mixer Concrete Pump		Mixer Truck Hino, HMM H-700, Capacity Max. 7 m3 Isuzu CVR, capacity of 110 m3 / h	diesel fuel
Prefabrication Methods				
Withdrawal PC Wire		Clamping Jam	Towing Machine Wire	diesel fuel
Sizing		Cutting Machine	Honda Engine Concrete Cutting Machine (FQG-500)	diesel fuel
Pouring concrete mixture		Mixer	Sicoma, Capacity 60 m^3/h	diesel fuel
Transport floor plate		Truck	Toyoto Dyna 300 SWB, 36.7 mpg (15.6 km/ltr)	diesel fuel

Table 2 Material Needs

Insitu Method	
Mix Concrete	3148.84 m^3
Reinforcement	522531.37 kg
Formwork	13093.72 kg
Prefabrication Methods	
mix concrete	1061.94 m^3
Reinforcement	74728.15 kg

Fuel usage data for the manufacturing activities of the reinforced concrete floor plate diesel fuel. The data is the data of the overall diesel consumption of each equipment used in each activity. In Table 3 below show the amount of information regarding the amount of diesel fuel used in liters.

Table 3 Resume of Fuel Consumption

Insitu Method	
Use of Solar's Bar Bar Cutter and Bender	795.50 liters
Use of Solar for Truck Mixer 1	24539 liters
Use of Solar for Concrete Pump	80.20 liters
Use of Solar for Vibrator	66.32 liters
Use of Solar for Truck Mixer 2	24496.60 liters
Use of Solar for Loader	1241 liters
Use of Solar for Genset	3056.07 liters
Prefabrication Methods	
Use of Solar for Clamping Jam	1142.96 liters
Use of Solar for *Cutting Machine*	996.53 liters
Use of Solar for Concrete Bucket Mover	3219.80 liters

3.2 Data analysis

Estimated energy consumption is done by converting the use of fuels and other energy sources that in this study is diesel and electricity into the energy units standard that Joule through the data of fuel used during the construction process multiplied by calorific value which has been determined by the Implementation Guidelines GHG Inventory. Estimated energy consumption conducted in the first case study is divided into three types of activities, namely energy consumption occurs during the transportation of materials, concrete mixing stage at the batching plant, as well as the implementation of foundry work at the project site. Model calculations used to obtain consumption of each of these activities using the following equation:

Energy consumption (joule) = Fuel Consumption (liters; kg) x
Calorific Value (joule/liter; joule/kg) (1)

Estimates of CO_2 emissions is done by converting the data of activities undertaken during concreting work is based on energy consumption with an emission factor, which is a coefficient that indicates the amount of emissions per unit of activity. Estimates of CO_2 emissions is done on each case study will be divided into three types of activities, namely CO_2 emissions that occur during the transportation of materials, the implementation phase transportation foundry work and concrete to the project site. Model calculations used to obtain estimates of CO_2 emissions from each phase using the following equation:

Greenhouse Gas Emissions (kg CO_2) = Energy consumption (TJ) x Emission factor (kg/TJ) (2)

or

CO_2 emissions (kg CO2) = Fuel Consumption (liters) x Emission Factor (kg CO2 / liter) (3)

Table 4 Comparison of Energy Consumption and CO2 Emissions Insitu Method and Method Prefabricated

<table>
<tr><th></th><th colspan="2">Insitu Method</th><th colspan="2">Prefabrication Methods</th></tr>
<tr><td rowspan="2">Volume of Concrete</td><td colspan="2" rowspan="2">3150 m^3</td><td colspan="2">Prefabricated floor plate 1861 m^3</td></tr>
<tr><td colspan="2">Topping concrete 1062 m^3</td></tr>
<tr><td>Energy Consumption</td><td colspan="2">21.695.294,4 MJ</td><td colspan="2">25.214.252,36 MJ</td></tr>
<tr><td>Energy Consumption per m^3 of</td><td colspan="2">6.887.40 MJ/m^3</td><td colspan="2">15079.12 MJ/m^3</td></tr>
<tr><td>CO_2 Emissions</td><td colspan="2">2.266.069,95 kg CO_2</td><td colspan="2">3.148.472,95 kg CO_1</td></tr>
<tr><td>CO_2 Emissions per m^3 of Concrete</td><td colspan="2">719,39 kg CO_2/m^3</td><td colspan="2">1911.52 kg CO_2/m^3</td></tr>
<tr><td rowspan="2">The Contribution Activities</td><td>Production of cement</td><td>Energy Consumption: 8.105.114,16 MJ (37,36%)</td><td rowspan="2">Production of cement</td><td>Energy Consumption: 0.513.622 MJ (41,65%)</td></tr>
<tr><td>Production reinforcement</td><td>CO_2 Emissions: 940.556,47 kg CO_2 (41,51%)</td><td>CO_2 Emissions: 2.057.013 kg CO_2 (65,33%)</td></tr>
</table>

From the results of the analysis carried out in the second case study there are considerable differences in energy consumption and CO_2 emissions. I needed a case study of 21,695,294.40 MJ of energy and CO_2 emissions by 2,266,069.95 kg of CO_2. Of all the observed activity, stage of cement production is an activity that most need energy that is equal to MJ 8,105,114.16 or 37.36% of total energy consumption concrete work with in situ method. The emissions generated in the production phase of reinforcing amounting to 940,556.47 kg of CO_2 or 41.51% of the total CO_2 emissions generated from the concrete work. The largest emission is caused by the need for reinforcement in the project due to the needs of the project is the floor with in situ methods intended as an engine cradle is quite heavy.

From the results of a second analysis, it is known that the second case study requires an energy of 25,214,252.36 3,148,472.95 kg MJ and emissions of CO_2. Of all the observed activity, cement production stage is also the greatest activity requires energy that is equal to 1.051.362,2,11 MJ or 41.65% of total energy consumption by using prefabricated concrete work. The resulting emissions also exist in cement production phase that is equal to 2.057.013kg CO2 or 65.33% of the total CO_2 emissions generated from the concrete work.

With advances in technology very rapidly lately in the world of this construction, the contractors competing to offer the product quality construction and a shorter implementation time and lower cost for these three variables are interrelated and influence. However, with the increasing awareness of the world, including Indonesia, on the issue of global warming caused by greenhouse gas emissions, one of which is CO_2 and followed by the Indonesian government's commitment to reduce emissions by 26% by 2020 from a variety of fields, one of which is the construction industry, then it can also affect the variables to be considered by the contractor in Indonesia on emissions should be reduced during construction. So in this study, the variables are used as a benchmark in selecting methods work when it will implement the project into four, namely quantity, quality, costs, and emissions.

a. Execution time

   If viewed from the aspect of time, in-situ method requires a relatively longer time in the implementation in the field compared to the prefabrication method for prefabrication method is not takes for concrete to be hardened, the construction work can be carried out without depending on weather conditions.

b. Implementation cost

   Production units of precast in large scale makes it more practical to use the machine so that it can reduce the amount of labor, is more economical because of the use of the concrete mold which is not a lot of variety and is used repeatedly, as well as an outline of reducing costs due to a reduction in the use of supporting tools , such as scaffolding and others.

c. Quality

The optimum use of materials as well as good quality material is one of the advantages that a concern for the contractor to determine the concrete construction method. With the use of quality materials, will produce concrete better accompanied by the results of the process plant is always under careful monitoring and strict because of elements prefabricated produced invariably through laboratory testing in the factory to get a structure that meets the requirements, both in terms of strength and of In terms of efficiency.

d. Emission

With the fulfillment of the three variables above, the contractor should also consider the environmental problems being faced by the global warming due to climate change which is one of the causes is the increasing concentration of greenhouse gases in the atmosphere. In accordance with the results of this research, it is known that prefabricated method emissions are greater than the insitu method.

4 Conclusions and Recommendations

4.1 Conclusions

Based on the analysis of energy consumption and CO_2 emissions from two case studies that have been conducted, the conclusion as follows:

1. Analysis of energy consumption and CO2 emissions performed on a project with the work area of the floor plate 28,224 m2 which uses two methods in the work floor is the method of in situ and methods prefabricated. The analysis was conducted using data from the primary data in the form of field work report, report the use of fuel as well as the use of data as well as data obtained directly from observations in the field as long as the work progresses. Data obtained in the form of daily data from all the work carried out regarding the work floor.

2. Estimated energy consumption for the first case study, namely the work floor with insitu method is 21,695,294.4 MJ and CO_2 emissions by 2,266,069.95 kg CO_2 by volume of concrete required is 3,150 m^3. Thus obtained produce CO_2 emissions to produce 1 m^3 of concrete amounted to 719.39 kg CO_2/m^3.

3. Activities that have the greatest contribution in energy consumption and CO_2 emissions the first case study is a phase of cement production requires

energy that is equal to 8,105,114.16 MJ or 37.36% of total energy consumption by using in-situ concrete work with CO_2 emissions is the production of reinforcement of 940,556.47 kg of CO_2 or 41.51% of the total CO_2 emissions generated from the concrete work.

4. Estimated energy consumption for the second case study, namely the work floor with prefabricated method is 25,214,252.36 MJ and 3,148,472.95 kg of CO_2 emissions and the volume of concrete required is 1062 m^3 as a topping and 1861 m^3 of prefabricated floor plate. Thus obtained produce CO_2 emissions to produce 1 m^3 of concrete amounted to 1911.52 kg CO_2/m^3.

5. In the second case study cement production stage is also the largest energy consuming activities that 10,513,622 MJ or 41.65% of total energy consumption by using prefabricated concrete work. The resulting emissions also exist at the stage of cement production in the amount of 2,057,013 kg of CO_2 or 65.33% of the total CO_2 emissions generated from the concrete work.

6. According to the observations that have been made, efforts have been made related contractors energy consumption savings and reduce CO_2 emissions in the project is the fuel saving equipment although the construction cost saving reasons.

4.2 Recommendations

Limitations found during the study is expected to be learning to the next can be a more in-depth studies to obtain more accurate data about the construction process in Indonesia to the environment. Here is mentioned several recommendations concerning the limitations contained in this research:

1. With limitations in this study, the scope of which was limited in scope observed gate to gate. It is expected that further research can observe the activities with the scope of the cradle to grave which in this case includes estimates of energy consumption and CO2 emissions from the stage of material processing, transportation and usage to final product in its life cycle that produced more accurate estimates.

2. To estimate CO2 emissions based on the cost still needs more complete data. The scope of this study is limited to the use of materials and work tools. It is expected that future studies also pay attention to some aspects that have not been covered in this research such as energy consumption and CO2 emissions produced by the workers as well as indirect emissions associated with the duration of the project.

3. The results obtained in this study is only an estimate of this project alone. Need to do research that estimates the energy consumption and CO2 emissions with different types of materials, distance quarry to the project, as well as the condition of the equipment used

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Comparison Study of Casting Concrete Methods Based On Cost and Time Used

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Abstract. The effective and efficient cost and time planning is one of the keys to succeed the construction project. The selection of implementation method is one of the influential factors in the construction project's effectiveness and efficiency. A structure work is the first phase in a construction project which consists of reinforcement, formwork, and concrete casting. Therefore, a research in the selection of implementation method of the structure work is valuable to conduct, especially the concrete casting selection method in purpose to gain the effectiveness and efficiency of the project. The aim of this study is to know the cost and time comparison value among the time scheduling model by concrete casting implementation methods using Ready mix concrete pump and site mix; Ready mix concrete pump and manual; and cast with all Ready mix concrete pump. The secondary data of this research was taken from Sewutomo Hotel of Yogyakarta. To make the data analysis of the cost and time based on the casting implementation, Ms Project and Ms Excel computer programs were used. The result of the analysis shown that concrete casting implementation methods using Ready mix concrete pump and site mix cost Rp. 3,195,687,978.53 by duration of 154 calendar days; casting with Ready mix Ready mix concrete pump and manual cost Rp. 3,268,397,006.86 by duration of 160 calendar days; and casting with all Ready mix concrete pump cost Rp. 3,368,235,460.86 by duration of 149 calendar days.

Keywords: *ms project, network diagram, project scheduling, Ready mix concrete*

1 Introduction

In today's era of globalization, construction service providers are required to improve high management professionalism and strive to take appropriate action and strategy in implementing a project. In the construction project, the planning stage is the first step that is very influential on the sustainability of a project in the future. Planning is needed and used as guidance in implementing the project, so that the project can be implemented effectively and efficiently. Without a proper planning it is potential for a project to experience a failure that will harm the company, such as waste of time and labor resulting in increased costs. Therefore a plan that suits the characteristics of the project will be helpful for achieving the project's targets; because in each construction project has its own characteristics whether in terms of the cost, quality, and time given.

A planning involves deciding what to do, when the work is started or done, who will be done and achieved. With the limited resources availability, a plan should be done as quickly as possible so that the resources can be used efficiently. In a good construction project, the cycle that should be done is planning - doing - checking – acting. The cycle must accompany the execution of a project. This is done to ensure that projects are running on schedule, within cost, and meet the quality.

One of the outcomes of the planning stage is project scheduling, which can provide information on project schedule and progress in terms of resource performance in the form of costs, labor, equipment and materials as well as project duration plans and time progress for project completion. In the process of scheduling, the preparation of activities and relationships between activities are detailed. Husen [1] stated that scheduling is used as a standard for project evaluation in term of time and cost. Project scheduling is the allocation of the available time to carry out each work in order to complete a project until an optimal result is achieved taking into consideration the existing constraints. Dipohusodo [2] has studied the project is a process of resources and the existence of certain funds in an organized manner to become the result of a steady development in accordance with the objectives and initial expectations by using the project's budget funds, so that become available resources within a certain time in accordance with its function.

Construction resources consist of materials, manpower, fund, implementation methods and equipment. Resources are planned to achieve project objectives with time, cost and quality restrictions. The challenge of project implementation is how to plan an effective time schedule and cost efficient planning without reducing quality. Time and cost are two important things in the implementation of construction work in addition to quality, because of the costs to be incurred at the time of implementation is closely related to the timing of the implementation of the work. To achieve the designated objectives the construction service providers and project owners require scheduling of project execution time which can also control and control the execution of the project.

In the implementation schedule, network diagrams are influenced by the implementation methods within the project. In this study the building is reviewed as its object. Building projects consist of components of structural work, architectural work components, landscape work, and mechanical electrical components. From the four components of the work, structural work is done at the beginning. Therefore the duration of the structure work will determine when the commencement of other work, both architecture and mechanical electrical.

Because of the success in the implementation of the components of the work of the structure is very important in a construction project, the selection of the method of execution of structural work has also become one of the key. In this modern era the implementation of structural components, especially casting works can be done with several alternative combinations of casting, such as Ready mix casting or still using site mix concrete tailored to the characteristics of each project.

To have a clear stand point, this study defines Ready mix concrete as factory-made concrete which is manufactured in a central mixer (Mahajan and Buthelo, 2015) according to particular formula and method, usually in a plastic condition (Indian Standard 4926:2003); and then the truck mounted transit mixers will deliver it to the worksite (Haq, et. al, 2016) [5]. Further, Haq, et. al (2016) [5] explained that ready mix concrete could be beneficial for its better quality, higher speed, better durability, more effective labor performance; and removed storage difficulty and material obtaining requirements.

Meanwhile, the site-mixed has the mixing process in the worksite place by using a concrete mixer or labor instrument whenever its volume is less of amount. During the mixing process, the coarse aggregate such as crashed stone is stored first, followed by the find aggregate such as sand and then the cement comes for the last. Each of the materials has its own proportion regarding to the quality that want to be produced (Oe, 2012).

In short, there will be three combination methods in this study namely the Ready mixed which uses concrete pump and manual site-mixed concrete method; Ready mixed which uses concrete pump and manual; and Ready mixed concrete pump only. The concern of this case study is to know which one of the combination method that has the most effective in time and the lowest cost; thus the findings of this study can be function as a reference in the academic as well as practical environment.

2 Case study

These case studies were conducted to determine the value of cost and time comparison between cast implementation method with Ready mixed concrete pump and site mix, cast with Ready mixed concrete pump and Ready mixed manual, and cast with Ready mix concrete pump entirely. The selected project was the Sewutomo Hotel in Yogyakarta.

3 Research methodology

The research being undertaken is included in the case study research. Based on the nature of the problem of the research, the design of this study can be classified in Descriptive Comparative research. Descriptive means the exposure of existing problems based on data, while comparative means comparing. Narbuko [3]. In this case the research is comparing and analyzing several methods of reinforced concrete work in high rise building projects. Figure 1 shows a flowchart of this research.

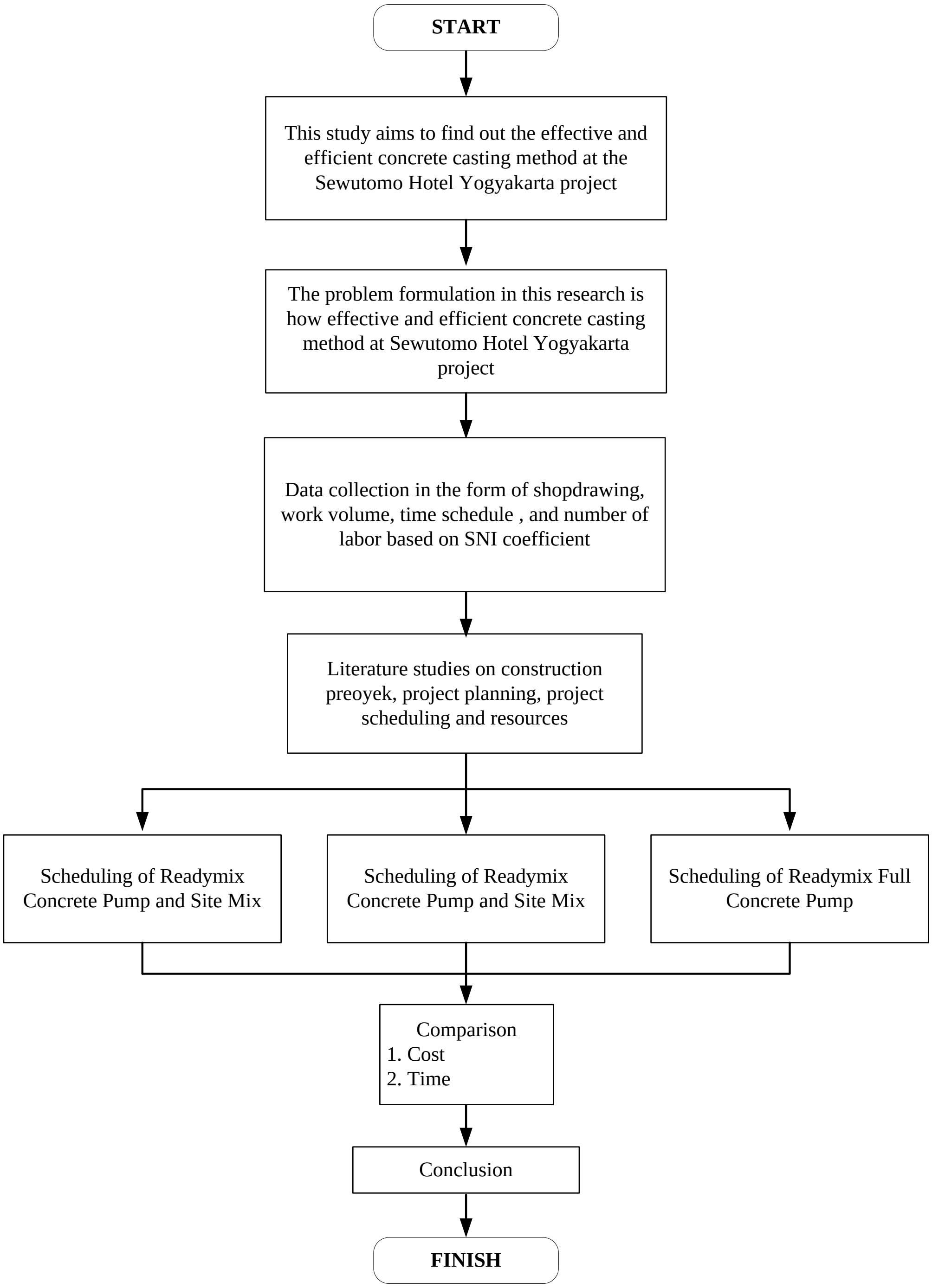

Figure 1 Flowchart of research

Object of study in this research is cost and time comparison between cast implementation method with Ready mix concrete pump and site mix, cast with Ready mix concrete pump and Ready mix manual, and cast with Ready mix concrete pump entirely in multi-storey building project. While the subject of this research is the development project of Hotel Sewutomo in Yogyakarta. For more details see the figure 2 which show the research site.

Figure 2 The location of Sewutomo hotel

In this research using secondary data as shopdrawing and project's time schedule. From the collected data then performed an analysis with Precedence Diagram Method (PDM) method using MS Project. To find the most effective and most cost effective duration. Scheduling determines when the activity is started, postponed and resolved, so that the financing and use of resources can be adjusted according to predetermined needs, Jaya [4].

The sequence of analysis to be performed are:

1. Determining list of job items
2. Calculates the volume each items
3. Determine the duration of each job
4. Create a network diagram with PDM

In this study it is reviewed only on structural work. The activity items on the structural work at Hotel Sewutomo can be seen on table 1.

Table 1 Structure Items of Project Hotel Sewutomo

NO	Work Description
	Land Clearing and Excavation
A	Concrete Works
A.1	Basement Area
	Lean Concrete
	Bored Pile
	Pilecap dan Tiebeam
	Slab
	Columns
	GWT and Pit lift
	Concrete Wall
	Stairs
A.2	1^{st} floors
	Swimming pool
	Beams and Slab
	Columns
	Stairs
A.3	2^{nd} floors
	Beams and Slab
	Columns
	Stairs
A.4	3^{rd} floors
	Beams and Slab
	Columns
	Stairs
A.5	4^{th} floors
	Beams and Slab
	Columns
	Stairs
A.6	Roof Top

NO	Work Description
	Beams and Slab
	Columns

The results of data collection and processing are described descriptively and systematically as shown in the figure 3.

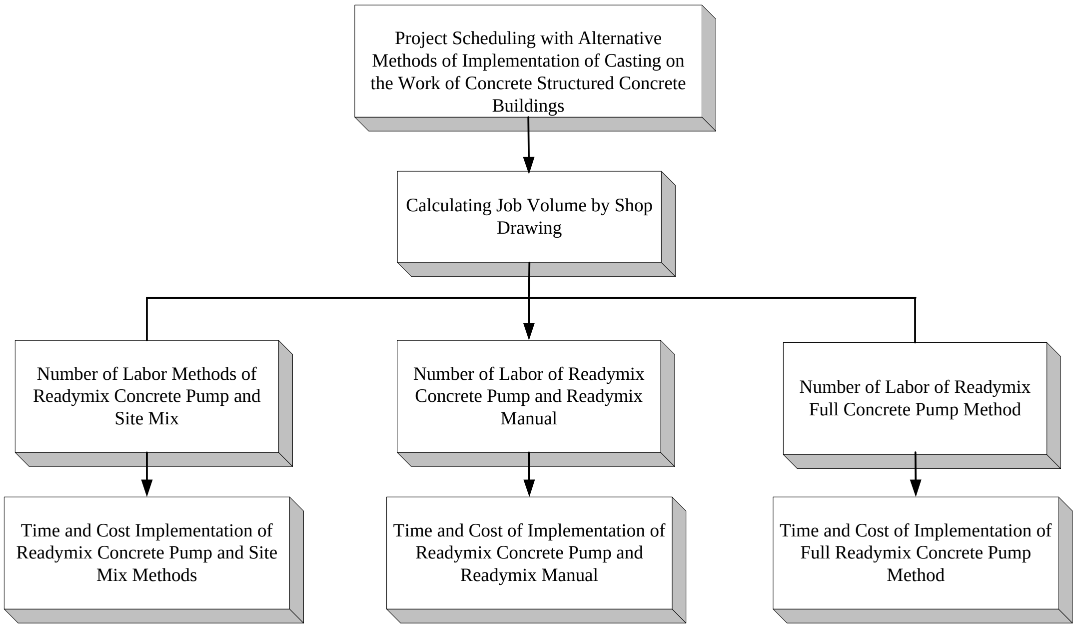

Figure 3 Outline research

The data analysis is looking for the most effective and efficient casting method alternatives among 3 combinations, such as:

a. Combination between casting with site mix and Ready mix with concrete pump.
b. Combination between casting with Ready mix poured manually and Ready mix with concrete pump.
c. Concrete casting with Ready mix with concrete pump for all structural concrete work.

For more detail, each method of combinations of casting concrete will show at Figure 4, Figure 5, and Figure 6.

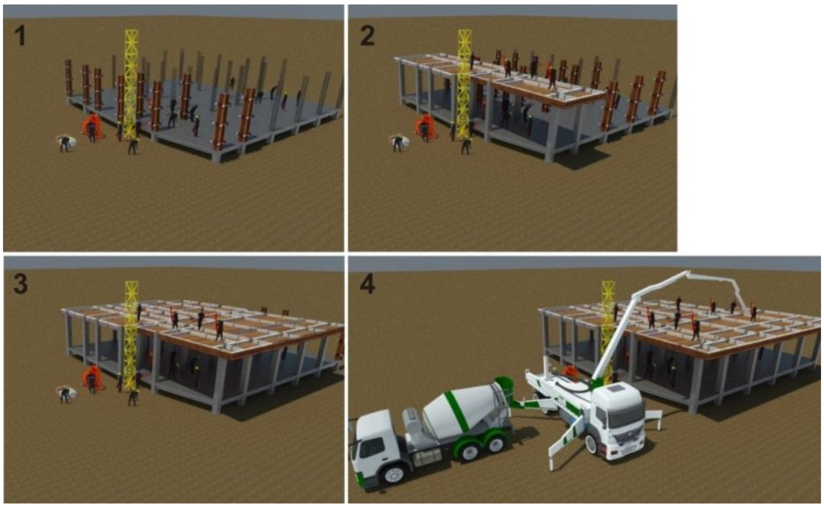

Figure 4 Implementation phase method of casting concrete with Ready mixed concrete pump and site mix

In the picture presented above, it shows that picture no.1 illustrated the process of reinforcement, formwork, and column concrete casting by using site-mixed for the first step. Then, in picture no. 2, the above formwork and reinforcement of slab and beams is constructed after the first concrete casting column is done. Meanwhile, picture no. 3 the formwork, reinforcement, and the second concrete are constructed; and this sequential phase is continuously constructed until the fourth step is casted. For the picture no. 4, the concrete casting slab and beams with Ready mixed which uses concrete pump is conducted.

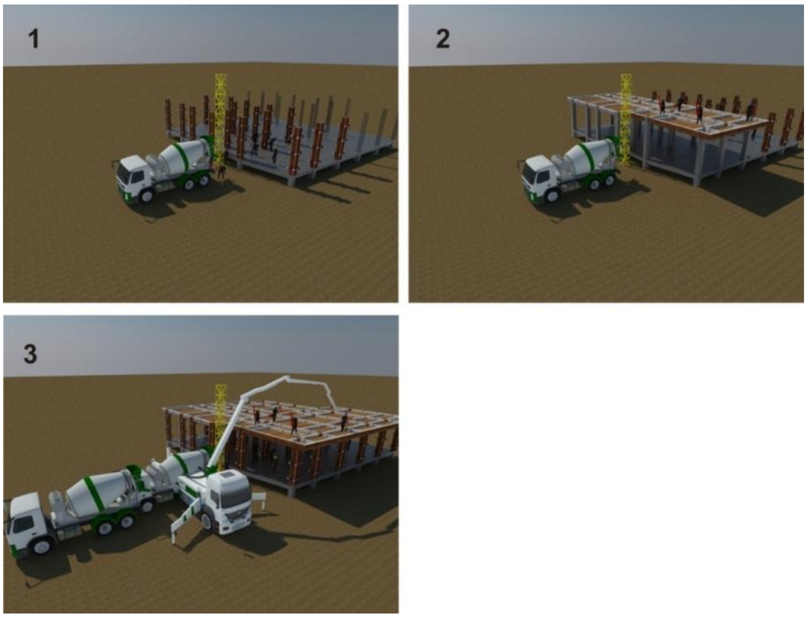

Figure 5 Implementation phase method of casting concrete with Ready mix concrete pump and Ready mix manual method

In the picture no.1 reinforcement, formwork, and column concrete casting by using site-mixed for the first step is done. Then, in picture no. 2, the above formwork and reinforcement of slab and beams is constructed after the first concrete casting column is done. And then, picture no. 3 the slab and beams concrete casting with Ready mixed which uses concrete pump is constructed.

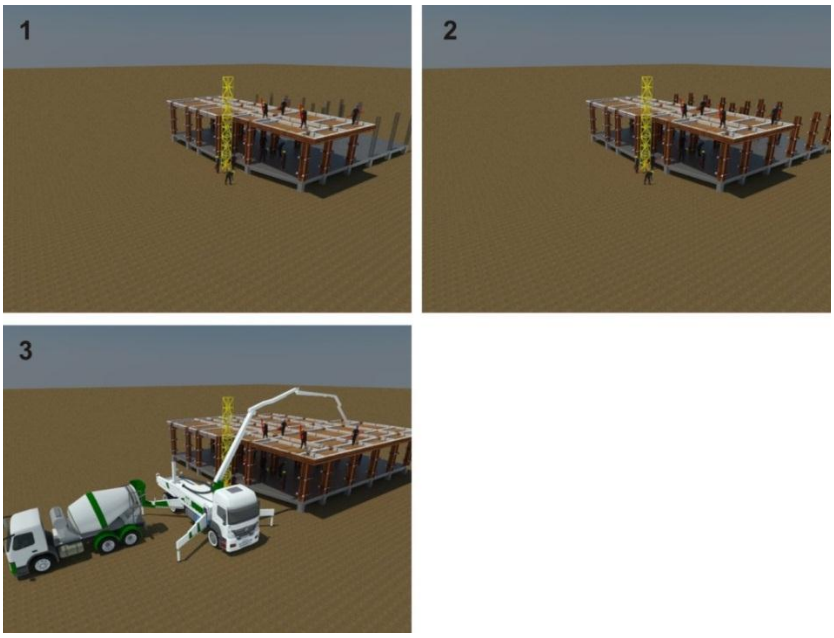

Figure 8 Implementation phase method of casting concrete with Ready mix concrete pump

For the first and second picture, the reinforcement, column formwork, beams, and slab are constructed until totally finished. And then, the third picture illustrated the concrete casting of the column, beams, and slab is done by using concrete pump in the same time.

4 Result

From the data item structure that has been mentioned, then made a breakdown to make it easier in the calculation of the volume of work and the determination of relationships between jobs in making the implementation schedule. Breakdown on structural work. Figure 7 shows the work breakdown of structure items.

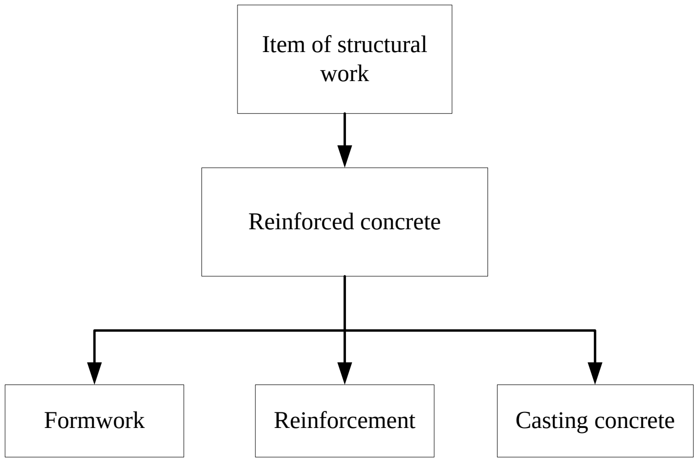

Figure 7 Breakdown Item of Structural Work

From the results of the analysis that has been done, the results obtained from each method of execution of foundry work on the construction project Hotel Sewutomo Yogyakarta can be seen in tables 2 and 3.

Table 2 Recapitulation of time each methods

Methods	Duration
Casting concrete with Ready mix concrete pump and site mix	154 days
Casting concrete with Ready mix concrete pump and Ready mix manual method	160 days
Casting concrete with Ready mix concrete pump	149 days

Table 3 Recapitulation of cost each methods

Methods	Cost of Materials (Rp)	Cost of Labor (Rp)	Cost of Equipment (Rp)	Total Cost (Rp)
Casting concrete with Ready mix concrete pump and site mix	2.211.177.978,53	556.460.000,00	428.050.000,00	3.195.687.978,53
Casting concrete with Ready mix concrete pump and Ready mix manual method	2.302.124.506,86	538.222.500,00	428.050.000,00	3.268.397.006,86
Casting concrete with Ready mix concrete pump	2.418.042.960,86	522.142.500,00	428.050.000,00	3.368.235.460,86

Based on the recapitulation of cost and time of each casting method, the results obtained as shown in table 4.

Table 4 ***Cost and Time Comparison of each Casting Method***

Methods	Total Cost (Rp)	Time deviation (%)	Cost deviation (%)
Casting concrete with Ready mix concrete pump and site mix	3.195.687.978,53	Base	Base
Casting concrete with Ready mix concrete pump and Ready mix manual method	3.268.397.006,86	-3,90%	-2,28%
Casting concrete with Ready mix concrete pump	3.368.235.460,86	3,25%	-5,40%

If the combination of ready mix concrete pump concrete mix and site mix method is used as a reference, the percentage of cost and time of the other method are:

a. Ready mix concrete pump ready mix method and manual ready mix 3.90% slower in terms of time compared to ready mix concrete pump concrete mix and site mix method, while in terms of 2.28% greater cost.
b. The concrete pump ready mix concrete pump method is 3.25% faster in time than the ready mix concrete pump and site mix, but 5.40% is greater in cost.

From the results of the recapitulation in table 2, 3 and 4 it can be seen that the Ready mix concrete pump concrete pump method is the fastest in its implementation time is 149 days. While the concrete pump Ready mix concrete pump method and site mix most efficient in terms of cost of Rp. 3.195.687.978,53.

5 Conclusion

From the analysis result, the combination method of casting job implementation at Sewutomo Hotel Yogyakarta construction project can be concluded that the combination of casting with Ready mix concrete pump and site mix is the most effective with the cost of Rp. 3,195,687,978,53 in terms of project costs. While in terms of time, casting with Ready mix concrete pumps all have the fastest duration among others, with total project duration for 149 calendar days. However, there are some suggestions for better achieving, such as:

a. There are need further study on the influence of the method of execution of work Structure to the work of Architecture and Mechanical Electrical.
b. Studied further, based on actual data in the field, especially for labor group productivity.

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Sustainable Development of Built Residential Design: The Concepts and Implementation In Padang City

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Abstract. Sustainable construction terminology intended that each stage of the life cycle of infrastructure, starting from the planning phase to demolition always consider sustainable development concepts. Likewise, indeed, to housing built by the developers. Often we see the phenomenon of the alteration /destruction of the house after occupancy by the user. The methodology of this research is conducted by distributing a questionnaire for 38 respondents of 9 residential. The classification of those residential is based on the level income which is from middle to lower standard and the maximum five years of stay duration of societies. The selections of respondents were taken by using Simple Random Sampling method. The distribution of sampling questionnaires was conducted for two months. The results of this study indicate that housing in Padang City does not implement the concept of sustainable development because consumers still need renovation after buying a house. The total cost spent to renovate according to respondents more than fifteen million Rupiah. The only reason why the owner did renovation is the needs of the owners to increase the capacity of the design of their home. A suggestion of this research is developers need to consult with the consumers before the purchase of housing with the indent system.

Keywords: *design, development, padang, residential, sustainable.*

1 Introduction

The concept of sustainable development has become the attention of all parties. From a statement about the importance of awareness about global environmental issues, the term sustainable development emerged. Sustainable development is development aimed at meeting the needs of the present generation without sacrificing the interests and needs of future generations. The sustainable design that is part of the continuous development in the design implementation takes into account the physical objects, built environment, and service facilities that adhere to social, economic and ecological principles. Kimberly [5] has studied that designing sustainable buildings depends on consideration of the entire life cycle when implementing sustainable features into designs.

Construction industry must inevitably change its historic methods of operating with little regard for environmental impacts to a new mode that makes environmental concerns a centerpiece of its efforts. Previously, the concern on environment is relatively a small part of most of construction development [6]. It is expected to developers who want to build a housing to apply the concept of sustainable development since the design phase. So that, the housing design can fulfill the residents needed in the present and the future. It aims to eliminate the actions of change to the initial design done by consumers. But in reality, we still see in the housing for the middle-low economy inhabitants, has undergone many changes to the initial design. The residents do the renovation process at the time it is still under construction and or when the house has been occupied. Viewed from the behavior of consumers who do renovations in their dwellings, the owner of the house may not feel satisfied with the initial design. To do the renovation, of course, the owner will incur additional costs. This resulted in the higher expenditure to obtain a house with the design and function room by owner's need. For the cost incurred in the renovation will be influenced by the number of reforms that are done, wages workers and the price of material in the area. Therefore, developers need to apply the concept of sustainable development on the design of housing.

This study aims to review the extent of sustainable housing design in the city of Padang. Sustainable housing design is reflected by the presence of the alteration/destruction of the house after occupancy by the user. This research is also to identify the cost incurred by consumers to make a revamp. The benefit of this research is to help the consumers (community) in providing adequate housing and following the desires as appropriate. Also, this research is expected to know the things needed by consumers so that developers can determine the design of housing that meets the needs of consumers. The analysis is expected to be drawn a conclusion and suggestions in providing decent housing and improve community satisfaction in Padang City.

2 Sustainable Development in Indonesia

Indonesia has begun to apply the principle of sustainable development which can be seen from the existence of several programs created by the government such as energy saving suggestion, a million tree planting movement, and green city development efforts in several cities. From the community side, there have been many initiatives implemented, such as the establishment of non-governmental organizations that pay attention to environmental sustainability, the application of environment-related ISO by industry, various research results and innovation of environmentally friendly technology by universities. We can learn from the UK government's policy of huge taxes for building collapse and waste disposal of construction materials. This will trigger and spur more mature thoughts of the construction community for the development of lean construction by trying to optimize the use of waste materials. The lack of policies related to sustainable development cannot be separated from the condition of the Indonesian nation which is a developing country. The Indonesian government is still focused on handling issues of social and economic problems compared to more detailed environmental issues such as sustainable construction. What now has been achieved in the development of sustainable construction is the development of SNI for Green Building which is still under review process, as well as Jakarta Green Building program. The private sector in Indonesia also plays an important role in establishing Green Building Council Indonesia (GBCI), an organization that develops green building certification in Indonesia. This certification is given to buildings that meet the principle of sustainability, starting from the planning process, construction to operation and maintenance. In this research the sustainable design terminology can be seen in the following figure:

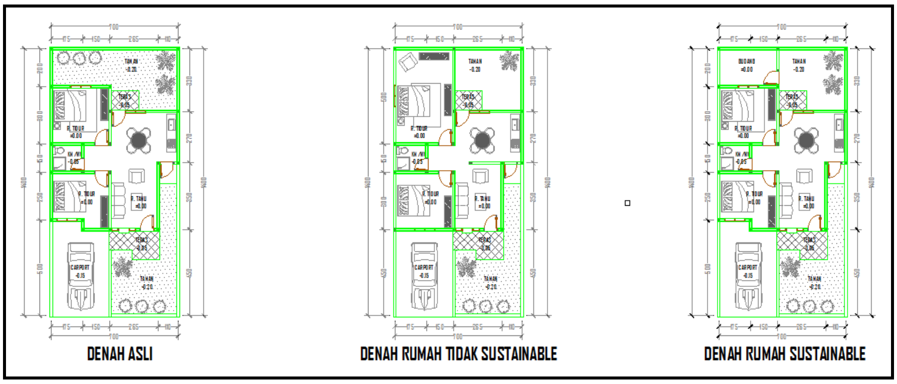

Figure 1. The sustainable design terminology

From the picture above can be seen that the unsustainable renovation is a renovation that changes the original structure of the design/floor plan such as widening or expanding the room. Otherwise, sustainable renovation is the renovation without changing the original structure of the house design or renovation that still retains the form of home design such as adding a room without collapsing the old wall.

Based on data from Lean Construction Institute, Abduh [1] wrote the waste in the construction industry is about 57% and the activity that gives added value is only about 10% only. According to Kiber (1994), Abduh also said the first point in the principle of sustainable development is to minimize the use of resources.

3 Methodology

3.1 Survey Objects and Samples

Nine housing build by the developer in Padang City is selected as sampling object. The criterion of housing is aimed at low and middle economic income resident. The length of stay of the owner in housing is maximum five years. The location of survey implementation can be seen in the following figure :

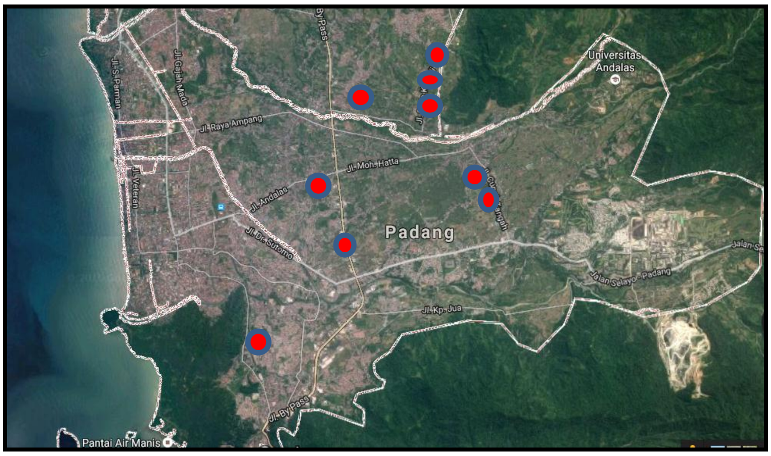

Figure 2. Research Location

3.1 Questionnaire

Questionnaires were distributed to homeowner randomly. There were 38 respondents namely 12 respondents with full purchase system and 26 respondents with credit purchase system. Questionnaire structure consists of respondent profile, housing information containing information on buying price of house and type of house, information of renovation providing information about related renovation time, renovated items / sections, renovation cost, and reason for renovation.

3.2 Analysis Method

Descriptive analysis is used to capture the extent of sustainable housing design in the city of Padang.

4 Identification of Factors Affecting Implementation of House Renovation

4.1 House Purchase Price

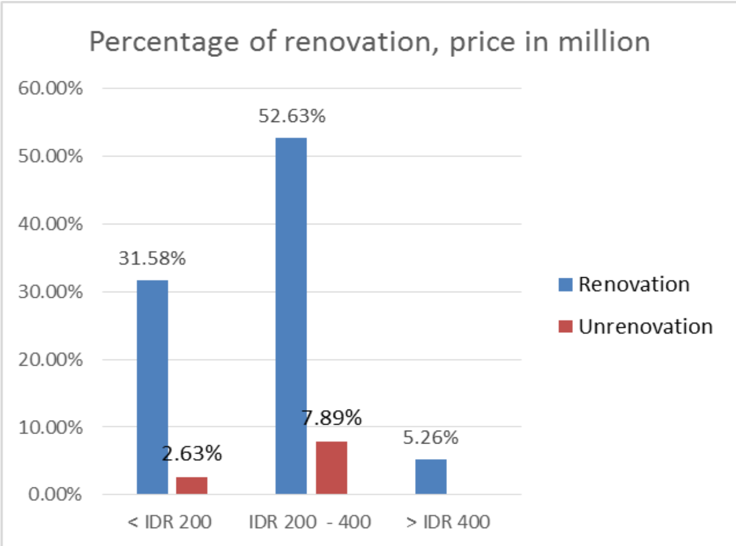

Figure 3 Percentage of Renovation at Various Home Purchase Price

The price of home purchase is expected to affect the implementation of house renovation by the respondents. House renovation is mostly done for houses with price range IDR 200 - 400 million as much as 52.6 percent. The percentage of renovation work decreases at the level of 31.58 percent in homes with a small selling price of IDR 200 million . As for the house with the highest selling price above IDR 400 million, renovation is only done by 5.26 percent of respondents

One of the differences in renovation at all three selling price ranges is the indent system implemented for medium-sized houses with a selling price greater than IDR 400 million. Whereas a simple house with a selling price lower than IDR 400 million, sales are made with a ready stock system. By using this ready stock system, there is minimal influence from buyers in the construction phase.

4.2 Type of The House

The types of the house may affect whether the renovations carried out by the respondents or not. The types of house concern the building of the house and the land. The smaller the building area of the house, the higher the tendency of respondents to do the renovation due to the increasing need for space.

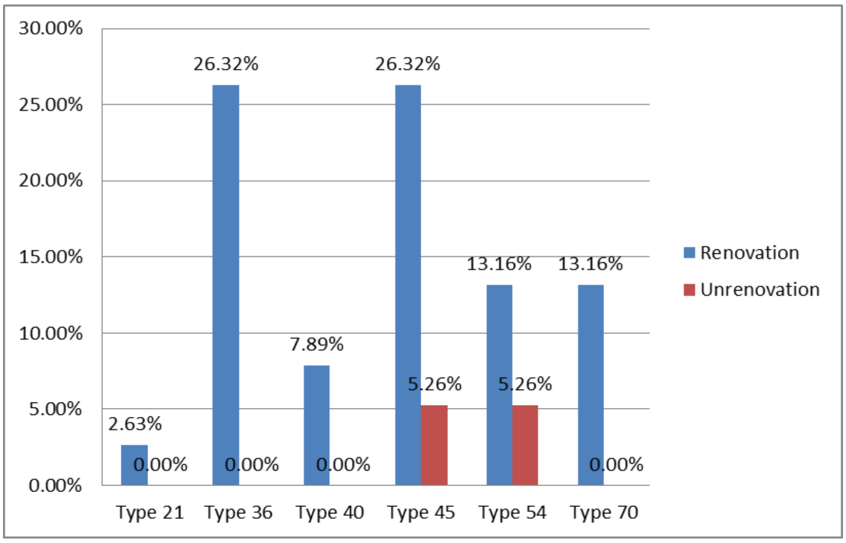

Figure 4 Percentage of Renovation Based on House Type

Most respondents who do the renovation of their homes are respondents with house type 36 and 45. With the hypothesis of the smaller the type of house, the more likely to do the renovation, it does not apply to housing types 21 and 40. This is because the number of respondents who have house Types 21 and 40 is too few to make it difficult to compare. However, the percentage of the renovation of the type of house 36 and 45 is higher than types 54 and 70.

4.3 Duration of Stay

The duration of stay may affect the renovation of the house by the respondents. The longer the house is occupied, the higher the tendency of respondents to do the renovation because the need due to the need for space is also increased.

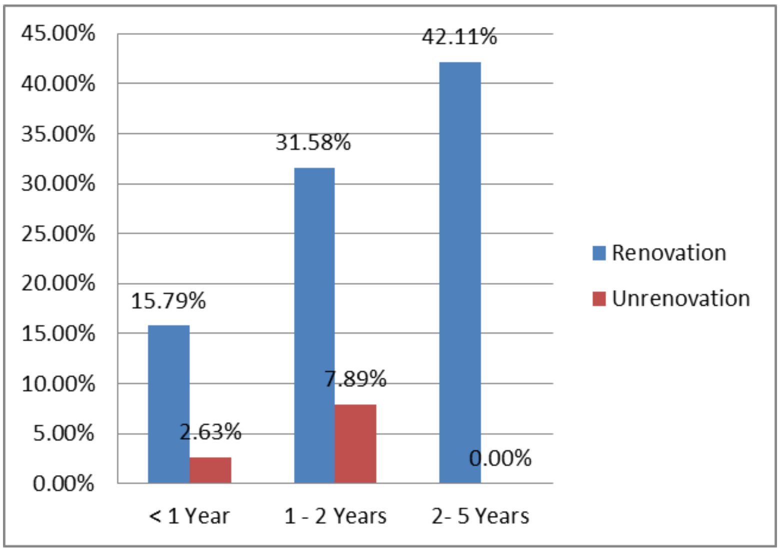

Figure 5 Percentage of Renovation Based on Duration of Stay

This is in line with the opinion of Fahminnansih [2] which says the renovation process is done by residents for some time after being inhabited after the purchase. The residents may not be satisfied with the standard house design that was purchased and also the expected functions from the residents may also change over time.

4.4 Home Purchasing System

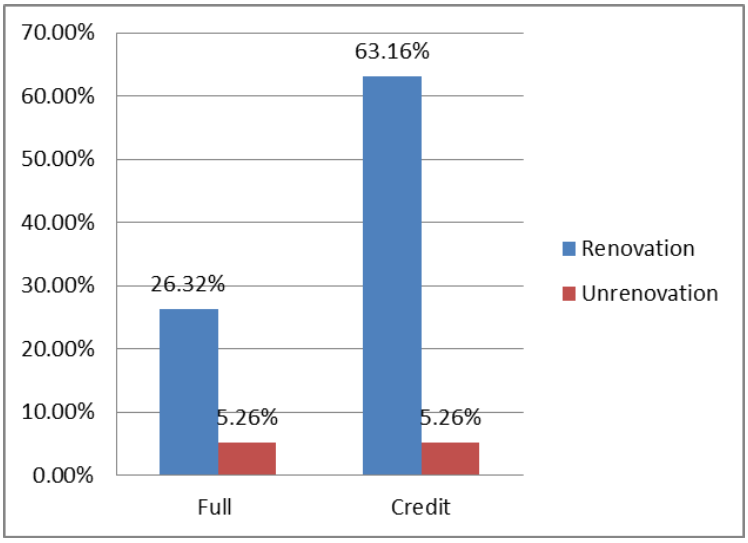

Figure 6 Percentage of Renovation Based on Home Purchasing System

The home purchase system is also suspected to affect the implementation of the renovation by the respondents. Most respondents bought a house on credit with a difference of 36.84% with respondents who bought the house in full. The cost incurred at the beginning of the purchase is enormous for respondents who bought the house in full compared to the house purchased credit. As a result, the desire or the tendency of respondents to renovate the house purchased is lower than the respondents who bought the house on credit.

4.2 Number of House Occupants

The number of residents in a house may affect whether or not the renovation is carried out by the respondent. The more occupants of a house, the higher the need for space, so the renovation needs to be done. This is confirmed by the picture below.

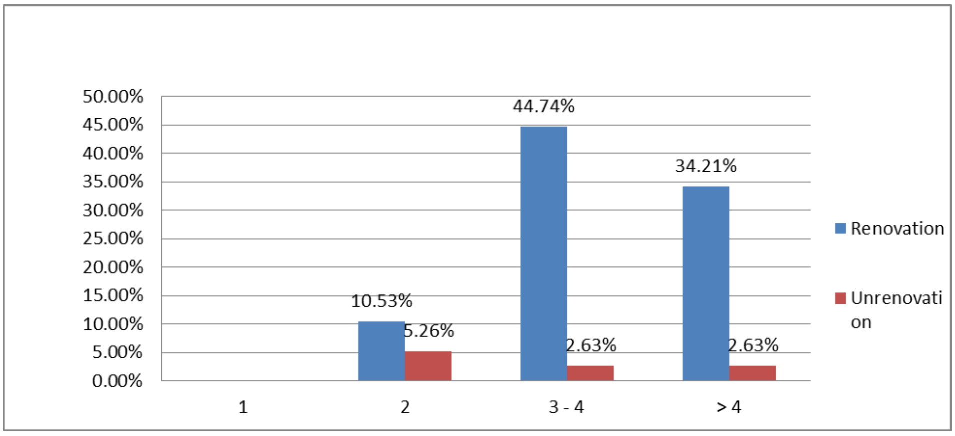

Figure 7 Percentage of Renovation Based on Duration of Stay

5 Characteristic of the Implementation of Renovation of Housing in Padang City

Spearman test aims to determine whether or not the relationship/correlation on any factors that affect the implementation of renovation to the implementation of renovation.

Tabel 1 Spearman Correlation Test Result

Correlations			
			Pelaksanaan Renovasi
Spearman's rho	Duration of stay	Correlation Coefficient	0.245
		Sig.(2-tailed)	0.139
		N	38
	House Purchasing System	Correlation Coefficient	0.136
		Sig.(2-tailed)	0.416
		N	38
	Number of Occupant	Correlation Coefficient	0.205
		Sig.(2-tailed)	0.218
		N	38
	House Purchasing Price	Correlation Coefficient	-0.036
		Sig.(2-tailed)	0.828
		N	38
	House Type	Correlation Coefficient	-0.185
		Sig.(2-tailed)	0.265
		N	38

From the table above, it can be seen that all the significance value of each factor that affects the implementation of renovation > 0.05 which means there is no significant correlation. So these factors cannot be said as a factor affecting the implementation of the renovation. Therefore, the current renovation of the sample housing in Padang City occurred due to the needs of respondents or consumers of such housing.

Implementation of the house renovation developers’ housing in Padang city is quite often done. Eighty-nine percent of 38 house samples were found to be renovated by the owners. In quantity, the renovation by the owner of the house inhabited is also frequent. Forty-six percent of the respondents who did the renovation stated that they did renovation twice. Only 42% stated that the renovation was done only once.

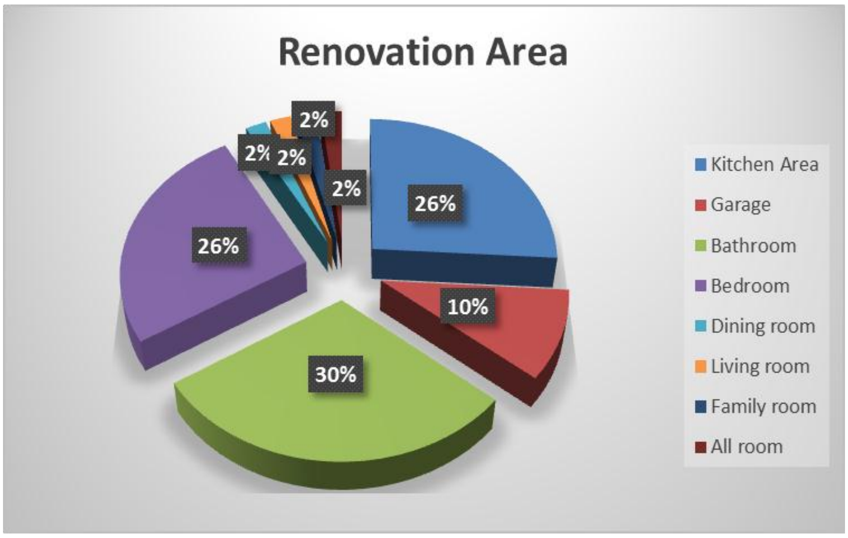

Figure 8 Renovation Area

It can be seen that the bathroom is the most widely done renovation by the respondents that is equal to 30%. Kitchen and bedroom are the second widely done renovation with a percentage of 26% each. The third order is the garage with a percentage of 10%. As for the dining room, living room, family room and other spaces from the house part each have a percentage of 2%.

Regarding financing, the most of the renovation cost issued by respondents is more than IDR 15 million with a percentage of 75%. The cost is borne solely by the owner either in the house that has been paid off or still credit. There is no cost sharing between homeowners and developers in the implementation of home renovation.

6. Conclusions

The construction industry especially housing developers in Padang City is still struggling with the inefficiency in the supply of housing products for middle and lower class consumers. This can be seen from the number of consumers involved in the research survey. Eighty-nine percent of the respondents were found to do the renovation to their houses. Surely this is apprehensive because consumers are harmed about the design of the house that does not fit the needs. 75% of the respondents who did the renovation stated that the cost incurred for renovation implementation is more than 15 million rupiah. The existence of renovation actions in the form of demolition and change of the house design indicate that the housing product from the developer has not minimized the use of resources to function by the needs of its occupant. 70 million tonnes of construction and demolition material ends up as waste. Renovation results in wasted time and money. Developers can contribute to sustainable development through the provision of housing development that provides better satisfaction and provides value for owners and users. To achieve, it needs to run sustainable design strategies, a decisive step for sustainable development for developers.

Minimizing waste through design can be achieved by providing coordinated approaches to design and construction within the supply chain [4]. For that, it is possible for developers to change business processes in the middle to lower class housing. Better developers provide homes with indent systems rather than ready stock, so developers and owners can meet and discuss the needs of each occupant.

Acknowledgment

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Success Indicators of Knowledge Transfer for the Transferee on the Construction Joint Venture in Indonesia

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Abstract. Generally, construction joint venture is a joint venture form in the construction sector of developing countries is used a tool of knowledge transfer from the foreign construction companies, or transferor, to the local construction companies, or transferee. For more than two decades, construction joint venture has been implemented, but it has not obtained the clarity of the extent on its success of the transferee. This research aims to explore a set of success indicators of knowledge transfer on the perspective of the transferee in the construction joint venture, as a result of the transferee's involvement in the construction joint venture on the construction sector during the time. By using the method of content analysis and Partial Least Squares in the Indonesian context, this study carries out to obtain a set of valid success indicators of the knowledge transfer for the transferee in usage. The result of the study shows that there are 22 identified valid indicators which can be relied upon to explain the success of knowledge transfer on the perspective of the transferee, as a result of the transferee's involvement in the construction joint venture during the time. The results of the study also answer the gap of the research regarding the scope of knowledge transfer in both the joint venture in the construction sector and the manufacturing sector widely.

Keywords: *construction; contractor; joint venture; construction joint venture; Indonesia; joint operation; knowledge transfer*

1 Introduction

Research related to the success of knowledge transfer in the joint venture (intercompany) has emerged since the last few decades. It causes a change of paradigm in respect of the company's competitiveness based on tangible asset switched to intangible assets in over the past decade (Davenport & Prusak [1], Volkov & Granina [2]). It is also supported by studies on organizational learning and knowledge transfer (Kogut [3], Cohen & Levinthal [4], Hamel [5], Doz [6], Lyles & Salk [7], Lane & Lubatkin [8], Inkpen [9], and Lane et al. [10]) which prove that knowledge is an important factor to strengthen corporate competitiveness. Moreover, the increased market intelligence and high competitiveness on the global market demand a company to improve the capacity of knowledge which is created internally or acquired externally (Oxley & Wada [11]).

The results of the study show that the literary researches concerning the success of knowledge transfer in joint venture are still widely performed in the non-construction sector, such as: manufacturing (Lyles [12], Lane et al. [10], Cummings & Teng [13], Anh et al. [14], Park [15], Cummings & Teng [13], and Oxley & Wada [11]), services (Lane et al. [10], Cummings & Teng [13], Park [15], Xiong & Deng [16], Oxley & Wada [11], and Atalay [17]), agricultures (Oxley & Wada [11]), and trading (Nordtvedt & Perez [18]). In contrary, the researches specifically in the construction sector (Gale & Luo [19], Eliufoo [20], Lihua & Greenwood [21], Dulaimi [22], and Osabutey et al. [23]) are still very limited. The limitations of these researches are not comparable to the rapid growth of the international joint venture in the construction sector as a new economic trend since the end of the 1980s (Park [15]). Moreover, the joint venture is very often used in construction sector in developing countries by the name of construction joint venture, particularly in handling the large-scale projects within the format of BOT, BOO, or BOOT (Chan et al. [24]). Generally, in developing countries, the construction joint venture is utilized as a tool in knowledge transfer from foreign construction companies as the transferor to local construction companies as the transferee. Focusing on the Indonesian context, this study aims to explore the success indicators of knowledge transfer on the perspective of the transferee in the construction joint venture or, popularly called in Indonesia, joint operation (JO).

To explore this research, the paper consists of four main sections: first, the conceptual framework; second, the research method, consisting of operationalizing of concept, questionnaire design, validation method, and sampling and data collection; fhird, the analysis of the collected data; and fourth, the conclusion of research, presenting important findings and offering guidelines for future research areas.

2 Conceptual Framework

Although researchers sometimes give different labels on the terms of knowledge transfer, in this paper, the meaning of the terms is encompassed in the knowledge acquisition, knowledge sharing, knowledge dissemination, and technology transfer. Technology transfer also means the same as knowledge transfer because the research undertaken, which is related to technology transfer in general studies, is related to technical knowledge, managerial knowledge, administrative knowledge, and marketing knowledge (Simonin [25]), rather than to the transfer of technology in the sense of the physical (hardware) as well as the traditional understanding of the technology.

Chini [26] explains that the aim of knowledge transfer of the recipient units is to integrate the new knowledge in the unit of context and to make use of it. The statement of Chini [26] implicitly explains that knowledge transfer is successful in the transferee (recipient) if the new knowledge is absorbed (integrated) and applied on the transferee's organization. According to Argote & Ingram [27], the success of knowledge transfer is affected by changes of embedded knowledge of the multi-repositories on the transferee. In this study, the terms of the change of embedded knowledge are interpreted as the increased of embedded knowledge. Argote & Ingram [27] define the repository as the locus of embedded knowledge on the transferee (the recipient), while multi-repositories as the people (Oner & Kayguzus [28], and Housel & Bell [29]), system (Oner & Kaygusuz [28]), organization (Oner & Kaygusuz [28]), organization's culture (Walsh & Ungson [30]) and process (Walsh & Ungson [30], Davenport & Prusak [1], Housel & Bell [29],Mertins et al. [31], Nonaka & Takeuchi [32], and King [33]). In the context of this research, the system is interpreted as construction equipment, while the organization is interpreted as the organization structure. Thus, these arguments can be modeled in the form of conceptual framework as shown below.

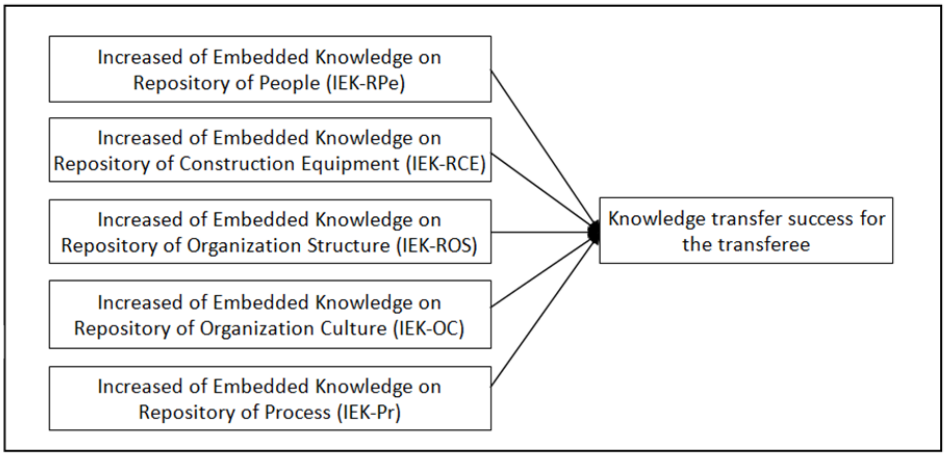

Figure 1 Conceptual framework

3 Method

3.1 Operationalizing of Concept

Based on the conceptual framework on Figure 1, each dimension (facet) of this concept is further operationalized into a set of indicators. Content analysis method is used for operationalizing the concept. Content analysis is one of the classical approaches used in the research (Holsti [34]). The method is considered effective and has been widely used in social science (Rattleff [35]). Using this method, the indicators are explored by pragmatic and semantic analysis (Krippendorff [36]) from the literary sources. The set of indicators of each dimension comes from the content analysis shown in Table 1.

Tabel 1 Indicators of Knowledge Transfer Success

No.	Increased of Embedded Knowledge on Repository of People (IEK-RPe)	Resources
X1	Increased quantity of work in the application of skills	[37]
X2	Reduction energy used in the application of skills	[37]
X3	Decreased time used in the application of skills	[37]
X4	Increased profits as a result of decisions made	[38]
X5	Increased cost efficiency due to the decision made	[38]
X6	Increased in terms of environmental friendliness as a result of decisions made	[38]
X7	Increased relevancy of the results and the predicted result of the decisions made	[38]
X8	Increased satisfaction as a result of decisions made	[38]
X9	Increased accuracy of objectives achieved as a result of decisions made	[39]
X10	Increased speed in decision-making	[39]
No.	**Increased of Embedded Knowledge on Repository of Construction Equipment (IEK-RCE)**	**Resources**
Y1	Decreased of the number of waste material in use CE	[27]
Y2	Increased cost effectiveness in the use of CE	[27]
Y3	Decreased of costs in the use of CE	[27]
Y4	Increased quality of results in the use of CE	[27]
Y5	Decreased time in the use of CE	[27]
No.	**Increased of Embedded Knowledge on Repository of Organization Structure (IEK-ROS)**	**Resources**
Z1	Increased support for the organizational structure of the missions and goals of the organization	[40]
Z2	Increased support for the organizational structure of the capacity building organization	[41]
Z3	Increased support for the organizational structure of the process of information within the organization	[41]
Z4	Increased support for the organizational structure of the communication process within the organization	[41]
Z5	Increased support for the organizational structure of the collective decision-making process within the organization	[41]
Z6	Decreased costs of coordination within the organization	[41]

Tabel 1 indicators of Knowledge Transfer Success (continuing)

No.	Increased of Embedded Knowledge on Repository of Organization Structure (IEK-ROS)	Resources
Z7	Increased organizational structure to support strategic change in the organization	[41]
Z8	Decreased complexity within the organization	[42]
No.	**Increased of Embedded Knowledge on Repository of Organization Culture (IEK-ROC)**	**Resources**
V1	Employees have the authority, initiative, and ability to manage their job	[43]
V2	There is existence of sense of ownership and responsibility for the organization of workers	[43]
V3	There is existence of mutual cooperative values and sense of shared responsibility in achieving common goals	[43]
V4	The organization relies on team effort to get work done	[43]
V5	The organization continually invests in the development of employee’s skills in order to stay competitive and meet on-going business needs	[43]
V6	Members of the organization share a set of values which creates a sense of identity and a clear set of expectations	[43]
V7	Members of the organization are able to reach agreement on critical issues, and also able to reconcile differences when they occur	[43]
V8	Functions and units of the organization are able to work together well to achieve common goals	[43]
V9	The organization is able to create adaptive ways to meet changing needs	[43]
V10	The organization is able to read the business environment, react quickly to current trends, and anticipate future changes	[43]
V11	The organizations understand and be responsive to business relations	[43]
V12	The organization is able to anticipate the future needs of the business relation	[43]
V13	The Strategies and policies of the organization forward are highly adapted to the degree of satisfaction of business relations	[43]
V14	The organization receives, translates, and interprets signals from the environment into opportunities for encouraging innovation, gaining knowledge, and developing capabilities	[43]
V15	The organization receives, translates, and interprets signals from the environment into opportunities for encouraging innovation, gaining knowledge, and developing capabilities	[43]
V16	The existence of clearly defined strategic intent is directed to the purpose of the organization so that every of workers can contribute and "make their mark” in the job	[43]
V17	The existence of a clear set of goals and objectives can be linked to the mission, vision, and strategy, and provide everyone with a clear direction in their work	[43]
No.	**Increased of Embedded Knowledge on Repository of Process (IEK-RPr)**	**Resources**
W1	Decreased costs in the process	[44]
W2	Increased quality of the output in the process	[44]
W3	Increased speed in the process	[44]

W4	Increased profits to the process used	[44]

3.2 The Questionnaire

A set of indicators that has been identified through the previous method then will be tested related to the validity in producing the set of the final indicators that valids for the usage. For these purposes, a questionnaire survey is constructed based on the set of indicators as shown in the table above. The questionnaire consists of five groups of questions related to the embedded knowledge on multi-repositories of the transferee, ie: people, construction equipment, organization structure, organization culture, and process. The total of 45 questions is composed of 44 questions for the purposes of validation indicators and a single dependent variable as the criterion for checking the correlation of the concept that is assessed. Each item of the questionnaire is complemented with four lickert scale ratings. The following paragraph is a detailed description of the questionnaire components.

For the dimension (group) of IEK-RPe (increased of embedded knowledge on repository of people), the question is: “after engageing so far in the project organized in the joint venture, we ask for assessing changes on the ability of your personal as well as your colleagues in the company where you work, as a result of that engagement based on a set of indicators of the following ratings. A four-point lickert scale is used here to assess the degree of embedded knowledge: 1 (no increased) through 4 (many increased) for item number X1, and X4 to X10; while for the item number X2 and X3, scale of 1 (no reduction) to 4 (many reductions) are used”.

For the dimension of IEK-RCE (increased of embedded knowledge on repository of construction equipment), the question is: “after engaging so far in the project organized in the joint venture, we ask for assessing changes in the ability of your construction equipment in the company where you work, as a result of that engagement based on a set of indicators of the following ratings. A four-point lickert scale is used here to assess the degree of embedded knowledge: 1 (no increased) through 4 (many increased) for item number Y2 and Y4; while for the item number Y1, Y3, and Y5, scale of 1 (no reduction) to 4 (many reductions) are used”.

For the dimension of IEK-ROS (increased of embedded knowledge on repository of organization structure), the question is: “after engaging so far in the project organized in the joint venture, we ask for assessing changes in the ability of your organizational structural in the company where you work, as a result of that engagement based on a set of indicators of the following ratings. A four-point lickert scale is used here to assess the degree of embedded knowledge: 1 (no increased) through 4 (many increased) for item number Z1 to Z5 and Z7;while for the item number Z6 and Z8, scale of 1 (no reduction) to 4 (many reductions) are used".

For the dimension of IEK-ROC (increased of embedded knowledge on repository of organization culture), the question is: "after engaging so far in the project organized in the joint venture, we ask for assessing the changes of the condition of your organizational culture in the company where you work, as a result of that engagement based on a set of indicators of the following ratings. A four-point lickert scale is used here to assess the degree of embedded knowledge: 1 (none at all) through 4 (more than enough) for item number V1 to V14".

For the dimension of IEK-RPr (increased of embedded knowledge on repository of process), the question is: "after engaging so far in the project organized in the joint venture, we ask for assessing changes in the ability of your process in the company where you work, as a result of that engagement based on a set of indicators of the following ratings. A four-point lickert scale is used here to assess the degree of embedded knowledge: 1 (no reduction) to 4 (many reductions) for item number W1; while for the item number W2 to W4, scale 1 (no increased) through 4 (many increased) are used".

For the final question, the single question which functions as criterion on this questionnaire is: "based on the experience of your involvement in the construction of joint venture (joint operation) during this time, please grade the degree of knowledge transfer success from the foreign contractor to the national contractor (the place you work now) until today. A four-point lickert scale is used here to assess the question: 1 (unsuccessful), 2 (little successful), 3 (successful enough), and 4 (highly successful).

3.3 Validation Method

Partial Least Square (PLS) as a variety of Structural Equation Modelling (SEM) method is used in the process of data analysis in this study. PLS-SEM is used widely by the researchers for indicating validation of instrument (Whitment [45], Recker [46], and Quaddus & Woodside [47]). A valid indicator has a value outer loading of more than 0.7 with the average variance extracted (AVE) value of more than 0.5 on the convergent validity testing; meanwhile, on the discriminant validity testing, it is suggested that all value outer loading in measured construct intended should greater than in measure another construct (Hair et al. [48]). In addition, the significance of each loading and R-square is also examined in this study.

3.4 Sample and Data Collection

The target population to validate the indicators in this study is construction practitioners who have experiences in the joint venture project with foreign companies. The specific respondent of the sample is construction practitioners who had served as a project manager on local contractors in the joint venture project with the foreign company.

The adequacy and readability of the questionnaire are tested using pilot study. Six expert practitioners are involved in this pilot study, and their suggestions are incorporated into final questionnaire. Once the questionnaire is finalized, then, the construction practitioners at local contractor are invited to indicate each item of the questions based on their experiences in joint venture project with the foreign company in Indonesia. Approximately, within three months, the data collection process is finished. About 60 respondents participate in the questionnaire, but only data from 24 respondents are feasible to be analyzed. The demographics data of respondent are shown in Table 2 and Table 3.

Table 2 ***Respondent profile***

Respondent Profile								
Based on Age		Based on Sex		Based on Education Level			Based on Institution	
< 40 old	> 40 old	Male	Female	Under Graduate	Graduate	Doctorate Degree	State-Owned Enterprises (BUMN)	Private
3	21	24	0	17	7	0	24	0

Table 3 ***Experince in joint venture project***

Based on Company Experinced in JV		Based on Personal Experienced as the P/S Manager in JV Project	
< 5 years	> 5 years	< 5 years	> 5 years
0	24	0	24

4 Analysis

Data analysis using software SmartPLS (version 2.0) is conducted to test the validity and significance of the 44 indicators. The data analysis is performed in three stages. In the first stage, the analysis is done by executing the algorithm iteration with SmartPLS to obtain the outer loading of the 44 indicators. The results of the analysis on the first stage are shown in Table 4. In the second stage, based on the outer loadings of each indicator, the convergent and discriminant validity test are performed on 44 indicators. The SmartPLS algorithm execution continues to be applied on every completed-elimination indicators that has not passed off the validity criteria. In the third stage, re-analysis is carried-out by the SmartPLS algorithm and bootstrapping on the indicators that pass the validity test in the previous stage. This analysis resulted in a set of final outer loading, AVE value and significance of these indicators, and the R-square value. The results of analysis are shown in Table 5.

Table 4 ***The first stage of PLS-SEM analysis***

Dimensions	Indicators	Outer Loading	AVE
IEK_RPe	*X1*	0,727697	0,570404
	X2	0,682323	
	X3	0,798757	
	X4	0,858182	
	X5	0,657134	
	X6	0,762682	
	X7	0,72524	
	X8	0,904064	
	X9	0,831641	
	X10	0,534792	
IEK_RCE	*Y1*	0,272996	0,538158
	Y2	0,726812	
	Y3	0,841283	
	Y4	0,89212	
	Y5	0,764442	
IEK_ROS	*Z1*	0,823057	0,359913
	Z2	0,636423	
	Z3	0,451108	
	Z4	0,433004	
	Z5	0,886079	
	Z6	0,485848	
	Z7	0,25604	
	Z8	0,564903	
IEK_ROC	*V1*	0,082296	0,351542
	V2	0,412767	
	V3	0,241248	

Table 4 ***The first stage of PLS -SEM analysis (continuing)***

	V4	0,728152	
	V5	0,763473	
	V6	0,492468	
	V7	0,469259	
	V8	0,694175	
	V9	0,29016	
	V10	0,564363	
	V11	0,74934	
	V12	0,523299	
	V13	0,7198	
	V14	0,751095	
	V15	0,584327	
	V16	0,602181	
	V17	0,81166	
IEK_RPr	*W1*	0,606623	0,472855
	W2	0,709162	
	W3	0,566378	
	W4	0,836502	

Table 5 ***The final results of PLS-SEM analysis***

Dimensions	**Indicators**	**Outer**	**T-statistic**	**AVE**	**R-square**
IEK_RPe	*X1*	0,775067	9,739086	0,671972	0,800306
	X3	0,836927	14,491009		
	X4	0,845754	11,452047		
	X6	0,779027	10,995728		
	X7	0,712137	6,576205		
	X8	0,905955	14,855041		
	X9	0,867498	16,771842		
IEK_RCE	*Y2*	0,702205	10,470926	0,664235	
	Y3	0,844664	26,223796		
	Y4	0,911193	66,586795		
	Y5	0,787474	21,876462		

Table 5 ***The final results of PLS-SEM analysis (continuing)***

IEK_ROS	*Z1*	0,90393	65,780478	0,822206
	Z5	0,909573	67,996293	
IEK_ROC	*V4*	0,756804	13,406582	0,57052
	V5	0,814083	34,042546	
	V8	0,759232	19,823239	
	V11	0,702052	11,937192	
	V13	0,717705	11,316573	
	V14	0,706505	14,041294	
	V17	0,821341	24,983064	
IEK_RPr	*W2*	0,798189	3,498962	0,673394
	W4	0,842427	10,224054	

5 Conclusion

Based on the results of the analysis above (Table 5), there are 22 indicators that pass the validity test. They are seven indicators on the dimension of IEK_RPe, four indicators on the dimension of IEK_RCE, two indicators on the dimension of IEK_ROS, seven indicators on the dimension of IEK_ROC, and two indicators on the dimension of IEK_RPr.

The analysis also shows that the indicator X8 (increased satisfaction as a result of decisions made) with a score of 0.905955 implies that the indicator has the greatest ability to explain the construction of (dimension) IEK_RPe (increased of embedded knowledge on the repository of people). The indicator Y4 (increased quality of results in the use of construction equipment) with a score 0,911193 implies that the indicator has the greatest ability to explain the construction of (dimension) IEK_RCE (increased of embedded knowledge on the repository of construction equipment). The indicator Z5 (increased support for the organizational structure of the collective the decision-making process within the organization) with a score 0,909573 implies that the indicator has the greatest ability to explain the construction of (dimension) IEK_ROS (increased of embedded knowledge on the repository of organization structure). The indicator V17 (existence a clear set of goals and objectives can be linked to the mission, vision, and strategy, and provide everyone with a clear direction in their work) with a score 0,821341 implies that the indicator has the greatest ability to explain the construction of (dimension) IEK_ROC (increased of embedded knowledge on the repository of organization culture).The indicator W4 (increased profits to the process used) with a score 0,842427 implies that the indicator has the greatest ability to explain the construction of (dimension) IEK_RPr (increased of embedded knowledge on the repository of process).

Table 5 also shows that the whole construction (dimensions) has AVE value of more than 0.5 and it is meaningful that the overall indicator is eligible convergent validity. R-square value of 0.800306 (more than 0.75) means that the overall indicator is substantial (Hair et al., 2014). it also means that the overall indicator is able to explain 80% of the concept of knowledge transfer success from the perspective of the transferee in the construction joint venture (joint operation) in Indonesia. AVE values and R-square also supports the validity of the twenty-two indicators mentioned above.

Further research can be carried out on a national consulting service company which carries on the business as transferee with a foreign consulting service company as transferor in the context of the construction joint venture in Indonesia. The concept and methodology of in this study can be used as a reference to elaborate further research. The authors are aware that the indicators produced in this research are still subjective. Therefore, further research can be carried out to develop the objective indicators based on the subjective indicators of this study for a better set of indicators.

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ENVIRONMENTAL PROTECTION AND MANAGEMENT

Risk Assessment Method for Identification of Environmental Aspects and Impacts at Ore Milling Process Industry

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Abstract. PTFI applies the international standard of environmental management system based on ISO 14001:2015. The implementation of clause 6.1.2 requires every organization to identify the environmental aspects of its operations, as an initial step in environmental management. Concentrating Division operates in ore processing into concentrate as PTFI main product. The objective of this research is to obtain a structured approach in identifying environmental aspects and impacts so that an evaluation on the risks, opportunities as well as severity of possible environmental impacts can be conducted. The methods used life-cycle approach and risk assessment method, with four-cell risk assessment matrix in environmental risk determination. The results of this risk assessment can give an overview on the risk rank on the significance value of environmental aspects and impacts, so that control priority can be determined in order to reduce the risks.

Keywords: *environmental aspects; environmental impacts; environmental management system; ISO 14001:2014; life-cycle; risk assessment.*

1 Introduction

PT Freeport Indonesia (PTFI) is a company that operates in the field of copper and gold mining, and has been operating since 1972 in Mimika Regency, Papua Province [1][2][3]. PTFI has a commitment to develop an Environmental Management System (EMS) that complies with ISO 14001 or SNI 19-14001 standards in AMDAL300 K 1997. In 1998, PTFI started formulating this environmental management system in order to comply with ISO 14001 standards. Since the result was that PTFI obtained ISO 14001 certification [4].

The Standard of EMS used by the PTFI Concentrating Division has changed. The 2015 version of ISO 14001, which superseded the 2004 version, has been published and an organization is given a three-year transition period after the revision to migrate into the latest version of EMS. This is intended for use by organizations to manage their environmental responsibility in a systematic way that contributes to the environmental improvement approach in the units of production.

According to clause 6.1.2 in ISO 14001:2015, PTFI is required to conduct identification of environmental aspects from its operations. The identification of environmental aspects and impacts is one of the initial processes in environmental management [4]. Based on the identification results, the important aspects in a process on each activity unit in Concentrating Division can be defined, so an environmental control and management planning program, as well as the follow up actions in the important aspects handling. The objective of this research is to obtain a structured approach in identifying environmental aspects and impacts so that a planning and evaluation on the risks, opportunities as well as severity level of environmental impacts that can possibly occur in PTFI Concentrating Division.

2 Methods

In identifying and determining the environmental aspects and impacts, referring to risk assessment method [6] with four-cells risk assessment matrix, and calculating the life cycle according to the clause in clause 6.1.2 of ISO 14001:2015 environmental management system standards [7]. Meanwhile, life-cycle assessment or usually known as life-cycle analysis is the continuous and interrelated stages in product system and/or services, starting from material procurement or making from natural resources to the final disposal [8] [9].

This risk assessment method considers normal, abnormal and emergency conditions that can possibly happen, and becomes a part in the method [7]. Normal condition refers to the regular or expected condition from an organization activity or plan operation, while abnormal condition refers to the unplanned or unexpected condition that is not part of the organization operation plan, and emergency condition refers to an unexpected or serious, urgent and sudden situation that requires immediate action.

3 Results and Discussions

Environmental management system is a system that is dynamic and able to follow the dynamics or development on the related parties, therefore organization has to be able to follow the development by proofing that the environmental aspect list is always updated, either when there is a development from external factors like environmental regulation change or when it is done regularly to accommodate changes in the organization.

According to clause 6.1.2 in ISO 14001:2015, PTFI Concentrating Division must guarantee that the aspects related to their important aspects are considered in defining environmental objectives, and keep paying attention to the followings: (1) considering life cycle in determining environmental aspects and impacts by considering changes including planned development, process and whenever there is modification; (2) considering normal, abnormal and emergency conditions that may possibly happen; and (3) determining the method to define important environmental aspects so that PTFI Concentrating Division can make follow up programs and actions on the results of environmental aspects and impacts identification that have been done previously.

In ISO 14001:2015 standard implementation performance and indicators, there are several parameters and indicators of environmental management system performance stated from several items:

1. *Significant environmental aspects.* PTFI Concentrating Division shall identify environmental aspects from its operational activities according to the requirements and determine the environmental aspects that significantly give impacts on the environment. And to ensure that the control has effectiveness and efficiency in achieving targets, monitoring and measurement have to be conducted.

2. *Compliance obligations.* Compliance obligations consists of law regulations and other requirements, which regulate the obligations that must be complied by PTFI Concentrating Division, i.e. key parameters stated in the environmental documents such as AMDAL (Analysis on Environmental Impacts), environmental permits etc.

3. *Operational Planning and Control.* In order that the environmental aspects are in line with their objectives, PTFI Concentrating Division shall conduct monitoring and measurement from the operation activities, through monitoring on the standard operating procedures (SOP) compliance, abnormal operation condition, operation implementation to the incompetent personnels etc.

	Consequences			
Likelihood	1	2	3	4
1	1	2	3	4
2	2	4	6	8
3	3	6	9	12
4	4	8	12	16

Rating Level	
	High Risk
	Medium Risk
	Low Risk

Figure 1. Four-Cells Risk Matrix

The identification result is a list of environmental aspects and impacts that cover the whole environmental aspects comprehensively, in normal, abnormal and emergency conditions, as well as all components explained per part of production activity etc. Environmental aspect is defined as part of activity that interacts with the environment while the impact is the result of an aspect. In other words, there is a cause-and-effect relation between environmental aspects and impacts.

For example, kiln operation in lime production activity, where this lime is used as the material for production process to improve mineral recovery, is one of the main activities in the lime plant consisting of sub-activities that interact with environment or create impacts such as dust emission. Gas emission resulted in the calcination such as SO_X, NO_X and mainly particulate is environmental aspect,that can create impacts in the form of air pollution. Meanwhile, other aspects from lime production activity, i.e. used oil and diesel oil usage as lime production fuel mixer that can create impact such as oxidation gas emission [10].

Other example from aspects is laboratory activity in the form of metallurgy analysis that has sub-activity or environmental aspect like chemicals addition, fire assay waste generation [11][12], which if the impact creation process is examined, these activities are categorized as the environmental aspects that create land and water pollution impacts from hazardous waste generation and air pollution from the potential of exhaust dust release which can potentially become a hazard on occupational health. It can also be seen here that several aspects can cause one or several types of environmental impacts, i.e. air pollution, water pollution and/or land pollution.

Aspects in abnormal condition of activity can exist when, for example, machinery and equipment maintenance activities are conducted so the environmental impacts are not from normal activities, i.e. used oil and grease spills, used spare part disposal, chemically contaminated waste, etc. Meanwhile, emergency condition contributes environmental aspects in the form of particulate 'blow up' to the air due to operational temperature that is too high, which may exceed threshold values stated in the environmental permits. These three conditions (normal, abnormal and emergency) must be listed and differentiated between the two conditions, where emergency condition is a beyond-normal condition that gives sudden huge impacts and cannot be prevented except to reduce the impacts aftermath.

The identification must be done not merely limited to the operational activities related to the largest waste source, but reaching the aspects of their products. The examples that have been mentioned above are aspects that appear from production main activities. While aspects from products have wider coverage, such as overview on the products when pumped from mill tower through concentrate pipeline system, dewatering process, dry concentrate storage in barns, and concentrate product loading to the transporting ship. This process can cause impacts to the environment. Land and water pollution appear from the potential of pipeline leak, air pollution from concentrate particles and gas emission from the oxidation of used oil and diesel fuel mix [10].

Various types of impacts can clearly be caused by those aspects and have risky category, so this is an example of product aspect classified as significant aspect. After it is clear for identification coverage, PTFI Concentrating Division can conduct evaluation on the whole aspects to determine the aspects classified as important aspects, or the ones that will get handling priority based on their risk study. This stage is a critical stage and strongly determines the success and effectiveness of environmental management system implementation.

In ISO 14001:2015 environmental management system standard, it does not require a certain risk assessment method and evaluation, including whether it has to be with qualitative or quantitative method, however what needs to be made is a method that is appropriate with the complication level of the organization activity itself. In this risk study, risk assessment method using four-cells risk matrix is used, as illustrated in figure 1.

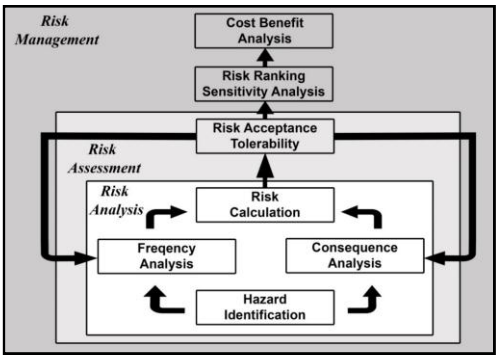

Figure 2. Relationships of risk analysis, risk assessment and risk management

3.1 Compliance Obligation Evaluation

Compliance obligation refers to two items, i.e. law regulation and other requirements. Law regulation requirements covers: (1) requirements from government body or other relevant authorities; (2) international, national and local law and regulations; (3) requirements stated in the permits; (4) orders or regulations from law bodies; (5) court or administrative court decisions. Meanwhile, other requirements are the requirements identified by respective and related parties with the environmental management system where organization must comply and/or dan choose to adopt, for example agreements with community of non-governmental organization; agreements woth public authority or customers, voluntary labelling or environmental commitment; agreements that exist based on contract agreements with organization and relevant organization standards.

3.2 Risk Assessment

Risk has two dimensions, i.e. consequences and likelihood (figure 3) [6][13][14], while figure 2 shows the relationship between risk analysis, risk assessment and risk management. Risk analysis can be defined as the process of determining of likelihood of undesired events, harm (consequences) or loss [6][14][15].

Table 1. Likelihood Indicators

Likelihood		
Frequency of Potential Impact	(1) Seldom	May occur more than once when facility operates
	(2) Possible	May occur once or more when facility operates, but less than once in 20 years
	(3) Often	May occur once or more every 20 years but less than once a year
	(4) Very Often	May occur once or more in every year
Frequency Description	(1) Seldom	Events that seldom occur <1 per facility operates
	(2) Possible	Events that may occur <1 per every 20 years; >1 per facility operates
	(3) Often	Events that may often occur <1 per year; >1 every 20 years
	(4) Very Often	Occur regularly $\geq$ 1 per year

Risk assessment is overall process of risk identification, risk analysis and risk evaluation [13]. Risk management has several meanings and is often associated with obtaining insurance coverage to transfer risks [6]. The concept of likelihood [14] (or frequency) is central to risk, and to define these is that frequency is given units of events per unit time.

Aspect and impact frequency illustrates how often the impacts will appear with an explanation that the more often an impact is released, the more important the impact. The impacts that appear in normal condition has higher frequency than the impacts in abnormal or emergency conditions. Likelihood indicators are described in table 1.

Table 2. Consequences Indicators

Consequences		
Financial	(1) Minor	\$0 - \$25M
	(2) Moderate	\$25 - 50M
	(3) Significant	\$50 - \$100M
	(4) Major	>\$100
Legal / Compliance	(1) Minor	Not a compliance issue on regulation requirements or informal notification
	(2) Moderate	Non-compliance issue on regulation requirements at moderate level by notification of violation with minimum penalty
	(3) Significant	Non-compliance issue that is significant with regulation requirements by notification of violation with good potential > \$100,000
	(4) Major	Major and/or chronical non-compliance on administration
Reputation	(1) Minor	No news coverage

	(2) Moderate	Local coverage and from stakeholder whose level is low
	(3) Significant	Provincial or regional level coverage or from important stakeholder
	(4) Major	International or national news or critics from stakeholder
Environment	(1) Minor	Temporary and measured impacts
	(2) Moderate	Short-term but repairable impacts
	(3) Significant	Significant damage but the impacts outside or inside organization can be restored back to initial condition
	(4) Major	Major or hazardous damage outside organization that is possibly hard to repair
Local Community	(1) Minor	Minimum reaction from outside parties and mostly from individuals or there is no complaints
	(2) Moderate	Moderate complaints with minor media coverage and there is a dispute that occurs
	(3) Significant	Significant complaint and media attention and there is a dispute that occurs
	(4) Major	Main complaints with international or national coverage as well as the loss of social permit and/or support from community
Stakeholders (regional, national, international)	(1) Minor	Minimum reaction from outside parties and mostly from individuals or there is no complaint
	(2) Moderate	Moderate complaint and there is a dispute that occurs from several groups
	(3) Significant	Significant complaint and regional media attention and there is a dispute that occurs
	(4) Major	Main complaints with international or national coverage as well as the loss of social permit and/or support from community
Production	(1) Minor	< 1%
	(2) Moderate	1 – 5%
	(3) Significant	5 – 90%
	(4) Major	Shutdown
Schedule	(1) Minor	< 1 month or delay
	(2) Moderate	1 – 3 month
	(3) Significant	3 – 12 month
	(4) Major	> 1 year

Consequences [6][14] analysis of this research shown in table 2 considers the impact hazard level based on impact characteristics so it can be known that an impact is categorized as minor, moderate, significant and major, and is based on the impact spread area, i.e. how wide and many environmental components that will get impacts.

These consequences consist of eight categories: (1) financial aspect, i.e. the number of economic impacts on the organization; (2) legal or compliance aspect, i.e. whether there is a difficulty to comply regulation and permit requirements; (3) reputation aspect, i.e. company profile; (4) environmental aspect, the number of impacts on the environment; (5) local community aspect, i.e. assessment from media or community related to environmental issues; (6) stakeholder aspect, i.e. assessment from international and/or national media for environmental issues; (7) production aspect; and (8) schedule aspect in the form of delay on production.

Risk ranking is a powerful technique used to simplify the risk analysis process [6], it can be used as part following a likelihood identification, at arive at a list of control and planning, prioritised according to risk [17][18].The simplest form (fig. 3) is four-cell matrix where the cells in one direction represent increasing degrees of severity of consequences, while the cells in the other direction show increasing likelihood. The factor, n, is an attempt to futher weight the index on order to represent the public's aversion to multiply environmental impacts.

Parameters of impacts and costs represent economic interest or company business, so according to the ISO 14001:2015 objectives that there has to be a balance between economic interest and environment. The final product of aspect evaluation stage is the list of environmental important aspects, which may be listed from the most important to the less important, based on the achieved score as described in table 3. It shows that the company has succeeded creating priority of many works and is the objective of clause 6, i.e. Planning on ISO 14001:2015.

Table 3. List of Environmental Aspects with Four-Cells Risk Matrix Method

Activity	Aspect	Risk & Opportunities	Consequence	Conseq. Category	Likelihood	Risk Ranking	Planning & Control
Discharge of Tailings	Amount of tailings to be releases to the river	**Risk:** Exceed permit treshold during compliance monitoring of process outfalls	4	Compliance Environmental Reputation	2	8	Frequent check for discharge of tailings not exceed permit treshold for pH and dry amount of tailings
Maintenance Shop	Oil Water Separator	**Risk:** Exceed permit threshold during compliance monitoring of process outfalls	3	Compliance Environmental	3	9	Skimmer installation and chamber maintenance and clean up

Diesel Fuel Usage	Kiln burner	**Risk:** Green house gasses and conservation of energy	1	Compliance	4	4	Used oil utilization at Lime Plant
Used Oil	Utilization of used oil	**Opportunity:** Utilization hazardous waste	2	Compliance	4	8	Used oil consumption
Settling pond	Effluent from Pond	**Risk:** Impact to estuary water quality	3	Compliance Environmental	2	6	Routine maintenance; sludge dreging
Spillage of petroleum, hazardous waste, hazardous materials	Petroleum, hazardous waste and materials transport, shut-down, storage tanks, and barge (Abnormal)	**Risk:** Spill could impact to surface water and soil	2	Environmental	3	6	Frequent check for tanks before transport; storage tanks inspection and NDT (non-destructive testing) and condition monitoring, spill response protocol and team, secondary containment
Fuel and concentrate transport by pipeline	Spill of fuel and concentrate (Abnormal)	**Risk:** Contamination to soil and water	2	Financial Environmental	3	6	HSE patrol
Lime Plant	Lime Spillage	**Risk:** Reduce the quality of groundwater	1	Environmental	4	4	Contamination water use to neutralization
Maintenance Shop	Degreasing Solvents	**Risk:** Could impacts to discharge of effluent from oil water separator	1	Compliance Environmental	4	4	Water-based and degradable substance
Natural Disaster	Petroleum products and chemical substances (emergency condition)	**Risk:** Declining of water quality and quantity	3	Financial Compliance Environmental	1	3	Crisis management procedures
Lime Plant and Dewatering Plant	Emission (Normal)	**Risk:** Ambient Air quality	2	Compliance	3	6	Scrubber and filter bag house maintenance; stack emission test
Dewatering Plant	Concentrate movement to loading dock	**Risk:** Ambient Air quality	2	Environmental	3	6	Improving containment on conveyors system; closed system for drainage and sump pump optimization

Ore Stockpile	Fugitive Dust	**Risk:** Ambient air quality	1	Environmental	4	4	Water sprayer installation and maintenance
Electrical	Emission of Ozone Depleting Chemicals	**Risk:** R22 refrigerant	1	Environmental	4	4	R22 reduced and change with other non-CFC refrigerant
Dewatering Plant	Emission (Abnormal)	**Risk:** Exceed permit threshold during compliance monitoring of process	1	Compliance	3	3	Cyclone and wet scrubber maintenance and control
Fire Assay Laboratory	Emissions and Fugitive Dust	**Risk:** Emissions from fume hood and dust control	1	Compliance	2	2	Indoor air quality monitoring
Lime Plant	Emission (Abnormal)	**Risk:** Impact to emission standard	1	Compliance	2	2	Filter bag house replacement and maintenance
Concentrate & Petroleum Product	Spillage	**Risk:** Spills and leaks from concentrate, fuel tanks, pipelines, and or misshandling wastes	2	Financial Compliance	3	6	Frequent check for storage facilities, secondary containment availability, spillage response and protocol
Instrument	Radioactivity exposure or release (Abnormal)	**Risk:** Radioactivity exposure	1	Environmental	3	3	None
Laboratories	Discarded solid samples	**Risk:** Soil quality	1	Environmental	2	2	Reclaimed unused mineral samples are discarded to ore stockpile

4 Conclusion

Identification of environmental impacts is the implementation of clause 6.1.2 from ISO 14001:2015 environmental management system where the comprehensiveness of system, coverage compliance and work priority are resulted from this standard clause. The success of a system very depends on a good understanding on the environmental aspects and impacts. The result of risk assessment can be used as reference and data information in operation control determination and administration control to minimize the risks related to the impacts of environmental aspects in PTFI Concentrating Division.

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Environmental Analysis for Supporting Water Resources as Availability of Water Supply System Using AHP Method

(Case Study: Subang District, West Java)

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Abstract: Water supply system in Indonesia, in addition to relying on self-provision of public or private water distribution, managed by Local Water Company (PDAM) as the sole provider of water services in each city and district. The water need rates are increasing continuously affected by population growth. In the other side, raw water to support water supply have decreasing capacity. Several factors in environment was evaluated using AHP method to achieve policy priority in decision making for conservation and rehabilitation the availability of water resources. A multicriteria approach for combining prioritization methods within the analytical hierarchy process (AHP) was proposed. The method will be used depends on the result of multicriteria evaluation of their vectors priority performance with rank reversal measures. From the AHP environment analysis, water catchment area was important priority factor to support the availability of water resources with 0,294 in that scoring. Surface water condition determine the water resource potential for water supply to guaranteed quality, quantity, and continuity of water supply. Rainfall and topography in distribution area was influencing the water discharge. AHP method overcame the decision making support in water resources management, beside on environment evaluation.

Keywords: *AHP, environment, decision making support, water resources, water supply*

1 Introduction

Water is one of the natural components whose existence is very important to human needs. Water is a resource that is needed by living things to meet the needs and to sustain life naturally. Water availability for a few places in Indonesia still depend on spring water, which is limited for water need distribution. The increasing of water resources arises because of the demand for water availability to meet the needs. Water resources will be used to meet the needs of household water, agriculture, and other purposes.

Increased public attention to the excessive use of water resources has led to the development of tools that can be used to reduce the amount of water use in residential areas. The water need rates is increasing continously affected by population growth. In the other side, the raw water to support water supply have decreasing capacity. People awareness of the importance of water supplies leads to a reduction in water consumption through a future oriented, effective education program. As a result, other residents change their behaviour by saving water.

Water supply system in Indonesia, in addition to relying on self-provision of public or private water distribution, managed by Local Water Company as the sole provider of water services in each city and district. The drinking water system in Indonesia has not reached the MDGs (Millenium Development Goals) target, while the rate of population growth continues to increase in line with the increasing demand for drinking water. Different geographical, topographical, geological and human resource aspects in each region, besides the availability of raw water implies different water supply system implementation for each region. In meeting the The Long-Term Plan Targets on Water Supply (RPJMN) targets, it is necessary to determine what factors can affect Local Water Supply Company service performance. Subang Regency was chosen as a case study of improving water availability to continue develop this region.

This area has more than enough potential water availability to serve the whole population, which has used streams, springs, and deep wells as a source of raw water by Tirta Rangga Local Water Supply Company in 16 units of Local Water Supply Company Production. Evaluation of both technical and non technical aspects is needed on the service performance of Subang District Local Water Supply Company. The technical problem on environmental conservation toward geographical and nature support.

The problem of environmental management as an effort to protect drinking water supply in Indonesia, especially in Subang Regency was dominated by topographic problems, water absorption area, water condition, average rainfall, and disruption of general human activity. These factors will impact on environmental protection and preservation in water availability as a result of development and evaluation of potential capacity of water sources that have not able to be optimized.

Failure to effectively and efficiently manage water resources might lead to crisis, if not properly addressed, can become social and political problems. Stakeholder where the water availability was used for supporting community daily activities, should manage the decision making for the assessment process of water resource management in order to map multiple objectives and analyze multiple variables in a complex situations. Many decision making methods support are available to make an appropiate policy.

The analytical hierarchy process (AHP) was developed by T.L. Satty, since (1980), has been applied as a tool for multiple criteria decision-making in several fields, for example, in engineering, economics, industry, medicine and healthcare, social science, environmental management, and water management. AHP is a decision-making tools for prioritizing alternatives based on criteria. This approach comprises three steps.

The first step is the construction of a hierarchy by decision makers in order to provide a structure for complex problems. The second step comprises priority analysis, whereby decision makers compare each pairwise comparison to obtain a ratio scale of measurement. The third stage provides verification by computing the degree of consistency among the pairwise comparisons.

The objectives of this paper are a multicriteria approach for combining prioritization methods within the analytical hierarchy process (AHP). Futhermore, available methods to estimate final alternatives priorities should also be the best possible, which is in natural concordance with an additive compensatory structure of the AHP for deriving priorities from comparison matrices that are identified as candidates.

2 Methodology

The objective of this study was water resources evaluation in effort to ensure quantity, quality, and continuity of water availability. Problems aspect was identified to determine environment improvement purposes. Environmental problems was analyzed to solve water resources degredation.

Futhermore, several factors in environment was evaluated by using AHP method to achieve policy priority in decision making to conservate and rehabilitate the availability of water resources. Because, the changes in human activity, infrastructure development, and land conversion have led to degradation in environment as support and conservation factor of water resources existence.

This paper focused on studies of the application of AHP for environmental analysis to support water resource management. The initial stage of this research was related to the environmental analysis for water supply resources, including literature review, formulating the problem, and field surveys. Basic concepts of environmental analysis system, water resources management, water supply for community, human activities, environment prevention improvement analysis and the basic concept of AHP.

According to Saaty (1980), there are several stages in the AHP method, such as problem formulation and main objectives determination, factors determination, hierarchical structure preparation, pairwise comparison, respondent rating consistency measurement, respondent value integration, and factors weighting.

Problems formulation as well as objectives determination in the research or the use of AHP in the research, became the first step in the AHP method. The initial stage was to determine the factors and sub-factors that affect the improvement of water supply system.

Determination of factors included stages of identification, verification, and determination of factors. In the first stage, all factors are identified by relevance to the main objectives. In this stage there are still possible factors that are not mutually exclusive or overlapping.

While the process of determining the factors, can also be done through a questionnaire with expert respondents (expertise). In order to comply with the provisions, the factors have been identified are further verified and eliminate.

Table 1 Factors affecting the improvement of water supply system

Factor	References
Topography area	Thungngern (2015), Nowak (2015)
Water catchment area	Thungngern (2015), Setiawati (2012), Wibowo (2010)
Water surface condition	Thungngern (2015), Meixner (2003), Setiawati (2012), Qu (2016), Srdjevic (2008),
Rainfall period	Tolman (1977), Srdjevic (2008), Prakoso (2015)
Human public activity	Thungngern (2015), Qu (2016), Wibowo (2010), Okeola (2012)

Factors that exist in Table 1 developed into sub-factor of each factor. Each of these factors was included in the questionnaires for the assessment of weighting factors. Meanwhile, the scale of pair wise comparisons used were as follows Table 2.

The preparation of a hierarchical structure was the process of regulating the factors in stages. The preparation of hierarchical factors was intended to simplify the problems to be more systematic for help researchers achieve goals of decision making.

Table 2 Definition and explanation of comparative importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the
3	Somewhat more	Experience and judgement slightly favour over the other
5	Much more important	Experience and judgement strongly one over the other
7	Very much more	Experience and judgement very strongly favour one over the other. Its importance demonstrated in practice
9	Absolutely more	The evidence favouring one over the of the highest possible validity
2,4,6,8	Intermediate values	When compromise is needed

There is no standard procedure for constructing factors into a hierarchical system (Saaty, 1980), but it can be done with literature studies to enrich ideas or discuss with experts. Respondents were considered to know about the problems of water supply system improvement, particularly in the Subang district were 32 of the 50 expertise respondents.

Respondents consisted of some stakeholders that were respondents from the local water company as facilitator, BAPPEDA (Regional body for planning and development) as the bureaucracy, and academician as consultant of public works, who were considered to be capable of representing stakeholders who have a different point of view. It is according to the research conducted by Pangeran et al (2012). In addition, respondents also came from a group of community leaders as stakeholders to complement the linguistic scale presentations (Okeola, 2012).

To measure the relative importance between factors, a pairwise comparison is required. This method is considered effective in encouraging a person to improve consistency by using as much supportive information as possible. The scoring scale used in pairwise comparisons is 1 to 9 with a reciprocal axiom. If A is preferred over B with intensity A, then B must be preferred over A with intensity 1/8. This consideration should always be consistent in the weighting assessment.

The rating scale is considered appropriate because it can illustrate differences in value-weighting.

Weighting value matrix tabelling factor of 1 to a factor of 2, and will be divided by 1 inverse vote weighting factor of 2 to 1, and so on. The entire value of the series weighting summed table column, such as equation (1) below.

$$A = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1K} \\ \cdots & \cdots & \cdots & \cdots \\ x_{N1} & x_{N2} & \cdots & x_{NK} \end{bmatrix} \tag{1}$$

X = matrix weighting factor assessment results

A = comparison between factor ratings

Calculation of the priority value vectors to produce the policy priorities of each factors affecting the improvement in water supply management system. Multiplication of each value factor in the later series to be rooted by 4 (four). Vector results factor divided between the vector sum of values, the formula in equation (2).

$$\sqrt[4]{\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1K} \\ \cdots & \cdots & \cdots & \cdots \\ x_{N1} & x_{N2} & \cdots & x_{NK} \end{bmatrix}} = \begin{bmatrix} V_1 \\ \cdots \\ V_K \end{bmatrix} \tag{2}$$

V = vector between factors of results $\sqrt[4]{}$ (root four) weighting the value of each factor

X = matrix weighting factor

Network modeling was described by the hierarchy of the factors and sub-factors which help to determine the weight and the order of factors priority. Weighting results were processed using Expert Choice 11 application, by considering the level of inconsistency. The value assessment inserted to factor determination table, by seeing questionnaire result of selection by expertise.

The pairwise pairs can be arranged in a matrix A. The matrix has a whole positive value and can meet its inverse value, called the reciprocal matrix. In common cases, we usually unable determine the exact value for weighting, but it estimated. That reason expertise have a minimum error rate. Small weights on weighting will only cause small deviations on eigen value. The result of questionnaire have a consistent opinion only if the value λmax -n. The greater the number of λmax, the result is more consistent.

3 Result and Discussion

3.1 Identification of Environmental Factors for Water Supply

In this research, the process of determining the factors that influence was done with the stages of identification, verification, and determination. The distribution of questionnaires is a verification process after identifying each factor, with a total of 27 respondents who were considered experts in improving the water supply system in the case study.

These respondents come from academics, lecturers and consultants, community leaders, bureaucrats, and water supply management system facilitators themselves that were employees of water supply management system, such as Okeola (2011) research. In the early stages the process of significance factor in **Table 3**. The environmental factor value has an influance for water supply process, when more than 65% expertise undoubt with that statment. AHP expertise assign any factor, where it valued by weighting.

Table 3 Result of verification of factor significance

Factor		Questionnaire Result		Questionnaire Percentage		Description of Factor Verification
		Yes	No	Yes	No	
Environmental	Topography area condition	20	7	74,07	25,93	Selected because the questionnaire results showed 74.07% of respondents agreed that topographic conditions affect water supply
	Water catchment area	24	3	88,89	11,11	Selected because 88.89% of respondents stated that water absorption area significantly influence environment for water resources
	Water surface condition	23	4	85,19	14,81	Selected as many as 85.19% of respondents stated the condition of surface water good quality and significant quantity on water supply
	Rainfall period	21	6	77,78	22,22	Selected because the results of the questionnaire showed 77.78% of respondents agreed the average rainfall affects water resources
	Human public activity	20	7	74,07	25,93	Selected because the results of questionnaires almost 3/4 of respondents agreed the disruption of general activity affect water supply

3.2 Selection Analysis and Weighting Method with AHP

The entire sub-factors were influencing water supply system improvement in Subang district, with the value for each factor was above 65%. A total of 33 (thirty three) expert respondents were invited to undertake a weighted assessment. The value of each line was combined and then made an AHP model, where the result of combining questionnaire values between factors in the factors, seen in the Table 4.

Table 4 Result of merging questionnaire value among environment factor

Factor	AHP score	Factor
Topography area	1.34	Water catchment area
Topography area	2.00	Water surface condition
Topography area	1.48	Rainfall period
Topography area	2.17	Human public activity
Water catchment area	1.69	Water surface condition
Water catchment area	1.72	Rainfall period
Water catchment area	2.45	Human public activity
Water surface condition	1.55	Rainfall period
Water surface condition	2.34	Human public activity
Rainfall period	2.97	Human public activity

It is explained that the words marked red informs factors that have a higher weighting value, compared to other factors that are written with black markings. The final value of the paired comparison questionnaire results was inputted into the AHP model, where the final results illustrate the opinions of the expert respondents to improve the water supply system from environmental aspect.

The final results of the paired comparison questionnaire were inputted into the AHP model with Expert Choice 11 program, which begins by describing paired comparisons matrix, as seen in Table 5. That aplication showing the weighting value by graphical. Every factor have each role in environmental improvement not only very significant influance, but also a little important factor.

Table 5 Paired comparisons matrix between factors

	Topograph	Water catch	Water surfa	Rainfall per	Human pub
Topography area		(1,34)	(2,0)	(1,48)	2,17
Water catchment area			1,69	1,72	2,45
Water surface condition				1,55	2,34
Rainfall period					2,97
Human public activity	Incon: 0,03				

The highest was water absorption area and followed by surface water condition which has not much different weight value because both of them become the reason abundant water source in Subang Regency in Table 5. Preventive action was needed to prevent degradation of raw water availability potential. Land reforestation were being increased in line with regional development and prevention of waste water pollution to water bodies. In the weighting analysis of factors, it has an inconsistency level below the value of 0.1 so that the results of the questionnaire accounted for environmental improvement (Romdoni, 2013).

Next was analyzing the weighting value between the factors and sub-factors to make a ranking by 33 respondents experts, this was the output of the matrix calculations.

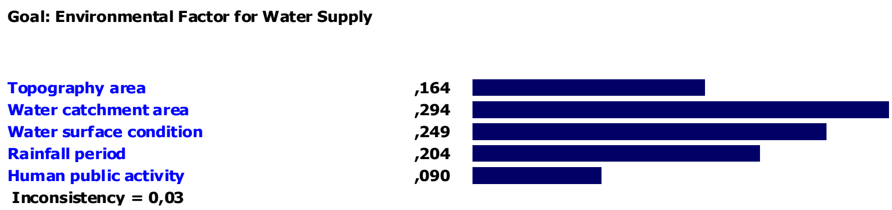

Figure 1 The value of weighting among factors

Based on the results of the analysis in Figure 1. it can be concluded that the average rainfall in Subang Regency has no effect on the improvement of environmental carrying capacity, it was possible that the average rainfall in this area which was always high above 1000 mm, while the topography condition had high slopes that will be able to improve the environmental carrying capacity, especially in terms of pipeline distribution which should minimize pumping system.

Topography with high slopes on the water source would be able to maximize the distribution of water drainage with non-pumping system. Aspects of environmental carrying capacity was naturally to be the one of the company management responsibilities besides to technical operational in by The Local Water Company utilize water resources with environmental prevention and conservation.

The company's capability and supporting capacity of the managers to optimize the performance of drinking water supply, was considered to have a major effect on the accessibility of drinking water supply. It also need support from an adequate environmental aspect. Each region has the potential of different environmental carrying capacity in the potential of raw water, drainage system, or water quantity, continuity, and quality.

The research was undertaken to make an alternative decision on improving the services, by analyzing it using Analytical Hierarchy Process that was done with the aim of researching drinking water supply in Offa, Kwara State, Nigeria and combining it with Multicriteria Decision Making method by Okeola et al. (2010), and a research study by Thungngern in 2015 that undertook a water resources management approach, on social, economic, and environmental factors with the AHP method in Thailand. In this study AHP approach used for environmental analysis to support water supply system, especially to make environmental decision making in Subang Regency.

4 Conclusion

The method will be used depends on the result of multicriteria evaluation of their vectors priority performance of vectors with rank reversal measures. From the AHP environmental analysis, water catchment area was important priority factor to support the availability of water resources with 0.294 in that scoring. Surface water condition determine the water resource potential for water supply to guaranted quality, quantity, and continuity of water supply. Rainfall and topography in distribution area was influencing water discharge. AHP method overcame the decision making support in water resources management, beside on environment evaluation.

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The Role of Occupational Accident Risk Assessment In The Implementation of Total Quality Management In A Textile Industry

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Abstract. Issues of occupational safety and health in Indonesia are still often overlooked. It is indicated by the high number of accidents, especially in manufacturing industries. This study aims to identify, calculate, and control risks of occupational accidents in the implementation of Total Quality Management (TQM) in a textile company. This study consists of four phases, namely: data collection, data analysis (FINE and Quantitative analysis), determining risks control (QCC), and conclusions. The results showed occupational accidents has increased over the last three years, most often in male workers (84 %), for the morning shift (6 am to 2 pm), with the category of minor accidents (54 %), and the highest score occurred in the production division (74 %). The risk assessment showed the substantial level, namely: due to hitting objects, pinched by tools, affected by falling objects, and risk of falls, with the highest occupational risk score for hitting objects (79.44 %) causing hand injuries (53.67 %). The result of QCC implementation showed that an administrative training for workers could reduce accidents. It can be concluded that risk assessment has an important role in providing inputs to improve the performance of TQM's companies, particularly in reducing the number of occupational accidents.

Keywords: *occupational accident, risk assessment, total quality management*.

1 Introduction

Occupational Health and Safety (OHS) is one of the issues, which is growing and becoming an important concern in the industry, especially for manufacturing industries in Indonesia in recent years [1]. This is due to the high number of occupational accidents and diseases that occur in Indonesia. Data obtained from the Ministry of Labor and Transmigration convey that until 2013 in Indonesia there are no fewer than six workers having died everyday caused by occupational accidents. The figure is relatively high compared to European countries that have as many as two people have died per day due to occupational accidents. While according to the International Labor Organization (ILO), in Indonesia, on average per year there are 99,000 cases of occupational accidents. Off the total number, it has approximately 70 % of fatal causes, namely death and lifelong disability [2]. The highest number of occupational accidents is caused by the lack of attention industry’s attention in implementing the management system of Occupational Safety and Health (OSHMS) effectively and sustainably [3].

The textile industry is one of the central major industries in Indonesia, especially in Bandung. The existence of the textile industry in the city has participated to develop economy, created jobs, and contributed significantly to produce and supply the clothing needs locally, nationally, and internationally. However, the competition has increasingly been fierce to textile industries in requiring companies to optimize all available resources to produce higher quality products. The quality of products cannot be separated from the role of the companies’ human resources. Labor or worker is a resource that plays an important role in the production [4]. The production process can run well because it is controlled by the workers, so that it can produce higher quality products. In addition to labors, the company also uses high-tech equipments to support the production process. The use of various tools and modern machines increasingly causes that employees could not be separated from the risks related to OHS [5]. One of the textile industries which becomes the location of this research is PT. X, located in Bandung, West Java, where the industry has been producing denim fabrics as a superior product.

Based on the point of view of humanitarian and economics, the prevention of occupational accidents is an important issue that must be taken seriously by companies, organizations, and industries involved in other stakeholders [6]. Therefore, PT. X has implemented the procedures of OHSMS and also has a special organization that cares about OHS issues in the occupational environment, which is called by the Committee of Occupational Health Safety and Environment (P2K3 & LH). This organization aims to identify hazards in the corporate environment as well as how to prevent it. However, based on preliminary information and data in the company, it is known that there are still frequent cases of occupational accidents in the working environment of the company, especially in production division. Therefore, it is necessary for implementing the integrated OHSMS with the company's management system, in which is addition to the fulfillment of the obligations/legislations, and it is an effort to provide the demands of international trade. Nowadays, developed countries are beginning to care about human rights, which require a good product or service, and it must give a good quality, safe to use, regulate environmentally friendly, and implement international standards such as the ISO 9001 series, ISO

14000 series, OHSAS 18000 series, ISO 31000, and other related regulatory standards on integrated management system.

It is important to understand that accidents in the company are a loss for the company. In addition to losses in terms of materials, such as lost working hours, productivity decreases, defects in materials and machines, also other crucial aspects of losses, namely a decrease in the quality of products, the credibility of the company's brand, and consumer's trust. Controlling all aspects of OHSMS is necessary, so that production activities can be run effectively and efficiently [7]. The highest presentation of occupational accidents is more related to management than engineering. The highest management determines OHS policies such as working conditions, quality of work, and the quality of the equipments. Therefore, it is needed to prevent and control any risk factors associated with OHS in the enterprise/company, namely hazard identification, risk assessment, and risk control in order to improve the productivity and performance of the company.

Based on improving the quality of the company, one of the approaches, that can be undertaken by the company or the industry in achieving the goals, sets in the implementation of Total Quality Management (TQM) in every aspect of the company, in order to improve the competitiveness of company with the best quality of products/services. To produce the best quality, sustainable improvement efforts are needed on the ability of people, processes, and the environment related to the mechanism of TQM. The concept of TQM is a new paradigm of doing business that seeks to maximize the competitiveness of the organization through customer focus, process improvement on the quality of products, services, people, methods, and environmental organizations [8]. Based on that, it is very important to asses and determine the role of identification, assessment, and control of the risks of occupational accidents in the implementation of TQM, which is one of important factors in improving the quality of the company or industry, particularly in the textile industry, because the textile industry could consider an issue that is prone to cases of occupational accidents and occupational diseases.

2 Methodology

2.1 Research Design

This research was conducted by designing a flowchart of problem solving and analyzing the related problems to get the results of the proposed improvements being analyzed, namely assessing role of risk assessment of occupational accidents in the implementation of TQM in a textile company. Generally, Assessing the main points conducted to identify hazards/risks, calculate risk assessment, evaluate the risks obtained, provide the level of the highest risk to be controlled by using the concept of quality control circle (QCC), and conduct the review in implementation of QCC been applied. Stages of research were conducted on the stage of preliminary studies, data collection, data analysis, and determining conclusions based on research results been analyzed.

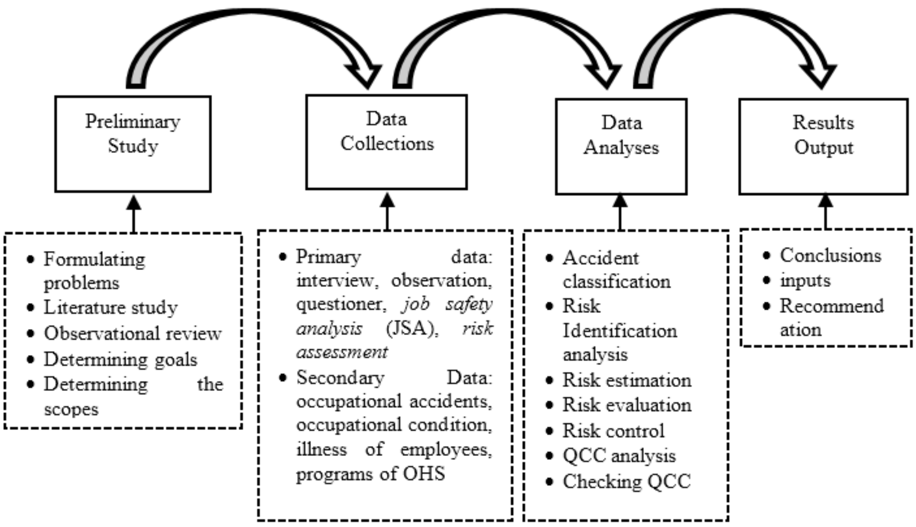

Figure 1 The stages of research.

2.2 Time and Location of Research

The time of this research lasted for three months, while the research location is in a textile company located in Bandung, West Java. The determination of location is based on the statistical description that states the number of central enterprises in the textile and garment industries is in Bandung area, which indicates the level of occupational accidents is high enough annually. The textile industry that became a case study in this research is PT. X, which is a company or a factory that produces a good quality of denim fabrics nationally and internationally. This company is one of the pioneers of the textile industry in Indonesia, particularly in the area of West Java.

2.3 Data Collection

Primary data were collected through observation, interviews, discussions, and questionnaires. Observational study conducted to observe the working environment and work processes in the company, while interviews and discussions were conducted by using a measuring instrument in the form of a list of questions aimed at workers, supervisors/managers, and OHS expert staffs of the company, to obtain information about the condition of the company, an overview of the OHS company, accidents been occurred, and another information to support this research. In addition, spreading respondents to the questionnaire was addressed to the organization of P2K3LH (OHS Committee) to get an idea of the perception of empowerment perspective in implementation of quality control circle (QCC) in the company, in order to obtain a recommendation to repair problems.

The secondary data were used to complete the results of research conducted. Secondary data were obtained from the company in the form of the company profile; organization profiles of P2K3LH (OHS Committee); occupational conditions, data of occupational accidents for last three years, data of employees' occupational diseases for last three years, and other data obtained by the study of literatures/references that can support this research.

2.4 Data Analysis

Identification of occupational accidents is based on the working environment, processes, and practices that affect the health, safety, and environment. The stage of risk assessment in this study uses Fine's risk score (semi-quantitative analysis) and quantitative analysis. In the semi-quantitative analysis, risk score table is used to perform a risk assessment with risk formula, where it is the result of multiplication factors consisted of consequence, exposure, and probability. These three factors are classified into several classes and determined to take a score level. Results of Risk calculation (risk score) can be used to estimate the incidence, allocate resources, and control hazards [9], while quantitative risk assessment components are measured by multiplying the exposure, probability, and consequences (lost cost).

The estimation and evaluation of the calculated risk on both methods are analyzed to determine the highest risk levels. For further analysis in order to obtain alternative results of risk control, QCC method is used. Stages in the process of QCC provide references to the concept of PDCA (Plan, Do, Check, Action), which is described in several steps include: Deciding on a goal; Setting a target; Analysis of existing conditions; Analysis of causation; Reduction plan; Accomplishing counter measures; Evaluation of the results; and Standardization and the next plan. In every step taken in the process of QCC, there are several tools that are used to facilitate the process of each stage. The measuring instrument known as the seven tools (7 tools), which include: Check Sheet; Stratification; Pareto Chart; Bar Chart; Fishbone Chart; Scatter Chart; and

Histogram. Here is the form of equation used to calculate the risk assessment of occupational accidents Eq. (1):

$$SR = C \times E \times P \tag{1}$$

SR: Risk Scoring; C: *Consequence*; E: *Exposure;* P: *Probability*

3 Result and Discussion

One of the factors that influence the incidence of occupational accidents in the company, namely occupational conditions. Based on observations and data retrieval working conditions in the company, it is known that the working conditions at PT. X showed some decent parameters and are still below the standard threshold value, such as ambient air quality, level of total dust, vibration, and working climate. As for the value of noise and lighting parameters measured exceeded the threshold value standard, namely the spinning and weaving departments of the production division. This indicates that working conditions in PT. X do not give a good standard yet that is conducive to work, in particular on noise and lighting parameters.

In addition to working conditions, the dominant factor having caused occupational accidents in PT. X is human error. Based on preliminary data for accidents that have occurred, the main cause of occupational accidents is the behavior of workers when during working hours. Other factors having caused occupational accidents are such as technical errors and unclear reasons. Based on data from occupational accidents in PT. X during the last three years (2011-2013), it is known that the number of occupational accidents that occurred is 169 incidences, with the distribution of 49 accidents (2011), 50 accidents (2012), and 70 accidents (2013). It indicates that the level of occupational accidents occurred in PT. X has increased for last three years. While the data of hospital employees' illness at PT. X showed that there are ± 89 complaints of diseases suffered by the worker, where the type of Inspection in upper respiratory (ISPA) is a type of disease that is often experienced by workers. Therefore, there should be an assessment of the occupational accident risk management in the enterprise (PT. X) to acquire measures in reducing the number of accidents.

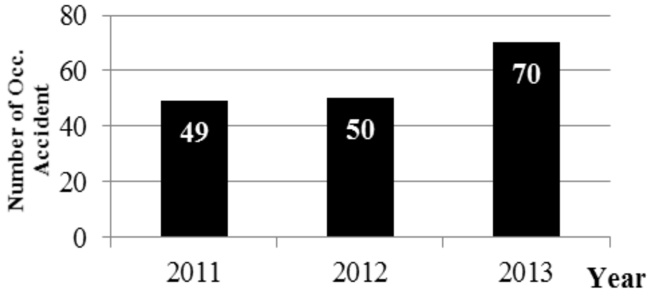

Figure 2 Occupational accidents in the company.

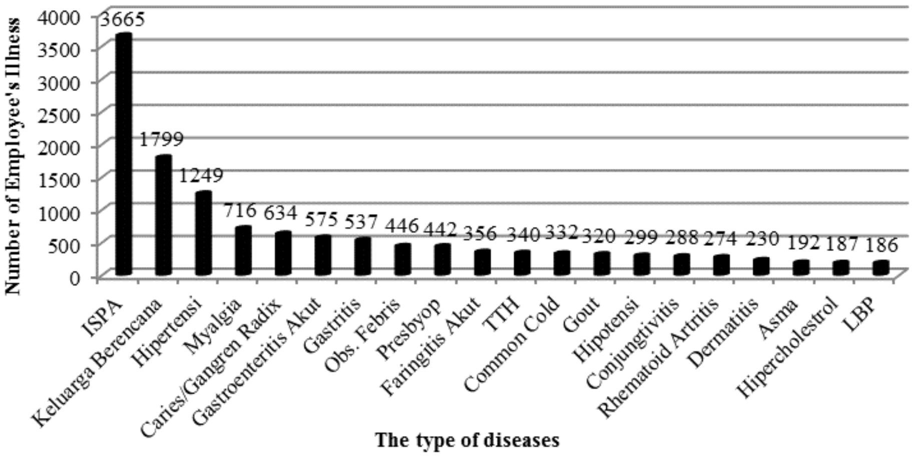

Figure 3 Employees' illness based on dominance of diseases.

3.1 Classification of Occupational Accidents

The data of occupational accidents are obtained from the division that is responsible for the problems of OHS issues, which carried classification to determine the accident rate by a few categories.

Table 1 Result analysis of occupational classification.

Occupational Accident Data	Information				
	Level of Occupational Accidents	**Genders**	**Time of Accidents**	**Category of Accidents**	**Production Division**
Total of Occupational Accident	2011 = 49 events 2012 = 50 events 2013 = 70 events	L = 84% P = 16%	I = 69.8% II = 19.5% III = 10.7%	R = 54% S = 34% B = 12%	–
Occupational Data of Production Division	2011 = 39 events 2012 = 38 events 2013 = 48 events	L = 85% P = 15%	I = 70.4% II = 18.4% III = 11.2%	R = 55.2% S = 30.4% B = 14.4%	SR = 27.2% W = 25.6% SOE = 16% P = 15.2% Mtc P&F = 10.4% F = 5.6%

Based on analysis of occupational accidents data in PT. X (2011-2013), the results showed:

1) The percentage of occupational accidents on male workers is higher (84%) than female workers (16%)
2) The percentage of occupational accidents that occur based on category includes: minor (54%), moderate (34%), and severe (12%)
3) The percentage of the occurrence time of occupational accidents includes: Shift I for the working range at 6 am to 2 pm (69.8%), Shift II for the working range of 2 pm to 10 pm (34%), and Shift III for working range at 10 pm to 6 am (12%)
4) The percentage of the production division of occupational accidents (74%) is higher than non-production divisions (26%), with the dominance of occupational accidents often occurred in the departments of Ring Spinning, Weaving, and OE Spinning.

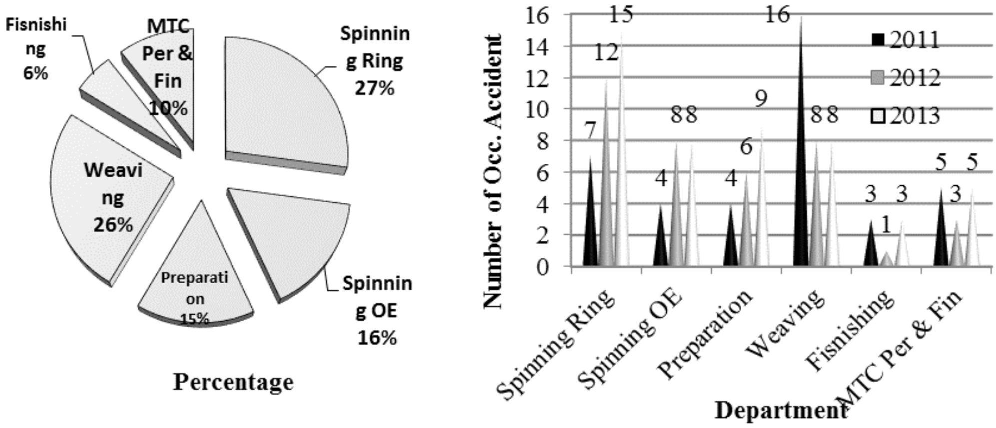

Figure 4 Classification and percentage of occupational accidents in production dept.

3.2 Identification of Risks

Identification of risks for semi-quantitative analysis in this research is based on the process of flow diagram from materials into textile products (denim fabrics). Risks/hazards are identified by the production process diagram, where the stages of the production process consists of 7 phases, such as Incoming Material (Storage), Spinning Ring and OE, Preparation, Weaving, Finishing, Quality Control, and Warehouse. Risk identification techniques were performed using a technique Job Safety Analysis (JSA). As for quantitative risk identification, it carried out classification of occupational accident data based on the type of occupational accidents and the injured limbs. Classification of potential risks that occurred in the semi-quantitative analysis is not much different from the description on the quantitative risk classification, where the risks are divided into 9 categories, namely the risk of falls, by hitting objects, by falling objects, pinched by tools, stretched by muscles/joints, exposed by heat, by electric shock, exposed by radiation/hazardous materials, and other factors. In addition, the risk is also classified into the category of the injured limbs for the purpose of quantitative risk assessment, such as the risk on the head/top, neck, shoulder/back, arm/hand, chest/stomach, waist, hips, thigh, knee/leg, and other parts of the body. Quantification of risks indicated that the highest risk level based on category of accidents is due to risk of collision (risk by hitting objects), while the highest risk level for injured limbs was occurred on the hand.

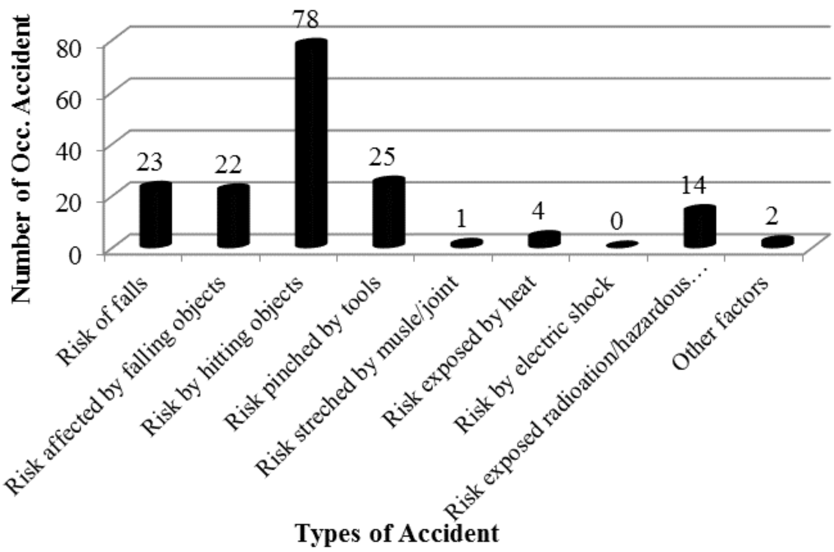

Figure 5 Classification of occupational accidents based on the types of accident.

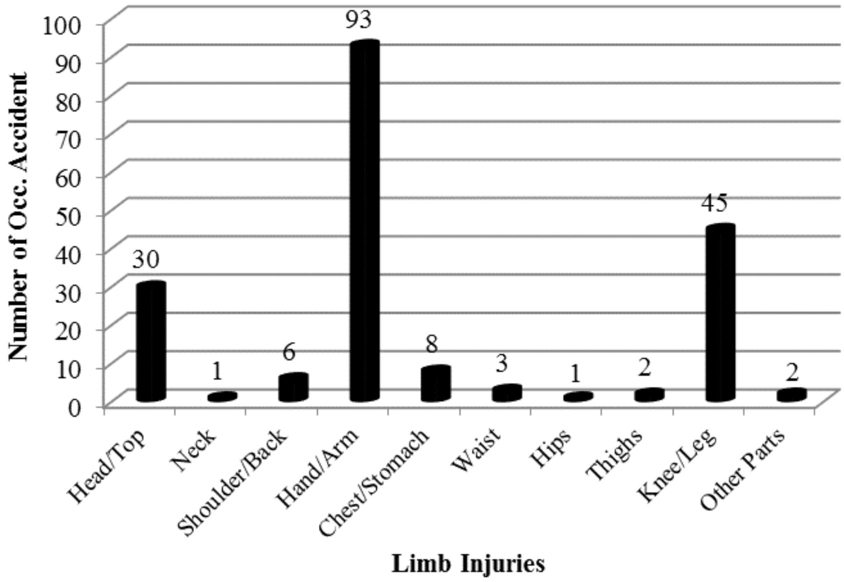

Figure 6 Classification of occupational accident based on limb injuries.

3.3 Analysis and Estimation of Risks

The purpose of the analysis and estimation of risk is to separate several risks and provide risk improvement and evaluation of data, and then determine measurable risks. By having conducted the hazard identification, then the next step of the risk management process is the analysis and estimation of risk, namely assessing the level of consequence, probability, and exposure. Methods of analysis and risk estimation carried out in this research used semi-quantitative and quantitative analysis. In the semi-quantitative analysis, assessment of risk values was analyzed by using method's FINE, which is done by asking P2K3LH's organization (OSH Committee) to consider expert's opinions, while the quantitative risk assessment was performed by calculating the incidence rate of work accidents every cell of the matrix calculations. Calculated risk score is the result of the multiplication of the three components of the variables used, namely: consequence, probability, and exposure.

Table 2 Result estimation of risks by semi-quantitative and quantitative analysis.

No.	Risks/Hazards	Risk Score (Semi-Quantitative)	Risk Score Quantitative
1	Risk by hitting objects	150	185,045,812
2	Risk pinched by tools	100	18,488,220
3	Risk affected by falling objects	90	10.687,173
4	Risk of falls	90	17,339,660
5	Risk exposed by radiation / hazardous materials	60	1,180,105
6	Other factors	50	60,733
7	Risk exposed by heat	30	121/466
8	Risk stretched by muscle/joints	18	2,094
9	Risk by electric shock	15	0

3.4 Evaluation of Risks

As a follow-up process of risk assessment, risk evaluation is carried out to determine whether the risks are acceptable or not. To get a good overview of risk assessment, it needs to evaluate a priority of risks. The rating scores are very important as a risk management tool in making decisions. Through risk management ratings, the priorities can be determined in handling [10]. Based on the results of the comparison between the two methods of risk assessment that were carried out, the determination of risk management is focused only on the level of substantial risks, as it requires immediate corrective action or treatment to reduce the risk level. Therefore, the next step is to determine the level of control measures against substantial risks, which include the risk by hitting objects, risk pinched by tools, risk affected by falling objects, and risk of falls.

Table 3 Comparison or risk evaluation both analyses used.

No.	Level of Risk	Semi quantitative Assessment of Risk	Quantitative Assessment of Risk	Action
1	Substantial	Risk by hitting objects Risk pinched by tools Risk affected by falling objects Risk of falls	Risk by hitting objects Risk pinched by tools Risk affected by falling objects Risk of falls Risk exposed by radiation/ hazardous materials	Requiring improvements immediately
2	Priority 3	Risk exposed by radiation/hazardous materials Other factors Risk exposed by heat	Risk exposed by heat	Requiring periodic attention well
3	Acceptable	Risk by electric shock Risk stretched by muscle/joint	Risk stretched by muscle/joint Other factors	Keep doing as usual

3.5 Evaluation of Risks

Risk management is an important and decisive step in the overall risk management [11]. On the unknown risks and potential risks must be managed appropriately, effectively, and in accordance with the capacity and condition of the company. The results of the risk assessment both semi-quantitative and quantitative analysis showed that the highest risk level at risk due to risk by hitting objects, where a stated percentage of the quantitative risk classification of risk level is 79.44% with the highest rate of injuries occurred on the hands (53.67%). Determination of risk control on the highest risk level, namely the risk by hitting objects having caused hand injuries, was done by using QCC instruments by implementing PDCA Steps. Here is the result schema of QCC steps used in this research.

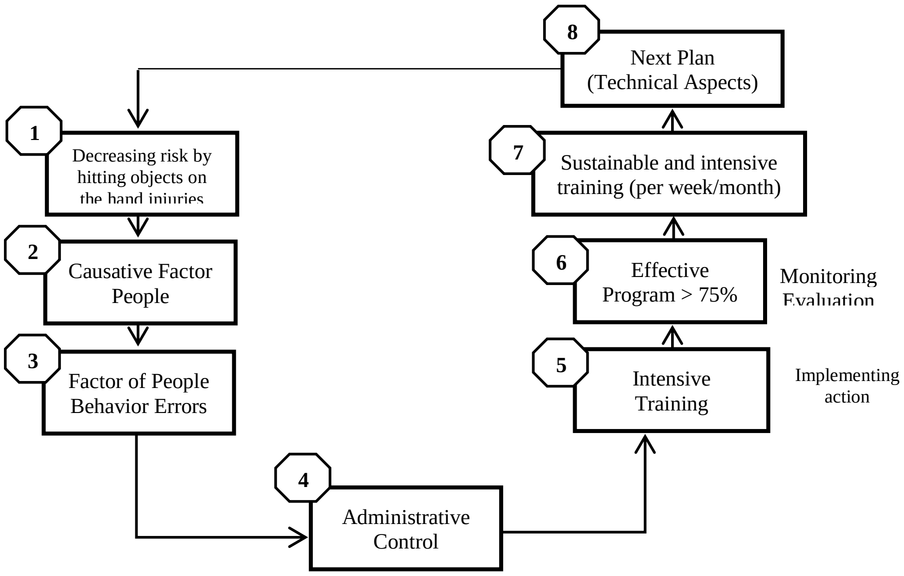

Figure 7 Implementation of QCC Concept.

3.6 Analysis and Inspection in Implementation of QCC

Implementation of QCC concept covers the application of the concept of PDCA, in which stage of the process takes a place in a sustainable manner. Based on the implementation of the QCC conducted on the proposed level of risk control against the risk by hitting object on the hand injuries, it delivered results and positive influence on the reduction of the risk of accident rates, particularly against the risk by hitting objects that can injure the hands. The percentage of success achieving the goals set more than 70%. To improve the quality of labor resources must be involved in QCC groups in the company, all workers generally and particularly are in OSH committee (P2K3LH), where the quality inspection of company to assess the performance of QCC is defined by measuring perception of empowering. Measurements made into three items assess determinants for improving the quality of performance QCC, namely autonomy, participation, and responsibility.

The results of measurements carried out concluded that the level of autonomy of each item of QCC committee is higher than the other items, while the parameter for the responsibility is the lowest level. However, factor of responsibility on every member of the committee is still low, especially at the level of workers, so this thing raises a crucial impact on the indifference of the OSH workers at the workplace. This indicates that the results of risk management analysis that performed in accordance with the measurement results on the perception of empowerment can provide an important input in improving the quality of TQM in PT. X, particularly reducing occupational accidents.

4 Conclusions and Recommendations

The textile industry is one of industries that is prone to cases of occupational accidents and work-related diseases [12]. Based on the results of preliminary company's data, observational analysis, and interviews in the PT. X, it is known that occupational accidents has increased during the last three years (2011-2013). Classification of data showed that the incidence of occupational accidents occurred most often on male workers, for the shift I (6 am to 2 pm), and caused injuries for minor category. Other analysis results showed that the occupational accidents occurred higher in the production division (74%) than in non-production divisions (26%), where the dominance of accidents occurred in the department of Ring Spinning, Weaving, and OE Spinning. The results of the risk assessment by semi-quantitative and quantitative analysis demonstrated the same level of risk to substantial risks, namely the risk by hitting objects, risk pinched by tools, risk affected by falling objects, and risk of falls.

Quantification result of risk assessment showed the highest risk level occurred at risk by hitting objects (79.44%) for the hand injuries (53.67%). However, the proposed control of risk management is focused on the highest risk level at risk by hitting objects for the hand injuries, where the results of the analysis QCC implementation of the proposed risk control, showed a high level of effectiveness (>70%) in implementing an intensive training for workers. In this research, it can be clearly to conclude that the role of the risk assessment of occupational accidents can provide important inputs to develop a company policy in order to improve implementing TQM in PT. X, especially for reduction in number of occupational accidents that occur.

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Mount Telomoyo, a New Aspiring Geopark Area In Indonesia As a Step Of Environmental Protection

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Abstract. Mount Telomoyo is a stratovolcano in Central Java, Indonesia located in the Semarang and Magelang district. The volcano was constructed over the southern flank of the eroded Pleistocene-age Soropati volcano, which has a height of 1,300 metres. The Soropati volcano collapsed during the Pleistocene, leaving a U-shaped depression. Mount Telomoyo grows on the southern side of the depression, reaching over 600 metres above the depression's rim. From that process as a mentioned before, we can found such as pyroclastic rocks and lava from the volcanism process and also we can found lahar deposits and alluvium from erosional process. There is a big opportunity if Mount Telomoyo pronounced as a new aspiring geopark in Indonesia, for example is Mount Telomoyo will be exposed globally which is good for many scope such as economic, education, and social view. The way to be a geopark area may be long, but of the government of these two district (Semarang and Magelang district) has a same vision,,mission, and strong intention for it, these thing can be happen for sure in the future. This is also may be the one of answer for the preservation of human living and the challenge of how to increasing not only Magelang and Semarang district tourism, but also Indonesian national tourism.

Keywords: *geopark, mount telomoyo, environmental, protection*

1 Introduction

Indonesia is known as a rich country and has a broad range of potential, such as geodiversity, biodiversity and cultural diversity. However, one of the problems is deforestation that we must face nowadays. The issue of deforestation in Indonesia has grown more serious than ever before. The environmental damage that deforestation has caused and continues to cause in Indonesia has given rise to more frequent floods, permanent land subsidence and the demise of endangered animals. Increased deforestation also contributes to rising temperatures in the archipelago. So, we need solution to solve this problem, one of the solution is Geopark. Geopark is a concept how to manage and build an area continuously with three nature heritage aspect such as geodiversity, biodiversity, cultural diversity, with the aim to build and develop the society economy based on principles of conservation. The focused area of this research was Mount Telomoyo area. Mount Telomoyo is a stratovolcano in Central Java, Indonesia. The volcano was constructed over the southern flank of the eroded Pleistocene-age Soropati volcano, which has a height of 1,300 metres located at the district of Semarang and Magelang regency, Central Java.

2 Aim and Objective

This paper is written to analyze the potencial aspect of geoheritage in Mount Telomoyo base on geodiversity, biodiversity, cultural diversity, threats and opportunities if this concept is implemented in Mount Telomoyo area.

3 Regional Geology

The physiography of Mount Telomoyo area is included in the Solo Zone. Merapi - Telomoyo Volcano occupies the western end of the Solo Zone (Bemmelen, 1949). This zone is formed in a volcano complex that extends northeast-south west direction that form a series of Mount Ungaran - Mount Telomoyo - Mount Merbabu - Mount Merapi which is in the area of quartenary volcanic zone.

Mount Telomoyo is formed on the slopes of Mount Soropati (1300 meters). Mount Soropati is a volcano in the Ungaran-Soropati-Merbabu-Merapi row. According to Bemmelen (1941) Mount Soropati active in the Middle-Upper Plistocene era which then collapsed due to eruptions and collapse on the eastern slopes and leaving U-shaped depression.

Currently, Mount Soropati is only as a caldera wall, then ahead of the Holocene, Mount Telomoyo (1894 mdpl) formed on the wall of the Soropati debris. According to Bemmelen (1949), the origin of magma from Mount Soropati is olivine basaltic, whereas in Telomoyo has undergone more acid differentiation (augite-hypersthene-hornblende andesites).

4 Method

This scientific paper is done by literature study base on primery and secondary data, such us field data, actual report and some related journals about Mount Telomoyo as aspiring geopark and geotourism area. So, the writter collect all data, arrange it and could make conclusion statement.

5 Result and Analysis

5.1 Peak of Telomoyo

From geological aspect,with the height of 1894 Mdpl, Mount Telomoyo (Figure 3.) offers a very beautiful scenery you know, from the peak of Telomoyo we can see other high mountain ranges such as Lawu, Sumbing, Sindoro and Prau, not only that, we also can see the extent of Rawa Pening lake.

The road to the peak of Telomoyo quite uphill with a narrow path, just fit for one car only, so it is more advisable to use the motor, along the journey we will be treated to natural scenery of Salatiga City, Magelang and Semarang regencies that look amazing.

The landscape of the Muria Peninsula built by the results of the activity or volcanic eruptions and volcanic along with the parasites in the past. Volcanism was followed by exogenous processes, ranging from weathering, erosion, transportation and sedimentation around the volcano, thus forming a precipitate rework.

5.2 Sumuran Waterfall

Sumuran waterfall (figure 4.) is a waterfall located in the west of Telomoyo Mount Magelang regency with the form of water trickling waterfall on a hillside upright. The location of this waterfall is quite and calm. Located about 15 km from Salatiga regency.

The access road to the site is inadequate even though passable by a motorcycle but the driver must have extreme caution through the trail in the form of soil and rock. When arrived at the location you will be astonished by its beauty. Great waterfall splash produce water that refresh the body. The atmosphere around the waterfall is also relatively natural. This place has already given ‘rockslide warning’ (figure 5.) so visitor can be warned.

In this waterfall we can observe how the waterfall itself can be formed that is interpreted is a presence of faults and terms of petrologic study we can learn how the rocks in this waterfall can be formed as andesite that can be studied together while enjoying the waterfall water falling down beautifully.

5.3 Telomoyo Waterfall

Telomoyo waterfall (figure 6.) located in the near of Peak Telomoyo, Magelang regency. It is located 12 km to the north of the center of the Salatiga regency. Precisely in Mount Telomoyo region.

There are two things that can be studied in this area. The first of the petrology, which are found in this area is andesite. Then the latter can be studied as well as to the structure geology, in the presence of fault indications.

5.4 Kalipancur Waterfall

Sumuran waterfall (figure 7.) is a waterfall located in the west of Telomoyo Mount Magelang regency with the form of water trickling waterfall on a hillside upright. The location of this waterfall is quite and calm. Located about 15 km from Salatiga regency.

The access road to the site is inadequate even though passable by a motorcycle but the driver must have extreme caution through the trail in the form of soil and rock. When arrived at the location you will be astonished by its beauty. Great waterfall splash produce water that refresh the body. The atmosphere around the waterfall is also relatively natural.

In this waterfall we can observe how the waterfall itself can be formed that is interpreted is a presence of faults and terms of petrologic study we can learn how the rocks in this waterfall can be formed as andesite that can be studied together while enjoying the waterfall water falling down beautifully.

6 Discussion

There are many impacts that can happen if Gunung Telomoyo mining site pronounced as a new geopark area in Indonesia even there are positive and negative impacts, but it worth to try if we do it.

The positive impacts are increasing the value of tourism in the region, automatically the three regency will be known by the people. We also do one of the stages to preserve the environment in the form of geoenvironmental conservation. From economic view, the making of new geopark area will make a job creation, which in general tourism is a labor-intensive industry where labor can not be replaced by capital or equipment and that will be helping locals increasing the earnings. In the large-scale, development of geopark will be expected to raise the country's foreign exchange.

Many of the negative impacts from tourism occur when the amount of visitors is greater than the environment's ability to cope with the visitor volume. Some of the consequences of exceeding the environmental capacity include strain on already scarce resources such as water, energy, food and natural habitat areas. In addition, unchecked tourism development may lead to soil erosion, increased pollution and waste, discharges into the sea and waterways, increased pressure on endangered species of plants, and heightened vulnerability to deforestation, as well as loss of biodiversity.

There is a big opportunity if Gunung Telomoyo mining site pronounced as a new geopark area, the name of Mount Telomoyo will be exposed globally, which is now just several peoples has know about it. But there are the threats that must be faced such as waste management, natural disaster such as landslide and flooding, the desire of three regenices government to have same vision and mission plus the support of local communities that can make it happen.

Permissions may be complicated, but it can be passed if the governments has strong intention about it. And the last, about the guide. It will need a lot of guides who can explain earth science. We must decrease mining activities to preserve the rock to be seen by tourist.

7 Conclusion

Mount Telomoyo is a wide area that has many geotourism aspects with 4 geosites, located in the Mount Telomoyo, including Mount Telomoyo itself, Sumuran Waterfall, Telomoyo Waterfall, and Kalipancur Waterfall.. Attention must be paid by government because it has bigger impact for rather than just being exploitated in wrong way from various viewpoints like economy and social. There is also a point of education that can be obtained as well as the preservation of nature for the answer of the challenge of increasing Indonesian national tourism.

There are some recommendation that writter noted in this paper :

- It is expected the local people to participate and have a great concern in respect of geodiversity and geoheritage in the Mount Telomoyo
- Government and local people can become more active in nationwide campaign of geological conservation
- Collecting the selected data on the geodiversity or geoheritage for further project

Governments and the local people should work together to evolve geodiversity conservation and refers to the local people condition and culture.

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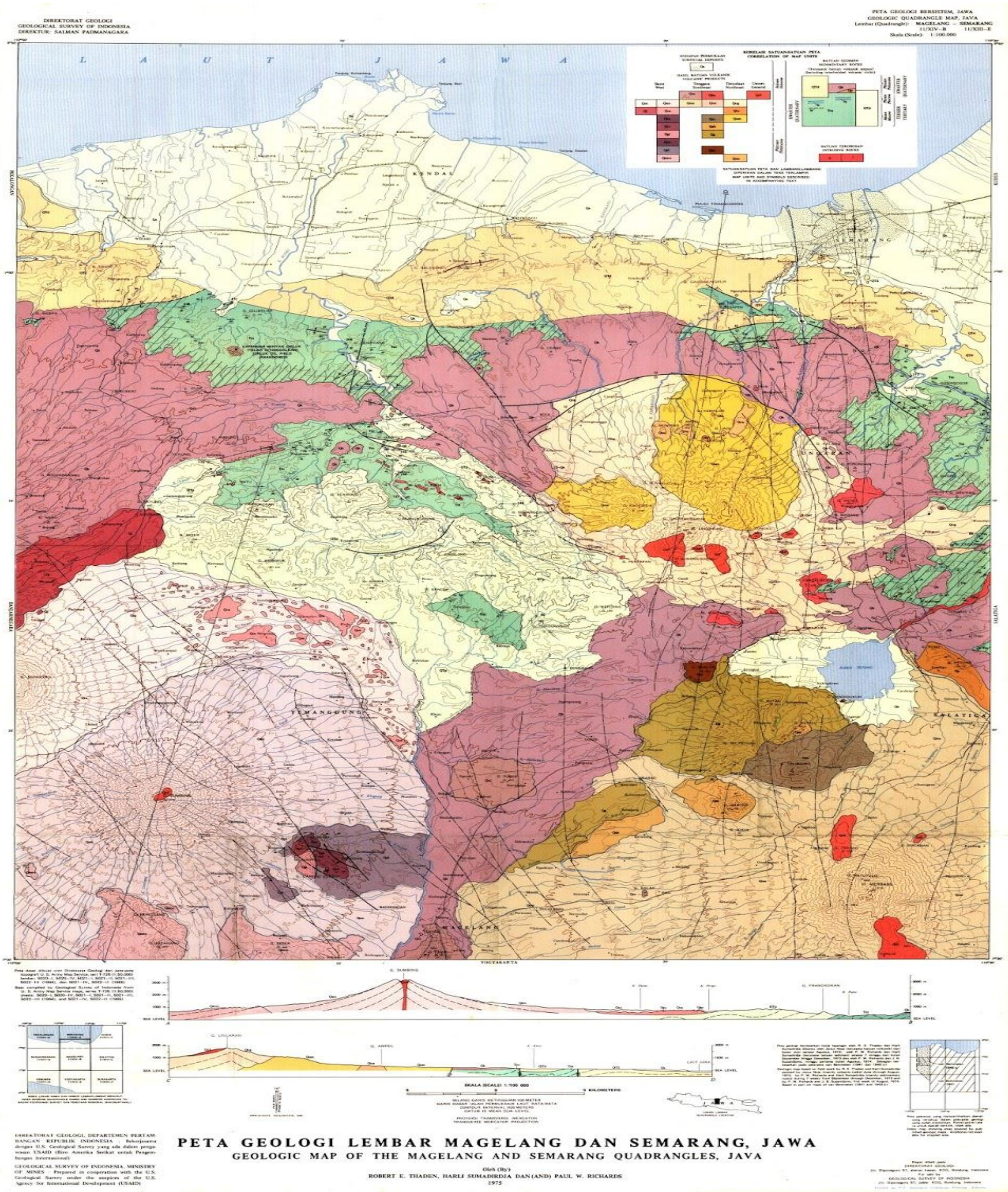

Figure 1 Geological map of Magalang-Semarang, Jawa (Suwarti and Wikarno)

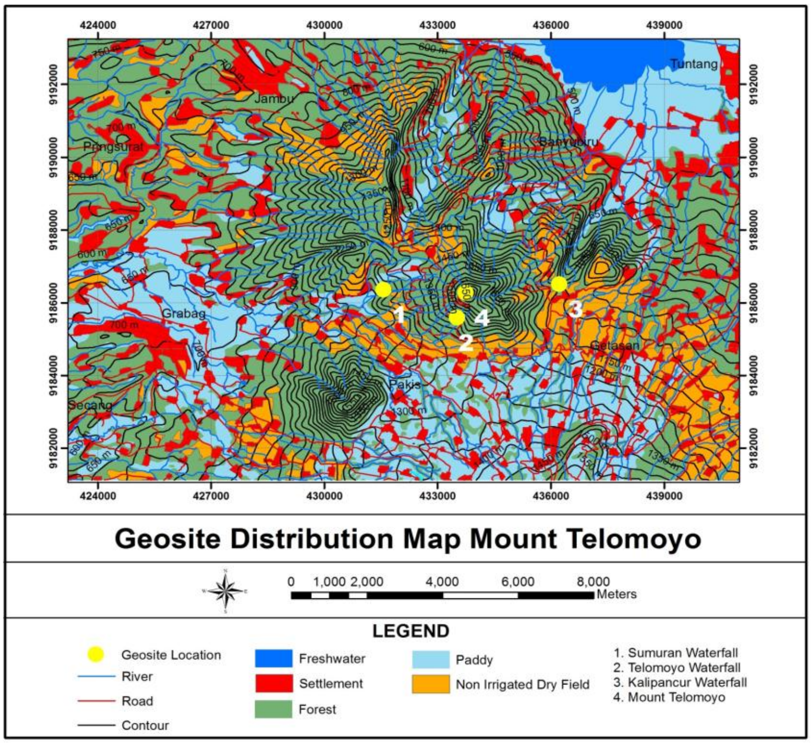

Figure 2 Geosite Distribution Map of Gunung Muria Mining Site

Figure 3 Peak of Telomoyo (Hananmedia)

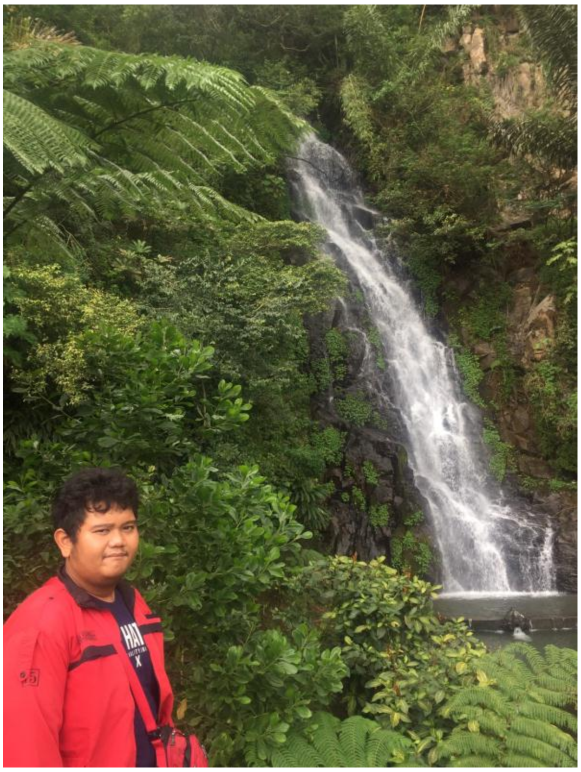

Figure 4 Sumuran Waterfall

Figure 5 Rockslide Warning sumuran waterfall

Figure 6 Telomoyo waterfall

Figure 7 Kalipancur waterfall

Evaluation of Waste Transfer Operation at TPS Patrakomala Bandung City

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Abstract. For years Bandung City has problems in its municipal waste management, due to a limitation of service coverage and transfer station (TPS) facilities and its management. One of the government's efforts to solve the problems was by implementing a waste-free area program, known as Kawasan Bebas Sampah (KBS). One way to support the KBS program is by having a waste transfer station with reduce-reuse-recycle treatment facilities (TPS 3R). The purpose of this study was to identify the potential TPS to be functioned as TPS 3R and evaluate its transfer operation system. This study was conducted by selecting potential TPS, collecting its infrastructure data, supporting equipment, and waste vehicles by observation, interview, and physical measurements (for 8 days) to identificating its existing operational and evaluating its collection-transfer operation system according to Regulation of The Minister of Public Works No 03, 2013. The criteria selection was developed based on government regulations, stakeholder interview, and related policies. It was identified that TPS Patrakomala was the most potential TPS to be functioned as TPS 3R, but still operates without scheduled operation system. In TPS Patrakomala, the waste vehicles consisted of four conventional handcarts, eight motor bikes, and two pick-up cars per day, collecting waste respectively 1,4; 2,6; 3,6 m^3/trip, which were done 2 trips/day. At the end, a city dump truck will pick up the waste from TPS Patrakomala once or twice a day, with a capacity of either 10, 13 or 14 m^3. Even with the average waste transported were above the truck capacity (respectively 20; 22; 26 m^3/truck/trip) there were still some waste unstransported from TPS. In the near future, the result of this study will be used to design a TPS 3R which is expectedly contribute to the improvement of wast managementin Bandung City.

Keywords: *transfer station, TPS 3R, Kawasan Bebas Sampah, Bandung City, municipal waste, waste vehicles, waste collection, waste transfer.*

1 Introduction

Bandung City has problems in its municipal waste management, due to limitation of service coverage and transfer station (TPS) [4]. It is also spoken by the CEO of PD Kebersihan Kota Bandung, Dedi Nurdiana, acknowledged TPS in Bandung is minimal. This resulted waste piled up in some place. Ideally in every sub district at least have three TPS, while now still two. However, he said that parties difficult to build new TPS because of the constrained availability of land [11]. In addressing the issue of waste problems Bandung's Government has 3R (reduce, reuse, recycling) activities [10]. One of the most common indicator in evaluating the performance of 3R activities is the level of cleanliness which can be seen visually, although waste management syste effectiveness should be measured from operational handling and waste reduction. There are various ways in waste management with 3R activites, even this activities involves elements of society [10]. The clean environment is essentialy the goal of every urban waste management [1].

The current program that involved 3R activities and society is a Waste-Free Area known as Kawasan Bebas Sampah (KBS). Kawasan Bebas Sampah (KBS) is one of the many components of the medium-term development program (RPJMD) Bandung City. Kawasan Bebas Sampah is a collaboration program between Bandung's Government and Badan Pengelola Lingkungan Hidup (BPLH) Bandung, aiming at making 6 waste-free areas per year since 2013. The existence of waste-free area with well waste management actually has become the target of Bandung's Government [1]. The target in 5-year period of the reign of Mayor Ridwan Kamil, there should be developed 30 waste-free area throughout Bandung City at 2018 [1]. Within the last two years there are already 12 waste-free models, which are located scattered within 12 districts, namely Sukasari, Bojong Kaler, Rancasari, Lengkong, Bandung, Batununggal Kidul, Mandalajati, Sumur Bandung, Cibeunying Kaler, Regol and Sukajadi [9].

In order to support the running of KBS program, required the presence of waste reducing, reusing and recycling activities at the sources (community) and/or having a waste transfer station with reduce-reuse-recycle facilities (TPS 3R) to support the community [1]. As described above there are a few things which become the background the needed of TPS 3R, first the problem of waste that piled up due the limitiation of TPS, secondly it is difficult to make a new TPS due availability of the land, and third there is a program that running 3R activities in community and required a facilities to support them which is TPS 3R. Based on interviewed with KBS parties, the community become more motivated to do 3R if supported with well-condition of TPS. For example the community already sorting the waste at home, but when taken by waste collector is mixed up in the waste vehicles, so the waste is also mixed up in TPS.

Further, the presence of TPS 3R will facilitied the need of community, so that waste will be processed and reduced. This will work if it is supported by the existence of operational mangement system in TPS 3R. There are two main focuses in waste management in TPS 3R which are waste reduction (waste minimization) and waste handling.Waste minimization consist of the waste reuse, reduce, and recycle, so only residue that will transported to landfill. Waste handling consist of sorting, collecting, hauling and waste processing [6]. The result of this study will be used to design TPS 3R, covering both waste reduction and waste handling.

2 Methods

This study was conducted as described in Figure 1.

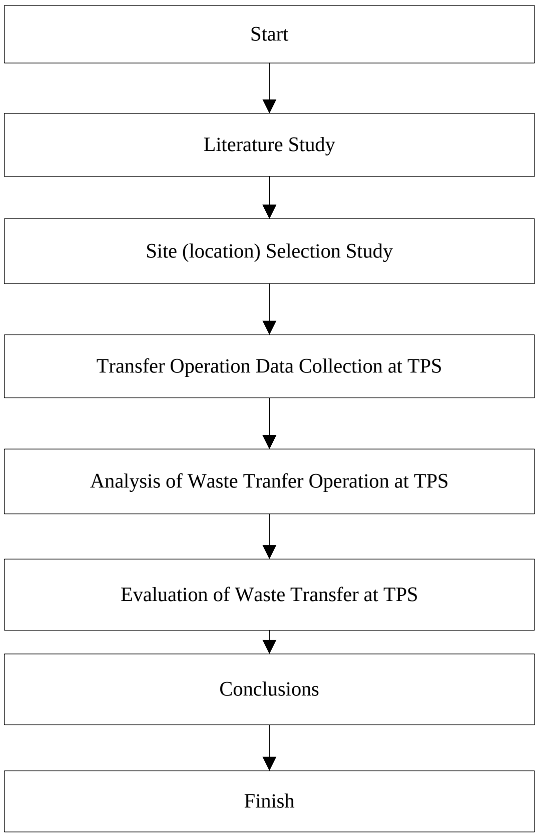

Figure 1 Method Flow Charts.

2.1 Site (location) Selection Study

Site selection study is important since the TPS 3R must meet the thecnical aspects of regulations and to ease the operational TPS 3R should be in KBS area [7]. To compile those requirement the selection was conducted using five criteria. The first and second criteria resulted from interviews and study on KBS program. The first criterion is to select TPS which are not a TPS 3R, TPS market, hospital, factory, commercial and/or institution. The second criterion, selects the location of TPS within KBS. The third criterion is to select land area > 200 m^2 as refered in the government regulation which is Regulation of The Minister of Public Works No 03, 2013 [5]. The forth criterion selects a TPS located in a land owned by Government of Bandung for the ease of operation. The fifth criterion selects a TPS that was priorites to be repaired but was still has to be done.

2.2 Transfer Operation Data Retrieval at TPS

At this stage the operational data collection aims to find out existing condition, waste collection and transport operation at TPS. Exsisting conditios are infrastructure, facilities and authority. Waste collection and transport are type, capacity, waste volume, time of the operation, activities of waste collection, and transport at selected TPS. Data-related to operation of waste collection are waste vehicle types, obtained through observation, measurement of waste vehicle capacity, and waste volume collected, operational time counting, and interview related activity of waste collection. Data-related operations of the waste transport are truck types obtained through observation, measurement of truck capacity, waste volume transported, operational time counting, and interview related activity of truck in TPS. Data collection was done for eight days.

2.3 Analysis & Evaluation of Waste Transfer Operation at TPS

In attempt to improved the TPS to TPS 3R became necessary to analysis and evaluate its existing conditions (infrastructure, facilities and authority) and operation system at TPS reffering to The Minister of Public Works No 03, 2013. There are several parameters that need to be evaluated such as land area and its capacity, availability of sorting and separate waste facilities, container, its operation should not interfere traffic and esthetic, do not pollute the environment and scheduled operation system.

According to Thecnical Guidance for the Realization of KBS Program [1] and Regulation of The Minister of Public Works No 03, 2013 [5] the data types, number, capacity, volume of waste collected, was used to find out suitability of collection operational in TPS and its analysis to sinchronized the transport operation which are type, number, capacity, volume of waste transported from TPS. The result of evaluation will be used to support operational of TPS 3R and other related data will be used to design or improve TPS 3R.

3 Analysis dan Evaluation

3.1 Site Selection

In the site (location) selection study, there were some result by using five criteria, described as follows:

1. Based on PD Kebersihan's data, in 2015 there are 159 TPS, comprise of 10 TPS 3R, 62 TPS markets, hospitals, factories, commercials and or institutions. Thus, from this first criterion. There are 87 TPS are eligible for this study.

2. Then with the second criterion, out of 87 eligble TPS, 45 of them are located in Kawasan Bebas Sampah (KBS) area.

3. Then, of the 43 TPS, 16 TPS meets the third criterion (land is owned by Bandung City Government) and 7 of them are the priorites to be repared namely TPS Komplek Sadang Serang, TPS Pasteur, TPS Kebun Binatang, TPS Patrakomala, TPS Ambon, TPS Gumuruh, and TPS Pagarsih.

4. The fourth criterion is the land must be greater than 200 m^2. There are 4 TPS which meets this criterion, namely TPS Komplek Sadang Serang, TPS Kebun Binatang, TPS Patrakomala, and TPS Pagarsih.

5. The fifth selects a TPS that was priorites to be repaired but was still has to be done, then produced TPS Patrakomala as the most potential location for this study.

Table 1 Potential TPS

No	Name	Location	Land Ownership (Pemkot)	Land Area > 200 m^2	Non Technical Aspect
1	TPS Komp. Sadang Serang	Jl Sadang Serang	√	√	
2	TPS Pasteur	Jl Dr Djunjunan	√		
3	TPS Kebun Binatang	Jl Tamansari	√	√	
4	TPS Patrakomala	Jl Patrakomala	√	√	√
5	TPS Ambon	Jl Ambon	√		
6	TPS Gumuruh	Jl Gumuruh	√		
7	TPS Pagarsih	Jl Pagarsih	√	√	

Based on the table above it can be concluded that TPS that meet the criteria to function to TPS 3R is TPS Patrakomala.

During the process of third stages site selection study, it was found that several TPS were already relocated or their functions have changed. It also can be analyzed that according to the Research and Development Division of PD Kebersihan, currently there is no formal authority responsible for updating data related to TPS. Consequently, in some cases written data owned by PD Kebersihan are not the same with the existing conditions.

3.2 Existing Conditions of TPS Patrakomala

TPS Patrakomala is located in Merdeka Sub-district, Sumur Bandung District. To the West it is bordered by the Merdeka District Office, to the North there is the Tongkeng Park, to the East is Jl. Tongkeng, and to the South is Jl. Patrakomala. Location of TPS Patrakomala can be seen in Figure 2 (in the picture TPS Patrakomala, also known as TPS Tongkeng).

Figure 2 Location of TPS Patrakomala

Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 [5], the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement. Currently the used area is 110 m^2 with a length of 11 m, width of 10 m, and a height of wall 2 m. The width of access road (Jl. Patrakomala) is 6 m. See Figure 3.

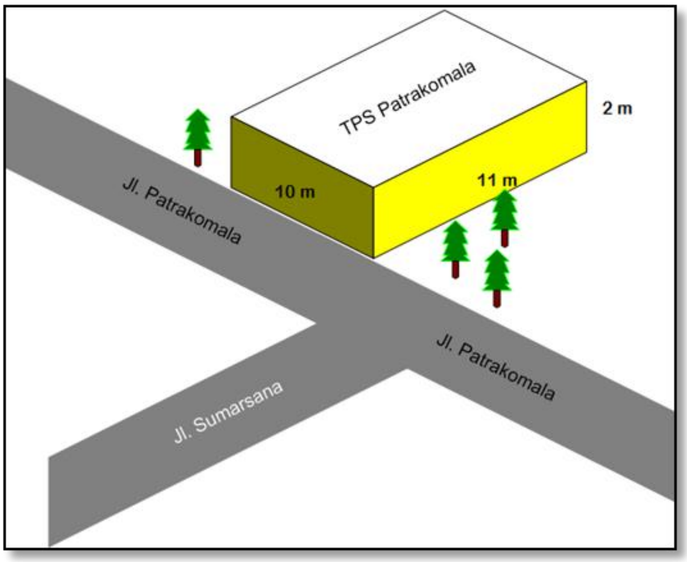

Figure 3 Currently Used Area 3D TPS Patrakomala

There was no waste container in TPS Patrakomala. According to statement of CEO PD Kebersihan, Dedi Nurdiana, he recommend that TPS should be equipped with a container, not only the walls [11]. It become a consideration in designing TPS 3R since it also require the needed of area or container for residue. Then in TPS Patrakomala there was no gate for waste vehicles and waste transport, so that vehicles can directly access TPS, as long as there is no other vehicles at the same time. If workers are doing the unloading; when the TPS is full, other vehicles had to wait in line. It can be analyzed if it too many vehicles are lining up, it will distrupt/interfere the traffic, this is contrary to the regulation, refered to Regulation of The Minister of Public Works No 03, 2013 [5] the activites of TPS should not interfere the traffic. The limitation in some facilities will need an improvement to run as TPS 3R.

3.3 Waste Tranfer Operational System

3.3.1 Waste Collection

During the 8 days of observations there were 32 waste vehicles. For the ease of observation vehicles are being labelled, and it was found to be 11 conventional handcarts, 16 motor bikes, and 5 pick-up cars. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] for area with relatively flat topography (slope < 5%) were able to use non-collecting machine such as traditional handcarts, whereas for the topography with the slope > 5% can use motorbikes. So for this area with relative flat topography was able to traditional handcarts.

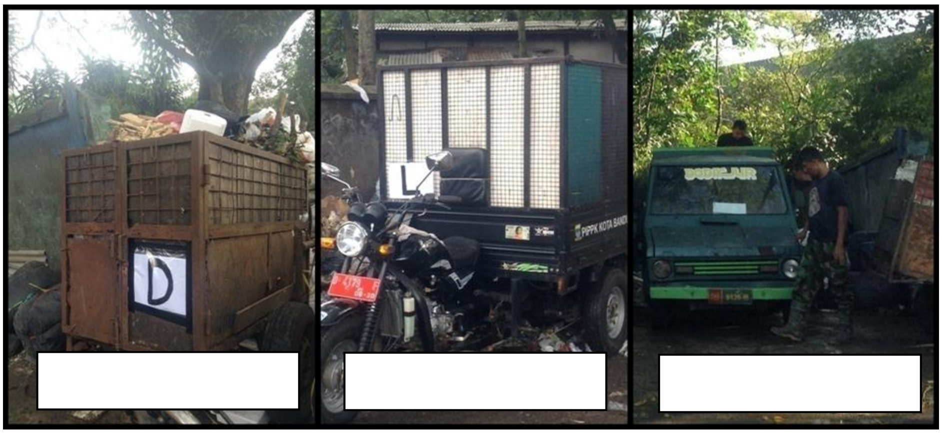

Figure 4 Types of Waste Vehicles

The entire waste vehicles did not operate everyday, therefore data of the average number of waste vehicles per day need to be counted. The average number of waste vehicles per day can be seen in Table 2.

Table 2 Number of Waste Vehicles

Types	Day								Average number per day
	1	2	3	4	5	6	7	8	
Traditional handcarts	3	7	8	3	3	3	2	2	4
Motor bikes	5	11	7	8	9	8	7	6	8
Pick-up cars	0	4	2	2	1	3	0	0	2
Average									14

From the table above the average number of waste vehicles were found to be 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day. It also can be seen compare to total number of each waste vehicles, motorbikes is the most operated everyday. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] waste collection need to be done by 1-4 trip/day. Based on observation the average of waste collection were 2 trip/day.

The dimensions and capacity measured can be seen in Table 3.

Table 3 Dimensions and Capacity of Waste Vehicles

Types	Dimensions P (m) x L (m) x T (m)		Capacity(m^3)	
	Minimum	Maximum	Minimum	Maximum
Traditional handcarts	1,50 x 0,75 x 0,90	1,55 x 1,25 x 1,20	1,01	2,33
Motor bikes	1,50 x 0,75 x 1,00	1,60 x 1,10 x 1,42	1,13	2,5
Pick-up cars	2,00 x 0,75 x 1,00	4,30 x 1,90 x 0,60	1,5	4,9

Based on the table above it can be concluded that pick-up car can carry or collect more waste as compared to other waste vehicles. The waste volumes carried or collected can then be calculated based on the dimension of the vehicles as follows:

$$\frac{(length\,cm\;x\;width\,cm\;x\;average\,waste\;height\,cm)}{10^6} \qquad (1)$$

Then the waste volume from each waste vehicles can be seen on the Table 4.

Table 4 Waste Volumes Collected

Types	Waste Volumes (m^3/trip)
Traditional handcarts	1,4
Motor bikes	2,6
Pick-up cars	3,6

Based on the table above it can be concluded that the waste volume carried or collected by a pick-up is higher as compared to other waste vehicles. Further, its will become a consideration in operational of TPS 3R since motorbikes found to be the most operated also can carry more waste.

From the Table 2 and 4, the average that collected to TPS Patrakomala from 4 handcarts with average vaste volume collected 1,4 m^3/trip, from 8 motorbikes with average vaste volume collected 2,6 m^3/trip and from 2 pick-up cars with average vaste volume collected 1,4 m^3/trip, and the average of either waste collection were 2 trip/day it calculated that the average waste collected is 67,2 m^3/day.

3.3.2 Activities & Operational Time of Waste Collection at TPS

Based on the interview with waste collectors at the TPS, activities of waste collection start from 6 AM until 5 PM. Because TPS operated with unscheduled operation system, then the waste collector adjusted their collection time by itself. The TPS has no gate and also an authority might caused the existence of waste collector that enter to TPS after 5 PM. Therefore there will be waste staying overnight in TPS Patrakomala. Operational schedule and officer is required to adjust activities of waste collector and trucks that will pick up waste. The objective is to prefent waste for staying overnight in TPS. The average time to collect the waste for each waste vehicle in their service can be seen in Table 5.

Table 5 Waste Collection Times per

Day	Handcarts (hour:minute)	Motorbikes (hour:minute)	Pick-Up Car (hour:minute)
1	1:06	1:24	-
2	2:08	1:55	1:40
3	1:04	1:28	1:37
4	1:10	2:05	6:20
5	2:09	1:25	2:15
6	2:46	1:29	4:04
7	0:59	1:41	-
8	1:05	1:34	-
Average	1:33	1:37	3:11
Maximum	2:46	2:05	6:20
Minimum	0:59	1:24	1:37

From the table above it can be seen that the average time for handcarts and motorbikes to collect waste was faster than pick-up cars. It was due to the volume of waste collected and the ability of the waste collector itself. Since motorbikes operated faster, even from Table 4 the waste that collected using motorbikes almost twice as waste collected from using handcarts, the average collection time relatively same. Therefore the waste volume collected using handcarts is not as much as collected by motorbikes and pick-up cars, it also stated in the Table 4. Those were the reason why waste collector who use handcarts can have faster time in waste collection than pick-up cars.

Unloading and loading activities counted at TPS Patrakomala can be seen in Figure 6.

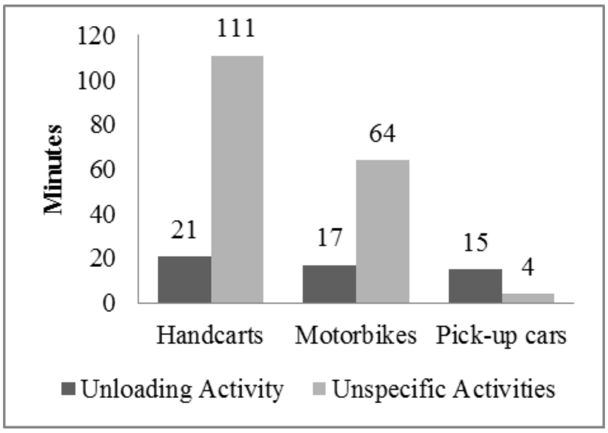

Figure 5 Average Time of Waste Collector-Waste Vehicles Activities at TPS

The average time needed to unloaded for waste collector who used handcarts, motorbikes and pick-up cars were respectively 21, 17, and 15 minutes. There are other unspecific activitessuch as queuing time for unloading, cleaning the certain vehicles, and resting. Queuing time occurs when TPS was full of waste so other waste collectors have to wait until the waste in TPS picked up by trucks. The average time for irrelevant (unspecific) activities of a waste collector who used handcarts, motorbikes and pick-up cars are respectively 111, 64, and 4 minutes. The waste collector using handcarts need a longer time to rest than the others, because they have to walk from sources to TPS. Data on time needed by waste collectors will be adjusted for recommendation of operational activity scheduling of waste collector, so there are no queues that could interfere the access of dump truck to enter the TPS, so the waste that already collected in TPS can be immediately picked up by dump truck.

3.3.3 Waste Transportation

Waste transported done by dump trucks, to transport waste from TPS Patrakomala to Sarimukti Landfill was conducted 1-2 trips/day. The capacity of a dump truck and the waste volume transported to the landfill can be seen in Table 6.

Table 6 Truck Capacity and Waste Volume Transported

No	Date	Types	Truck Capacity (m^3)	License	Waste Volume Transported (m^3)
1	17-Apr-16	*Dump truck*	14	R 1780 AB	26
2	18-Apr-16	*Dump truck*	14	R 1780 AB	27
	18-Apr-16	*Dump truck*	14	R 1780 AB	26
3	19-Apr-16	*Dump truck*	14	R 1780 AB	26
	19-Apr-16	*Dump truck*	14	R 1780 AB	26
4	20-Apr-16	*Dump truck*	10	D 8253 C	20
5	21-Apr-16	*Dump truck*	14	R 1780 AB	26
6	22-Apr-16	*Dump truck*	13	F 9179 AA	22
7	23-Apr-16	*Dump truck*	14	R 1780 AB	26
	23-Apr-16	*Dump truck*	14	R 1780 AB	26
8	24-Apr-16	*Dump truck*	14	R 1780 AB	26

From the table above we can analyzed that to maximize the amount of waste transported to the landfill, the truck driver fills the container twice as its normal capacity. The truck capacity is either 10, 13 or 14 m^3, whilst the average of waste transported to landfill were respectively 20, 22 and 26 m^3/truck/trip. Refered to the average waste collected was 67,2 m^3/day, it can be analyzed even the average of waste trandported to landfill as mentioned above, there were still some waste unstransported from TPS.

The waste in truck container was fully compacted its also raises problem such as dripping of leachate from the sides of truck and odor pollution, since the waste are mostly garbage [3].

The dimensions of truck measured can be seen in Table 7.

Table 7 Dump Truck Dimension

	Longest				Shortest		
	L	W	H		L	W	H
Dump truck	4 m	2,2 m	3,05 m	***Dump truck***	3,5 m	2 m	2,7 cm

Based on observation and refered to Table 3 and 7, with the existing length of TPS metre, ideally only 2 waste vehicles that can unload the waste at the same time as the truck which arrived to fill the container. Further, data from Table 3 and 7 will be used and adjusted to design a loading and unloading space at TPS 3R.

3.3.4 Activities & Operational Time of Truck at TPS

Currently, in TPS Patrakomala waste is transported to landfill once or twice per day. Truck arrival time and activities of waste filling can be seen in Table 8.

Table 8 Activities & Operational of Truck at TPS

No	Date	Type	License	Arrival Time	Departure Time from TPS	Filling Process (hours)
1	17-Apr-16	*Dump truck*	R 1780 AB	6:30	8:40	2:10
2	18-Apr-16	*Dump truck*	R 1780 AB	5:00	7:47	2:47
	18-Apr-16	*Dump truck*	R 1780 AB	12:05	14:23	2:18
3	19-Apr-16	*Dump truck*	R 1780 AB	5:00	7:45	2:45
	19-Apr-16	*Dump truck*	R 1780 AB	12:32	14:41	2:09
4	20-Apr-16	*Dump truck*	D 8253 C	11:08	13:57	2:49
5	21-Apr-16	*Dump truck*	R 1780 AB	11:50	14:10	2:20
6	22-Apr-16	*Dump truck*	F 9179 AA	8:01	9:30	1:29
7	23-Apr-16	*Dump truck*	R 1780 AB	5:00	7:30	2:30
	23-Apr-16	*Dump truck*	R 1780 AB	13:45	15:26	1:41
8	24-Apr-16	*Dump truck*	R 1780 AB	5:30	8:10	2:40

As mentioned above time of arrival and departure when the waste transported once a day the truck will come in 5:30 AM then will depart at 8:10 PM or come at 11:50 PM and depart at 14:10 PM. time of arrival of the truck. Time of arrival and departure when the waste transported twice a day the truck will come in 5 AM and depart at 7:45 AM, then the truck came again at 12 PM and leave around 3 PM at the most. From the table 6 and 8 it also can be analyzed that the trucks arrive in TPS with empty container, and it requires approximately 1,5 - 2 hours to fill the container.

The quality of waste collection with dump truck are significantly depent on TPS which essentially consist of haul time and waiting time at the site [8]. Hence, scheduling is required so the waiting time that may accur in TPS can be minimized. Since TPS Patrakomala operated with unscheduled operation system, there is a time when dump truck and waste vehicles went to TPS at the same time, which cause either waste vehicles or dump truck need to wait each other performed. Another problem is there are collectors that unload the waste in TPS after the final truck transported to the landfill. Consequently, some amount of waste stays overnight in TPS Patrakomala. Therefore, operational schedule is required to adjust activities of waste collector and trucks hauling, which at the end avoiding the waste unloaded in TPS Patrakomala for staying overnight to prefent there is wating time in TPS.

4 Conclusions

Several important conclusions can be drawn as follows:

1. TPS Patrakomala was identified as the most potential TPS to function as TPS 3R, based on several criteria. The limitation in some facilities will need an improvement to run as TPS 3R.

2. Currently TPS Patrakomalaoperated with unscheduled activities, there was no waste container and gate in TPS Patrakomala.

3. Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement.

4. The operating waste vehicles were 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day, with waste volumes respectively 1,4; 2,6; 3,6 m^3/trip. The average of waste collection is 2 trip/waste vehicle/day.

5. The dump truck to collect waste from TPS Patrakomala operated 1-2 trip/day, with capacities either 10; 13; 14 m^3, but the average of waste volume transported were respectively 20; 22; 26 m3/truck/trip which meant above its capacity there were still some waste unstransported from TPS.

6. Operational schedule is required to adjust activities of waste collector and truck, which at the end avoiding the waste unloaded in TPS Patrakomala for staying overnight or untransported to the landfill and waiting time in TPS.

7. Further, the presence of TPS 3R will facilitied the need of community, so the waste will be processed and reduced, supported by the the existence of operational management system.

8. The result of this study will be used to support operational of TPS 3R and other related data will be used to design TPS 3R, which is expectedly contribute to the improvement of waste management system in Bandung City

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Impact of Trend In The Wind Direction In The Tuban District Toward The Dust Spread

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Abstract. Indonesia is a developing country that is being carried out development in all fields, including to build physical infrastructure. For it was needed the construction materials, one of which cement. Cement has a great significance in the process construction because the presence of cement to make between the material construction such as sand, gravel, iron, etc., become desperate and are not easily separated. To meet the needs of the cement is established cement plants, one of which is PT. Semen Gresik (Persero) Tbk. Tuban Plant. This presence of cement plant gives effect to life the surrounding people at the plant site, one of on air quality, especially dust. This research tendence are to determine the model of trend the wind direction in the Tuban District and its impact on the spread of dust into the surrounding environment are affected by wind speed and direction and rainfall.

This research uses research methods such as collecting secondary data which includes data intencity rainfall, the average long rains, wind speed and the dust quality monitoring data. For determine the model of trend the wind direction in the Tuban District, using a soft file Windrose. For determining the impact toward spread of dust into the environment, it uses the air quality monitoring secondary data.

The result of research are that the trend of the wind direction is toward the east at a speed of wind around 3.6 m/s to 5.7 m/s. While the level of the spread of dust based on data from air quality monitoring at several locations showed that the levels of dust in free air is still below the environment quality standard. Because the high intensity of the spread of dust and constantly then it needs to be management of the dust with planting trees and the dust extraction tools that are environmental friendly.

Keywords : wind direction, dust spread, quality standard, the quality of dust

1 Introduction

According to Dimitriou and Christidou (2011), air pollution is one of the important environmental issues that contribute to the effects of high temperatures affecting public health, animal life, natural ecosystems, and man-made environments. Air pollution is also responsible for the occurrence of climate change, greenhouse effect, acid rain, and others. According to Saraswati (2000), the development of this industrial sector will encourage urbanization and threaten the environment through air, soil, and water pollution. Dust from the production process of PT. Semen Gresik (Persero) Tbk can be spread to the environment around the factory location. As a result, the environment will be exposed to dust. Exposure to dust is particles of dust that people inhale both outdoors and indoors. Exposure to this dust can disrupt the respiratory tract of people who are outside the home. (Thaib et al., 2014). In the cement industry, dust emissions are generated from processes in kilns, crusher, grinders, clinker cookers and material handling equipment and clinker cookers, which are destructive and pyro processes (Kumar and Armani, 2012).

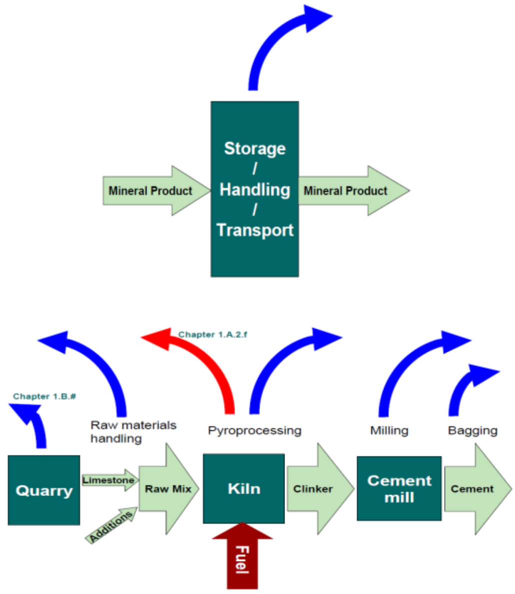

Figure 1. Source of emission of dust emission
(Source : EMEP/EEA Corinair, 2013)

Caption :
Clockwise, the process in a potential cement industry generates particulate emissions: (a) mining, (b) transport and storage, (c) production

According Nurbiyantara (2010), exposure via inhalation of dust particles in the respiratory tract will cause a variety of lung function impairment. The dust particles will accumulate in the respiratory tract according to the nature of chemistry, physics, and biology of the dust. According Naqpure (2014) termed TSP dust are defined as PM (Particulate Material) with aerodynamic diameter not more than 30 µm. Dust is one type of solid aerosols formed by a material separation process mechanically like the crushing, grinding and blasting. This process occurs because of the friction material with strong winds or shift to other materials. For example, cement dust (cement dust) and dust from the metal elements (metallurgical). Dust particles of solid material is regarded as finely divided with sizes ranging from 0.1 µm to 100 µm. Dust particulate characteristics including size, size distribution, shape density, adhesiveness, corrosive properties, reactivity and toxicity. One of the most important karakteriktik of dust particle suspensions is particle-size distribution of aerosols. Generally, particles with a diameter of less than 2.5 µm is considered fine and larger particles 2.5 µm is considered rude (Suhariyono et al, 2003).

Control of dust emissions in the cement industry generally use mechanical collectors/collectors mechanical/dust collector, electrostatic precipitators, fabric filters, or a combination of such equipment (Kinsey, 1987). According Zimwara et al (2012), air pollution control technology that is Flexible Pulse Jet Filters, Electrostatic Pricipitators, and Wet scrubbers. In wet scrubbers, the gas stream is polluted taken and contact with the liquid that is sprayed with a liquid, and the liquid will catch dust.

2 Methods

1. Determining the trends in wind direction by collecting secondary data rainfall intensity, long average rainfall, and wind speed and direction in Tuban last few years. The data was then entered into the file soft Wind Rose to know the trend of the wind direction.

2. Designing a dust catcher equipment fogging method.

3 Discussion

3.1 Determining the trends in wind direction

Table 1. Monthly rainfall during the year 2011-2015

Month	Rainfall (mm/month) at Year........					Average
	2011	2012	2013	2014	2015	
January	185.13	264	344	152	17	192.4260
February	107.79	219	161	187	45	143.9580

Month	Rainfall (mm/month) at Year........					Average
	2011	2012	2013	2014	2015	
March	214.50	267	147	312	15	191.1000
April	205.25	0	232	170	36	128.6500
May	213.13	123	148	45	83	122.4260
June	20.54	61	52	86	-	54.8850
July	21.88	0	93	117	-	57.9700
August	0.67	0	-	26	-	8.8900
September	9.29	0	-	-	-	4.6450
October	47.04	77	16	-	-	46.6800
November	273.17	27	150	57	49	111.2340
December	274.54	435	257	527	6	299.908
Amount	1,572.93	1,473.00	1,600	1,679	251	1,315.1860

Source : DPU Kabupaten Tuban (Bidang Pengairan) dalam Kabupaten Tuban dalam angka 2012-2016

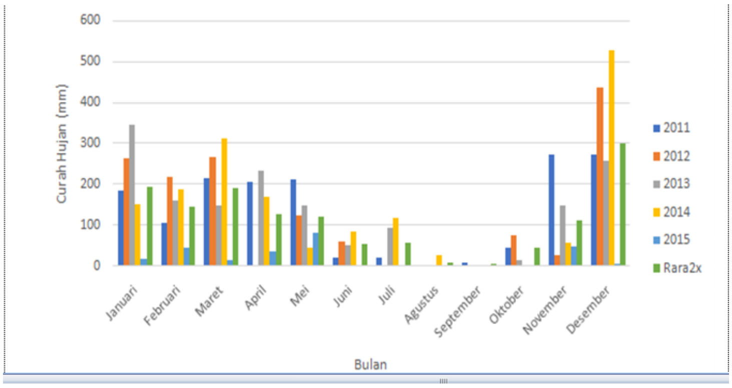

Figure 2. Graph rainfall monthly average in Tuban for 5 years (Years 2011-2015) *(Source: data processing constituent, 2017)*

Based on the chart above can be observed that for the highest rainfall in December 2014, because it is the peak of the rainy season, while the lowest rainfall in September in the year 2012-2015, when drought.

Table 2. The number of rainy days during the Year 2011-2015

Month	Number of rainy days /month in Year...					Average
	2011	2012	2013	2014	2015	
January	15.79	15	11	8	5	10.9580
February	8.54	12	7	6	12	9.1080
March	12.83	14	5	8	4	8.7660
April	11.58	0	11	5	9	7.3160
May	9.88	4	12	3	2	6.1760
June	1.50	2	9	4	0	3.3000
July	1.75	0	7	3	0	2.3500
August	0.08	0	0	1	0	0.2160
September	0.08	0	0	0	0	0.0160
October	0.92	3	1	0	0	0.9840
November	13.42	2	11	2	2	6.0840
December	14.50	9	18	13	7	12.3000

Amount	90.87	61	92	53	41	67.5740

Source : DPU Kabupaten Tuban (Bidang Pengairan) dalam Kabupaten Tuban dalam angka 2012-2016

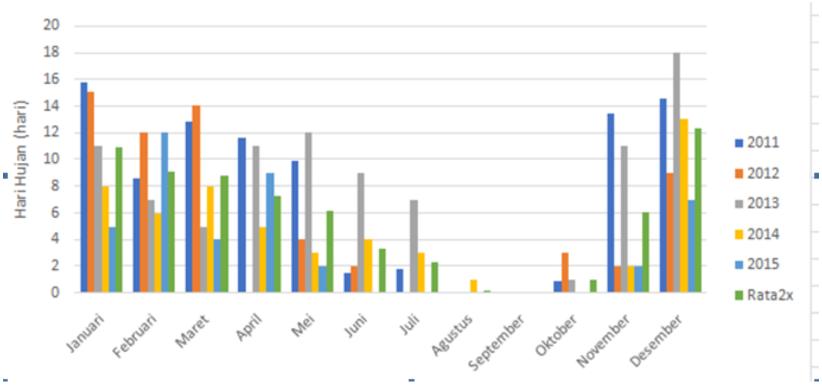

Figure 3. Graphic number of rainy days during the years 2011-2015
(Source: data processing constituent, 2017)

Based on the picture above it can be seen that the highest number of rainy days in the month of December 2013 which is 18 days, so in about the month, the dust can not be spread secar maximum because rain water is affected. While the number of rainy days was lowest in the few months in 2012-2015 with the number of rainy days 0 days of rain. In the months with the minimal number of rainy days it will contribute to increasing the deployment area of cement dust.

Table 3. Data monitoring wind speed and direction were done by. Semen Gresik (Persero) Tbk. Tuban At Some village in the district of Kerek, Tuban, East Java Province (2016)

No	Measurement Locations (Village)	Measurement Time	Wind Speed km/j	Wind Direction	No	Measurement Locations (Village)	Measurement Time	Wind Speed km/j	Wind Direction
1	Temandang	07-08 March	0.90	East	13	Temandang	01-02 August	0.60	North
2	Tlogowaru	08-09 March	0.70	East	14	Tlogowaru	01-02 August	1.20	West
3	Kasiman	11-12 March	0.70	West	15	Kasiman	02-03 August	1.00	West
4	Margomulyo	14-15 March	1.40	East	16	Margomulyo	02-03 August	1.40	North
5	Sumberarum	15-16 March	1.30	East	17	Sumberarum	03-04 August	1.10	West
6	Karanglo	16-17 March	1.30	East	18	Karanglo	03-04 August	1.20	West
7	Temandang	09-10 May	0.90	West	19	Kasiman	20-21 Nov	1.30	East
8	Tlogowaru	09-10 May	0.50	South	20	Sumberarum	24-25 October	1.30	West
9	Kasiman	11-12 May	1.10	North	21	Karanglo	25-26 October	1.40	North
10	Margomulyo	11-12 May	0.90	North	22	Margomulyo	26-27 October	1.30	East
11	Sumberarum	12-13 May	2.00	South	23	Temandang	17-18 October	1.50	East
12	Karanglo	12-13 May	1.00	South	24	Tlogowaru	18-19 October	1.30	East

Source: *Laporan Pelaksanaan RKL-RPL PT. Semen Indonesia Semester I&II 2016, 2016*

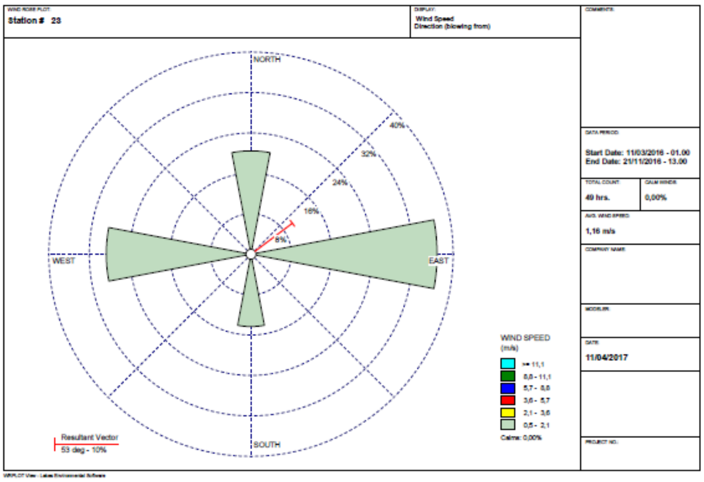

Figure 4. Windrose on March-November 2016
(Source: data processing constituent, 2017)

In the picture above it can be seen that the dominant wind speed in the area of 0.5 to 2.1 m/s and the average wind speed is 1.16 m/s. The tendency of the wind direction is east. This means that the spread of dust tends to the east so that the area on the east side impact sources will be potentially affected by the spread of dust more than the territory in the other direction.

3.2 Designing tools dust catcher with fogging method

The spread of dust can be overcome by using a dust catcher fogging method is environmentally friendly appliance because it uses the mist atomized water demand will be less than with other methods, Can catch cement particles whose size is very smal and Clots / floc capture results of this appliance can be recycled. To determine the concentration of dust particles, based on the data results of sampling and substituted into the following equation: $C = [(M_1\text{-}M_0) / (t.v)]$ $(\mu g/m^3)$. (1)

Information :

C : The concentration of dust particles measured ($\mu g/ m^3$)

M_1: Weight filter after dust measurements (pg)

M_0: Heavy dust filter before measurement (g)

t : Duration of measurement (hours)

v : velocity of volumetric air (m^3/ h), in this study v = 1,698 m^3/ h

Cement dust concentrations obtained in equation (1) to the model equations Canter conversion to obtain cement dust concentration at the time of sampling / sample for 24 hours so in accordance with Government Regulation No. 41 of 1999.

$$C_1 = C_2. [(t_2 / t_1) p \quad (2)$$

Information:

C_1 : The concentration of cement dust with long average sampling instance t_1 (µg/ m^3)

C_2 : an average dust concentration at the sampling time instance t_2 (µg/ m^3)

t_1 : The duration of sampling sampel 1 (in this study = 24 hours)

t_2 : The duration of sampling sample 2 (h)

p : conversion factor value between 0.17 to 0.2.

The p-value in equation (2) obtained from the Government Regulation No. 41 of 1999 with C_1 = 150 µg/ m^3, t_1 = 1 day, C_2 = 50 g / m^3 and t_2 = 365 days in order to obtain the value of p = 0.186.

Factors temperature, humidity, and pressure greatly affects the air concentration including the concentration of dust. Therefore the weather conditions recorded and accounted for in this study either temperature, humidity, wind direction, wind speed, and the season. (Suhariyono, 2003). Equation (2) corrected for the effects of T, P, and RHnormal to the following equation.

a. Normal wet air condition (≥ 50% RH): C n, f = CB. [T / TN] [PN/P] .... (3)

b. Normal dry air conditions (RH <50%): CN, tr = CN, f. [100 / (100-F)]..... (4)

Information:

C N, f: The concentration of dust in normal conditions (µg/m^3)

CB: The concentration of dust in the air in the normal condition at the measurement time= C_1µg/ m^3.

C N, tr = concentration of dust in the dry air conditions (µg/ m^3).

T = temperature at the time of measurement (ºK).

T N = air temperature in normal conditions (ºK)= 25ºC=298,15ºK

P N = The air pressure in normal conditions (Pa)= 760 mmHg = 1Atm.

P = absolute air pressure at the time of measurement (Pa).

F = humidity at the time of measurement / TN] [PN / P]

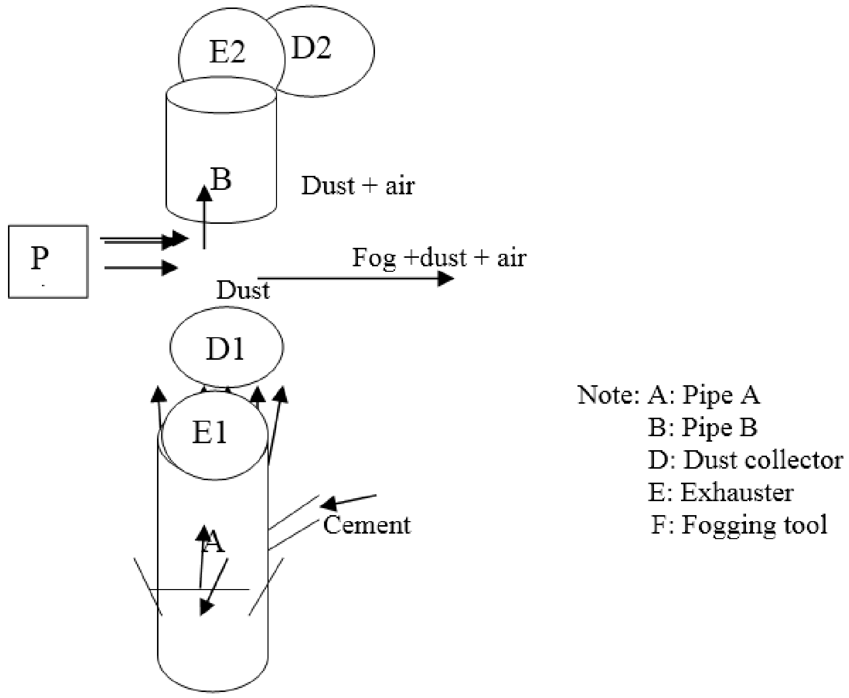

Figure 5. The circuit schematic tool in fogging method
(Source: the author, 2016)

This research will use the variabel of speed of water (Va) and stage (Z).

4 Conclusion

1. The trend of wind direction identical with the trend towards the spread of dust which is to the east with average wind speed is 1,16 m/s.

2. Found alternative means dust catcher with foggging method is more environmentally friendly with use the variabel of speed of water (Va) and many stage (Z).

Acknowledgments

I look forward to another opportunity to develop this research, namely by examining other variables to obtain optimal operating conditions for the dust catcher with the foggging method.

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Development Water Quality Assessment Using Macrozoobenthos Based Multimetric Concept (A Case Study Of Citarum River's Headwaters)

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Abstract. Development of water quality assessment using macrozoobenthos, one of which is the approaches of multimetric concept. macrozoobenthos were an organisms that can evaluated changing of environmental quality as long as they live because disturbance that happened in the river. The aim of this study was to develop and apply macrozoobenthos based multimetric concept for the assessment of streams and rivers quality Citarum headwater. The research methodology of this study was observation method. Specifically, the study examined the headwaters of Citarum river which were divided into four stations. Station 1 or the site reference was located in the foothills of Mount Wayang with height 1.886 m with land use secondary forest. Station 2, 3, and 4 or the site test were situated in four *Kampong*s (small villages), namely Cikitu with height 1.521 m and activity surrounded vegetable garden with dairy cows livestock, Babakan with height 1.057 m and activity surrounded plantation with settlement, and Andir with height 745 m and acitivity surrounded were field, settlement, and sand mining respectively. The research had been carried out from July 2014 to September 2015 to sufficiently capture the condition of the river in both wet and dry seasons. Macrozoobenthos sampling using surber net mesh with 0.5 mm pore size indicated that the site in Mount Wayang showed Cumulative Biotic Index (CBI) at 23 during wet season which can be categorized as no/low disturbances. Meanwhile in *Kampong* Babakan and Wangisagara, the CBI was found at 11 and 13 respectively which means medium disturbances were apparent. This study was also discovered that the classification of the sites on the basis of the commonality of macrozoobenthos community presented a correlation between the level of land use disturbances and organic pollution. In addition, index resulting from the application of multimetric approach through CBI was relatively sensitive to distinguish the area where disturbances were absent and the area which experienced land use disturbances and organic pollution. Apart from that, this study reported no significant difference caused by seasonal changes. Therefore, these development can be used as assessment tools in ecological biomonitoring and management of Citarum river.

Keywords: *cumulative biotic indeks; headwaters of citarum river macrozoobenthos; multimetric*

1 Introduction

River is an open aquatic ecosystem heavily influenced by morphology and land use. Changes in its water quality are generally affected by changes in land use and anthropogenic activities. To examine these changes, water quality assessment is usually utilized based on ecological conditions and chemical parameters of water.

Macrozoobenthos to assess water quality has been used in some countries or other specific locations for a long time (Rosenberg and Resh, 1993; De Pauw et al., 2006) and for all types of rivers. It is worth noting however that the composition of the community from headwaters to downstreams is likely to change (Vannote et al., 1980). The multimetric index of an ecosystem is a combination of several variables (or metrics). Each metric represents the quality of various ecosystem's components which are further combined into one index value. Multimetric Index was first developed for fish community (Karr, 1981; Fausch et al., 1984) and later becomes the determinant indicator for other groups including macrozoobenthos (Kerans and Karr, 1994; Thorne and Williams, 1997; Bohmer et al.., 2004). The advantages of using multimetric is that it is more flexible and adaptable in relation with the increased or decreased matrix which are used in the metric scoring system. The trend to employ biological materials to detect disturbance levels of a river's ecosystem has rapidly soared. One of the examples is the development of biocriteria utilizing biological integrity concept/multimetric approach of macrobenthic fauna/benthos (Sudarso et al., 2009).

United States, Germany, Belgium, and other developed countries have developed a concept of biological integrity model based on multimetric concept approach of macrobenthic fauna community in order to predict the pollution status and disturbances occurring in water resources. The basis of this model development is a comparison between macrobenthic fauna community living in the reference sites and those which live in the test sites but both sites must share similarity in their ecoregion characteristics (Reynoldson et al. 1997; Lucke and Johnson 2008; Solimini et al.., 2008, Bohmer et al.., 2004, and Gabriels et al.., 2010). Seasonal changes are influential in determining the composition of macroinvertebrates community (Furse et al., 1984; Rosillon, 1989: Linke et al., 1999: Beche et al.., 2006). Therefore, the sampling period may affect the evaluation of sampling locations. Nevertheless, not all metrics will show significant difference due to seasonal changes. For instance, Sporka et al (2006) found that metric categories based on EPT taxa were not significantly different because of seasonal changes for the fact that in every sampling period, the selected month has sufficiently represented the taxa in the EPT group.

In Indonesia, the use of macrozoobenthos for water quality evaluation has not yet been optimally developed and implemented regularly. Generally, the biological index applied in this country is still adopting the criteria employed in countries located in temperate zones which may not be suitable to apply in Indonesia. Furthermore, unlike the multimetric model, it has not been yet integrated. The tropical climate enables the number of macrozoobenthos taxa in Indonesia relatively to be higher and to potentially yield biocriteria which can adapt to geographical condition.

The first step to developed multimetric model has been done through several studies. The studies utilizing multimetric approach with biological attributes/metric were taxa richness, the number of EPT taxa, the number of sensitive taxa, BMWP index, and percentage of 3 dominant taxa in the tributary of Cisadane river (Sudarso et al., 2009). Besides, the concept of multimetric approach was also applied by using Chironomidae family, or Chironomidae Aggregate Index (CAI) to examine ecological disturbances in Ciliwung river with a metric which can determine the disturbance level in the form of Shannon-Wiener index, the total number of Chironomidae taxa, the percentage of dominant taxa, and the number of Orthocladinae taxa (Mayaningtias, 2010). Other studies utilizing Trichoptera larvae also taking place in Ciliwung river used attributes/taxa richness metric, percentage of 3 dominance, and the number of signal scores and signal index (Sudarso et al., 2013).

Citarum, a big river flowing across the Province of West Java, Indonesia, has important functions for people's life and is highly valued by the local people. In general, its water quality drops as it reaches to the downstream due to high pollution levels. Various activities along its river banks, such as domestic, agricultural, and industrial wastes, primarily contributes to polluting the river. The evaluation of Citarum's water quality was conducted by applying several macrozoobenthos metric such as Family Biotic Index (FBI), Lincoln Quality Index (LQI), and Shannon-Wiener Diversity Index (Muntalif, B., 2008). In this biocriteria research, multimetric was used in the headwaters of Citarum river.

2 Research Methodology

The research methodology for this study was observation. The study took place in four stations of Citarum river's headwaters, West Java, Indonesia. The following coordinates indicated the specific observed locations, namely 107°39'20.30''-107°44'53'' S, 07°04'29''-07°13'27.27'' E. Station 1 or site reference was situated in the foothills of Mount Wayang, specifically *Kampong* Pejaten in Tarumajaya village where the majority of its area was categorized as national park. Station 2 was located in *Kampong* Cikitu at Cibereum Village where half of its area was dedicated for farming and raising livestock and dairy cows in a traditional way. Station 3 was the site test in *Kampong* Babakan at Pangauban Village where the vast majority of its area was allocated for plantation and housings. Next, station 4 was also site test situated in *Kampong* Andir at wangisagara Village where most of its area was used for paddy fields, housing, and sand mining. The location of the aforementioned four stations can be seen in figure 1. This study took place from July 2014 to September 2015 in order to obtain the best representation of each season, namely dry and wet seasons. To take samples and to analyze the water sample were conducted in the location (*in situ*) and in laboratory (*ex situ*) respectively. Physical parameters measured on the field were pH and dissolved oxygen. Six chemical parameters, namely BOD, COD, TSS, TDS, Total Phosphate, and Nitrate. Dissolved Oxygen (DO) was examined by using Mettler Toledo Seven Gopro, temperature was measured by 2550 B method, while pH level was measured by using 4500-H^+-B model pH 6 Pocket-Sized pH meter Milwaukee. Moreover, chemical parameters were examined in the laboratory where water sample was kept in 4000 ml size plastic bottles, stored in a cool box at 4 °C temperature, and analyzed using APHA method (2012). The classification of pollution levels in each station followed the Pollution Index (The Decree of the Ministry of Environment No. 15 in 2003). The categories of Pollution Index (PI) is elaborated as follows:

Table 1. Pollution Index Criteria

PI Values	Pollution Category
$0 \leq PI \leq 1,0$	Meeting Standard Quality (Good Condition)
$1,0 < PI \leq 5,0$	Low
$5,0 < PI \leq 10$	Medium
$PI > 10$	High

Macrozoobenthos were collected by using square surber nets with 0.5 mm pore size (APHA-AWWA, 2012), 25 x 40 dimension, and 1000 cm^2 ^{s}urface area. Sampling was administered three times in each location. To identify macrozoobenthos, *aquatic entomology* references (1983) and fresh water mollusks in Java Island (*Moluska* et al., 2011) were selected to become the reference for the identification process. Research location can be seen in Figure 1.

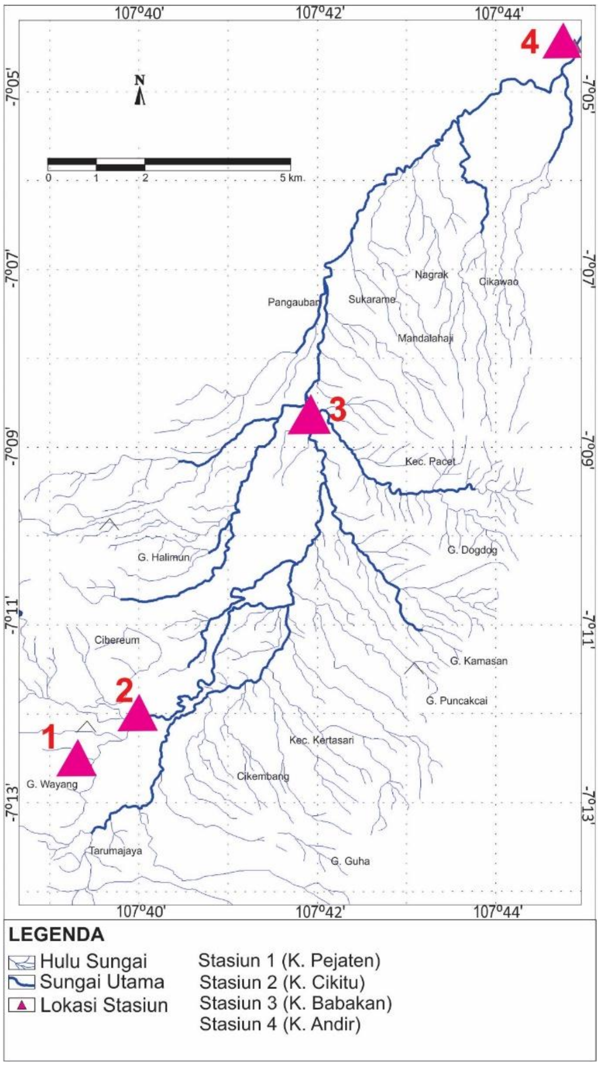

Figure 1. Research Location in the Headwaters of Citarum River

Furthermore, to find out the level of ecological disturbances in each sampling location, this research utilized biological attributes/metric as shown in table 2.

Table 2. Metric candidates used to discriminate disturbance levels of the river's ecosystem

Biological Attributes Classification	**Metric/Biological Attributes**	**Responses Predicted from Disturbance Presence**
Taxa Richness and Composition	Total Number of Taxa	Decreasing
Population Attributes	% 3 Dominance	Increasing
Tolerance/Sensitive	Family Biotic Index	Decreasing
	Signal Index	Decreasing
Diversity	Shannon-Wiener Index	Increasing

Sensitivity of each aforementioned metric/biologial attributes was depicted by a *Box-Whiker Plot* graphic. On the basis of five biological attributes above, normalization process was carried out to obtain cumulative index known as Multimetric model approach. Normalization phase was conducted by counting the percentile of each biological attributes above. The next stage was scoring the trisection (at 1, 3, and 5) in each biological attributes in Table 2.

In general, if the expected metrics rise due to the increase of disturbance/stress, the lowest value of the metrics at percentile 25% will be scored 5, the percentile from 25% to 75% would obtain score 3 while that of above 75 percentile will be given score 1. Likewise, when the expected metrics indicate decreased disturbances, this phenomenon shows high quality metrics. Therefore, the scoring system applied was actually contradictory to the previously mentioned scoring system (Barbour et al., 1999). After passing the scoring phase, the next step taken was to add the five biological attributes into a single index or Cumulative Biotic Index (CBI). Since there were five metrics used in the normalization process above, the lowest score value was 5 while the highest was 25.

Data analysis was executed by combining the aforementioned biological metrics into cumulative biological index. After normalization was done, the results were examined to find their correlation (using Pearson correlation method) with the pollution index through Pearson. This correlation test was administered to see the sensitivity of the Cumulative Biotic Index towards disturbance levels on macrozoobenthos and organic pollution. This correlation test analysis used PASW Statistic Data software.

3 Results and Discussion

Sampling stations were determined located in 4 different Citarum river basin located in Mount Wayang, Mount Guha, Mount Puncakcae and Mount Halimun. Conditions surrounding the sampling station still crowded with riparian vegetation. In addition, those sampling stations have relatively similar physical characteristics, in terms of water depth, substrate type and width of the river water. The water depth of four stations ranges from 3 cm to 5 cm, and the width of the river ranges from 14 cm to 4 meters. Station 4 has the lowest vegetation density of 3 other stations. It can affect the water temperature caused by higher light intensity. Type substrate of bottom river of the four stations is almost similar which is dominated by gravel and sand. The result measurement of physical and chemical parameters Citarum river in 4 location can be seen in Table 3.

Table 3. Physical and Chemical Paramater Water

Stations/ Locations	**TSS (mg/L)**	**COD (mg/L)**	**Total N (mg/L)**	**Total P (mg/L)**
Station 1	1 – 256	4,73 – 22,85	0,19 – 3,35	0,02 – 1,57
Station 2	1 – 29	3,49 – 40	0,09 – 2,71	0,001 – 1,96
Station 3	1 – 200	2,44 – 16,75	0,26 – 3,8	0,01 – 3,49
Station 4	1 – 56	9,77 – 34,27	0,6 – 5,3	0,01 – 1,57

Based on **Table 3** known that there were some chemical parameters with different concentrations ranges significantly between 4 stations such as parameter TSS, COD, Total N, and Total P. TSS concentration measured at 4 stations ranged between 1 to 256 mg/L. The high level of TSS concentration are at Station 1 and 3 caused by particulate inputs from the riparian areas that have changed function into open land, such as agriculture, residential, traditional sand mining and ranching. The difference in TSS value is presumably due to differences in flow velocity in each section of the river. The effect of a slower flow causes the accumulation of material suspended solids greater.

Range of COD concentration at 4 stations between 2,44 to 40 mg/L. The highest COD concentration is located at station 2 and 4 due to the load input of organic material has a large enough from settlement, a dairy farm and agriculture around the river, it is similar with the statement of Al-Shami *et al.* (2011) that the high value of COD in water is caused by a number of contaminants that enter the waters, especially organic pollutants from household waste, industrial, rice fields and aquaculture.

Range of Total N concentration at 4 stations between 0,09 to 5,3 mg/L. The highest Total N concentration is located at station 4. Range of Total P concentration at 4 stations between 0,001 to 3,49 mg/L. The highest Total P concentration is located at station 3. Presumably the increase was because the number of inputs of organic matter that comes from agricultural areas due to the use of nitrogen fertilizer around the river carried away by runoff water. Moreover, domestic waste from human settlements and farms also contribute to the increase of the nitrogen concentration.

The pollution status in Citarum river's headwaters according to Pollution Index in 2003 is presented in Table 4 below. The table informs that the status of organic pollution occurring in Station 1 through 4 was considered low to severe.

Table 4. Levels of Pollution in Wet and Dry Seasons

Stations/Locations	**Wet Season**	**Dry Season**	**Criteria**
Station 1	1,82	1,89	No pollution-Low
Station 2	5,22	6,3	Severe
Station 3	2,96	4,1	Medium
Station 4	3,16	4,19	Medium

In Station 1, it was reported that during the dry season, low level pollution was discovered whereas during the wet season the status slightly increased to very low pollution due to relatively stable dilution effect on the river and its habitat. Moreover, in station 3 and 4, the pollution status was found to be the same during dry and wet seasons. Meanwhile, station 2 experienced medium pollution in the dry season but the status changed drastically to severely polluted in the wet season because of contamination from agricultural and farm wastes which were carried by rainwater to the river.

Figure 2 to 8 depict five biological attributes/metrics used to discriminate the location on the basis of the ecological disturbance levels caused by organic pollution and land use alteration toward the macrozoobenthos community. Biological attributes selection was determined by the discrimination levels of Box-Whisker plot graph. The result from this selection is that five attributes in the wet season and one attribute in the dry season were reported. Therefore, by considering this finding, multimetric analysis was conducted during wet season only.

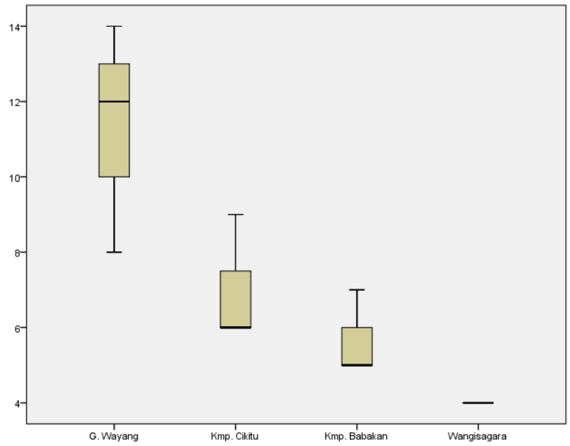

Figure 2. The number of taxa in wet season

The followings were the locations experiencing medium disturbances, namely *Kampong* Cikitu (Station 2), *Kampong* Babakan (Station 3), and Wangisagara (Station 4) with 4-9 values.

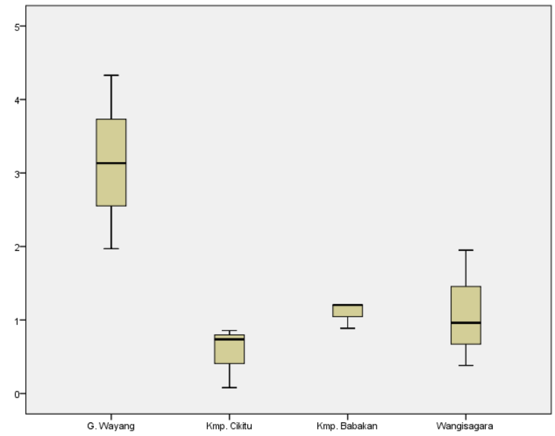

Figure 3. Shannon-Wiener Index in wet season

Based on the results of Whisker-Box plot from Shannon-Wiener Index, it was discovered that reference site like Mount Wayang was classified as a location experiencing minimum level of disturbances in the wet season with the value ranging from 2 to 4,5. With regard to *Kampong* Cikitu, the data spread was found to be the lowest followed by *Kampong* Babakan and Wangisagara. The location suffering from very low pollution was Mount Wayang while *Kampong* Cikitu was the most severely polluted area.

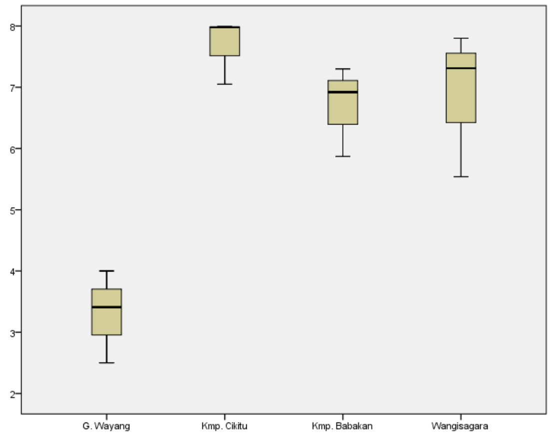

Figure 4. Wet Season FBI

The results of Whisker-Box plot in the wet season indicated that Mount Wayang became a location which possessed the best water quality during the wet season. In contrast, water quality in *Kampong* Cikitu, *Kampong* Babakan, and Wangisagara was discovered to be the worst. This severe pollution during the wet season was due to contamination from the soil surface carried by water and soil erosion.

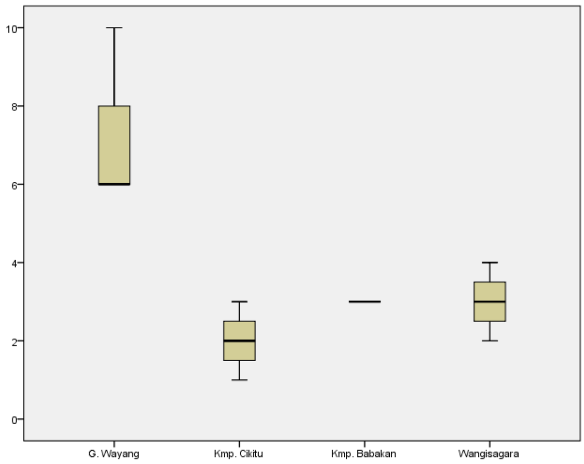

Figure 5. Macrozoobenthos > 3 % in wet season

The results of Box-Plot analysis showed that there were more than 3% macrozoobenthos during the wet season and they spread equally with the lowest median value to be documented in *Kampong* Cikitu and *Kampong* Babakan. The highest number of varieties of macrozoobenthos could be found in Mount Wayang. Meanwhile, *Kampong* Cikitu had the lowest number of varieties of Macrozoobenthos during the wet season as opposed to other locations.

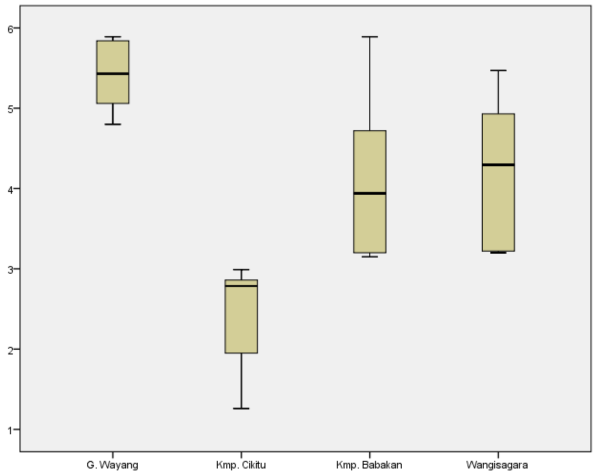

Figure 6. Dry Season Signal Index

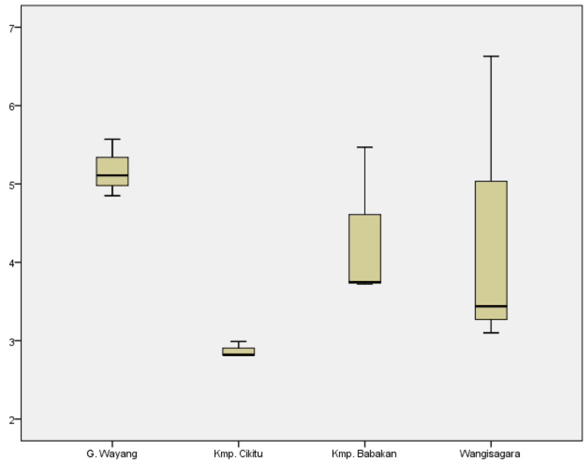

Figure 7. Signal Index in wet season

The results of signal index box-plot in both dry and wet seasons can be viewed in the figure above. The figure depicted that the lowest index was found in

Kampong Cikitu whose pollution level was considered to be very severe both in dry and wet seasons.

The figure of Box-Whisker plot above indicated that every metric responded to every disturbance occurring at every sampling point and the information reported from that metric was different from one another. This metric sensitivity could be seen from the presence or the absence (or the very minimum presence) of whisker graph and box plot which overlapped among locations where disturbances were either absent or present. In addition, the wide range value of each metric would be beneficial in determining the multimetric index. The high value of some aforementioned metrics in the reference site indicated that the existence of disturbances in the macrozoobenthos community was considered low/minimum.

Table 5. The results of criteria value of Cumulative Biota Index (CBI) to indicate disturbance levels

No.		**No disturbance/minimum disturbance**	**Medium level disturbance**	**High level disturbance**
	Score	**5**	**3**	**1**
	Biological Attributes			
1	Taxa Richness	≥ 26	25 - 12	≤ 11
2	Family Biotic Index	≤ 6,5	6,51 – 8,5	≥ 8,5
3	% 3 Dominance	≤ 42	43 - 74	≥ 75
4	Signal Index	≥ 6	6 - 4	≤ 4
5	Shannon-Wiener Index	> 3	1-3	< 1
	Cumulative Criteria Index	**17- 25**	**11 - 16**	**5 - 10**

On the basis of the five biological metrics above, this study attempted to carry out normalization process in order to obtain a new index called as Cumulative Biotic Index (CBI). The results of CBI calculation in each observed station demonstrated that regions which had minimally experienced disturbances/not yet experienced any disturbances was Mount Wayang. From a case concerning the classification of ecological disturbance levels occurring in several parts of Citarum river's headwaters, this study tried to compose local biocriteria by utilizing multimetrix approach as can be seen in table 4. Table 4 showed that a river which has not yet ecologically disturbed/which experienced low level ecological disturbances is likely to have CBI value ranging from 17 to 25 while a river which suffers from medium disturbance level possessed CBI level ranging from 11 to 16. Furthermore, a river which experiences severe disturbances has CBI values ranging from 5 to 10. Mount Wayang whose CBI value was 23 in the wet season was considered to have no disturbances/experience low level disturbances. Meanwhile, *Kampong* Babakan and Wangisagara whose CBI values were 11 and 13 respectively were considered to experience medium level disturbances.

Due to the limited number of macrozoobenthos community living in the research location which either experienced minimal disturbances or suffered from disturbances, the result of biocriteria composition in the form of Cumulative Biotic Index (CBI) needs to be further developed and validated. Nevertheless, this study is a stepping stone in the development of local biocriteria which is adaptive and flexible to the local climate. The benefits of using CBI is that the information yielded enables us to comprehensively examine the level of population balance, pollution tolerance, and macrozoobenthos diversity in order to find out ecological disturbances occurring in the headwaters of Citarum river.

The results from simple correlation test of Cumulative Biotic Index (CBI) along with the pollution index value showed that there was a very significant correlation as the r value was recorded at 0,978 while P < 0,05 in the dry season whereas in the wet season r value was documented at 0,86.

These correlation values suggested that the CBI value was relatively sensitive in detecting disturbance levels which occurred among macrozoobenthos and which was caused by organic pollution. However, the macrozoobenthos community did not exhibit any significant changes.

Table 6. Results of Pearson Correlation Test between CBI and IP

		CBI	IP
CBI	Pearson Correlation	1	-.860
	Sig. (2-tailed)		.140
IP	Pearson Correlation	-.860	1
	Sig. (2-tailed)	.140	

4 Conclusion

The classification on the basis of similarity in macrozoobenthos communities indicates correlations with disturbance levels of land use and organic pollution. Index yielded from multimetric approach through Cumulative Biotic Index (CBI) was found to be relatively sensitive to distinguish areas which had not been disturbed yet and areas which had experienced land use disturbances and organic pollution. In addition to that, seasonal changes did not cause any significant differences.

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Study of Heavy Metal Distribution (Cu, Cd, Cr, Pb, Zn And Ni) In Brantas River, Malang-Mojokerto Segment

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Abstract: Brantas River is the longest river in East Java province. Having utilized as water supply and wastewater disposal from industry containing heavy metals in their production process, Brantas River might have been affected by industrial wastewater discharge. This study aims to determine heavy metals concentration, namely Cd; Cu; Cr; Pb; Ni and Zn, in water and sediment at Brantas River, specifically segments of Malang City, Malang Regency, Blitar, Kediri and Mojokerto. This research was conducted in June 2016, by sample collection from 9 locations along the river. Heavy metal concentration (Cd, Cu, Cr, Pb, Ni and Zn) in water and sediment were determined through sample extraction then measured using ICP OES (Inductively Coupled Plasma Optical Emission Spectrometry). In water samples, concentration of Cu, Pb and Zn in Pagerluyung exceeded the stream standard in East Java Provincial Regulation No. 2 in 2008, while Zn was also found exceeding the stream standard in Bumiayu, Sengguruh, Kademangan, Mojoroto and Meritjan. Cd concentrations in sediment samples exceeded concentration standard based on Ohio EPA Standard (2010) across all locations. Cr concentration in sediment have exceeded the standard (Ohio EPA, 2010) in Bumiayu, Sengguruh, Kademangan, Mojoroto, Meritjan and Kertosono. Pagerluyung water sample had the highest heavy metal concentration, while Sengguruh and Mojoroto was the highest for sediment samples. Water pollution index can be measured using equation of pollution index referencing to Minister of Environment and Forestry Decree No. 115 in 2003, which made Brantas River categorized as lightly polluted rivers.

***Keywords**: Brantas River, Heavy Metal, Pollution, Quality Standard, Water & Sediments.*

1 Introduction

Brantas River located in East Java Province. With 320 kms long and drainage area covering 12,000 km^2, Brantas River is a source for water supply, transportation, recreational fisheries, conservation, etc. Both domestic and industrial wastewater is discharged into the river, holding in the stand of 483 industries in 14 districts and cities with various industry type such as paper, textiles, sugar, beverages, animal feed and others (SLHD, 2011). Dominating industries in the location were sugar, cigarette, paper and textile, which have characteristics as shown in **Table 1**.

Table 1 Wastewater content characteristics for several types of industry

Type of Industry			
Sugar Industry (Sudhakar, 2015)	*Cigarette Industry (Adenike, 2014)*	*Paper Industry (Bond & Straub, 1974 in Alturkmani, 2009)*	*Textile Industry (Palar, 2012)*
Zinc Nickel Copper Manganese Cadmium Chromium Iron Lead	Zinc Cadmim Copper Cobalt Iron Nickel	Chromium Lead Mercury Nickel Zinc	Chromium Cadmium Nickel Lead Zinc

Prior researches had been conducted in Brantas River, showing some of the location had been exceeding the stream standard based on East Java Provincial Regulation No. 2 in 2008. Maulana (2012) recorded lead content on 3 monitoring points around Sengguruh Dam: (1) Brantas and Lesti intersection, (2) Sengguruh Dam and (3) Sengguruh Dam outlet. Exceeding lead concentration to the stream standard had been found on the intersection and on the dam, expected to occur from industry. Lower concentration at the dam outlet might had occurred due to dilution or precipitation.

In addition to research on heavy metal content, monitoring data on water quality status was conducted. Based on the Minister of Public Works Decree No. 268 in 2010 concerning Management Pattern of Water Resources Regional Brantas River, 76% of water quality status in Brantas River segments was categorized as heavyly polluted and 24% was moderately polluted for water class I; as for water class II, 59% were categorized as severely polluted, 35% moderately polluted and 6% lightly polluted. While based on Yetti, et al. (2011) Brantas river at upstream segment categorized as lightly polluted. Those measurements was calculated using Pollution Index Method (Minister of Environment and Forestry Decree No. 115 in 2003).

The aim of this study is to evaluate the heavy metals (Cd, Cr^{6+}, Cu, Ni, Pb, and Zn) pollution in water and sediment at Bantas river specifically in Malang - Mojokerto segment.

2 Methodology

Sampling points in this study based on East Java Environmental Agency, SNI 6989.57-2008 and distribution of industries in Brantas watershed. Water and sediment samples were collected with the details shown in **Table 2** and **Figure 1**. Determination of sampling point, sample preservation and sample extraction carried out by methods listed in **Table 3**.

Table 2 Sampling Time & Points

No.	*Location*	*Coordinates*	*Date*	*Time (WIB)*
1	Pagerluyung	7˚27'23.544" S 112˚23'48.408" E	01-Jun-16	11.02
2	Pendem	7˚54'35.154" S 112˚34'41.357" E	02-Jun-16	9.05
3	Kertosono	7˚36'05.003" S 112˚06'33.293" E	02-Jun-16	12.18
4	Meritjan	7˚46'55.628" S 112˚00'29.567" E	02-Jun-16	15.07
5	Waru Turi Dam	7˚45'54.242" S 112˚01'28.299" E	02-Jun-16	16.02
6	Mojoroto	7˚48'50.078" S 112˚00'28.625" E	02-Jun-16	17.04
7	Bumiayu	8˚00'13.561" S 112˚37'59.042" E	03-Jun-16	8.34
8	Kademangan	8˚08'45.336" S 112˚08'32.283" E	03-Jun-16	11.54
9	Sengguruh	8˚10'56.855" S 112˚32'48.401" E	03-Jun-16	17.13

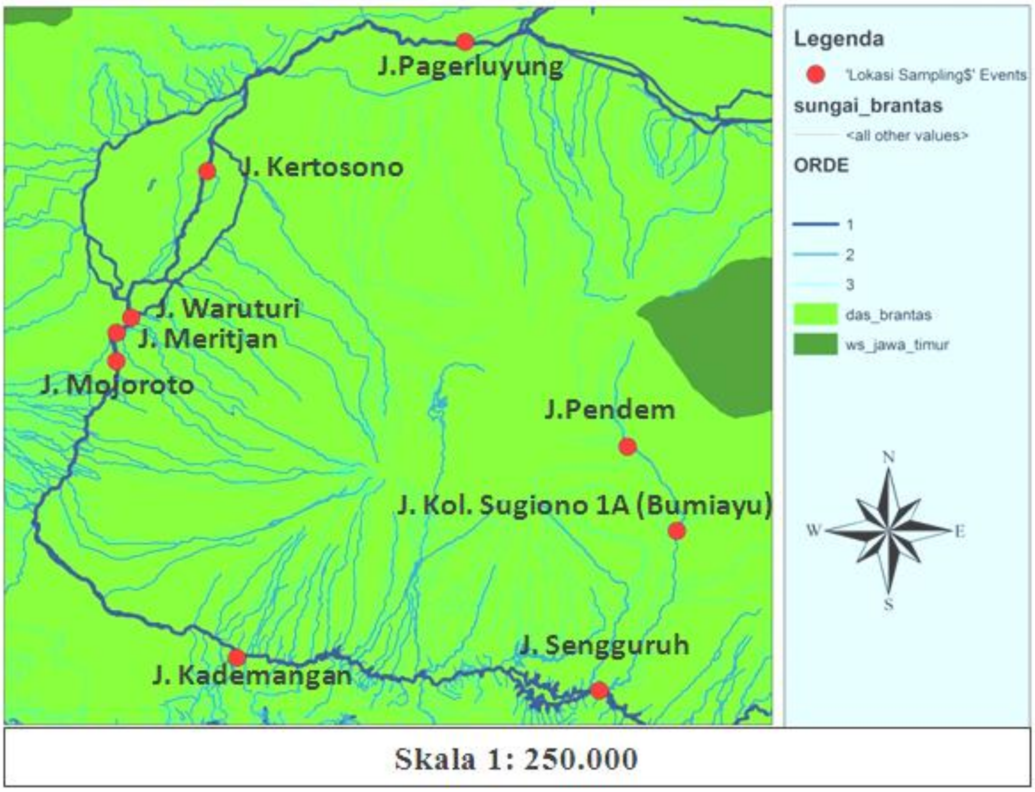


Figure 1 Sampling Points

(Source and modified: Local Development Planning Agency of East Java Province, 2015)

Table 3 Reference Methods

No.	*Methods*	*Standard Methods*
1.	Sampling point determination	SNI 6989.57-2008
2.	Water sample collection	SNI 6989.57-2008
3.	Sediment sample collection	Ohio EPA (2015)
4.	Water sample preservation	SMEWW 21st Edition (2005)
5.	Sediment sample preservation	US EPA (3050b) (2007)
6.	Water sample examination	SMEWW 21st Edition (2005)
7.	Sediment sample examination	US EPA (3050b) (2007)

The quality standard used to determine the quality of water is from East Java Regional Regulation No.2 2008 and for sediment, the quality standard based on OHIO EPA 2010 about Guidance on Evaluating Sediment Contamination Results **(Table 4)**.

Heavy metal measurements in this study were chromium, cadmium, copper, nickel, lead and zinc.

Table 4 Water and Sediment Quality Standard

Parameters	*Standards*	
	Water (mg/L) (East Java Prov. Reg. No 2/2008)	**Sediment (mg/kg dry weight)** (Ohio EPA, 2010)
Cd	0.01	0.99
Cr	0.05	43.3
Pb	0.03	35.8
Zn	0.05	121
Cu	0.02	31.6
Ni	-	22.7

3 RESULT AND ANALYSIS

3.1 Distribution of Industry

Data from Environmental Agency of East Java Province (2015) showed that 150 different types of industries around Brantas river discharged their wastewater into the river basin, that shown in **Figure 2** and in **Table 5** it is shown the industry density at 9 sampling point.

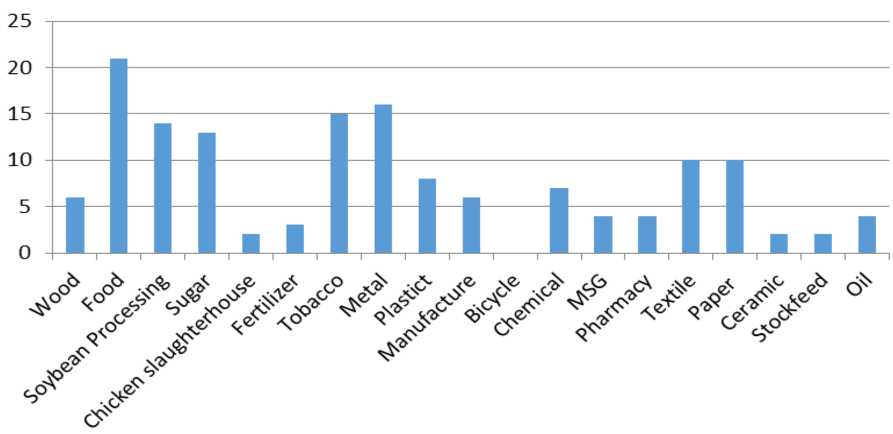


Figure 2 Distribution industries in the Brantas watershed (Source: East Java EPA, 2015)

The dominant industries around the Brantas river are food industry (14%), soybean (10%), sugar (9%), cigarette (10%), metal (11%), paper (7%) and textile (7%).

Table 5 Industrial density at 9 sampling points, (EPA of East Java Province, 2011-2015)

Location	*Wood*	*Food*	*Soybean*	*Sugar*	*Fertilizer*	*Cigarette*	*Metal*	*Plastict*	*Manufacture*	*Chemical*	*Farmacy*	*Textile*	*Pulp and Paper*	*Animal feed*	*Total*
Pendem															0
Pendem-Bumiayu		3		1		3	1	1							9
Bumiayu-Sengguruh		3							2		1	2	1		9
Sengguruh-Kademangan		4	4	1	2			1							12
Kademangan-Mojoroto	1	1	1		1	5	8	4	4	2		5	1		33
Mojoroto-Waru Turi		4				1									5
B. Waru turi-Meritjan		4				1									5
Meritjan-Kertosono	1	4		2									1		8
Kertosono-Pagerluyung	4	10				5		1		3	3		1	1	28
Total															109

In Table. 5 can be seen areas with high industrial density is Brantas River middle segment that is Kademangan to Mojoroto and Brantas River downstream segment that is Kertosono to Pagerluyung.

3.2 Measurement of Physical and Chemical Parameters

Table 6 shows measurement result of physical and chemical parameters at 9 sampling point.

Temperature varies during research in the range of 24.6 - 31,3 ^oC. River water temperature met the stream standard of East Java Regional Regulation No. 2, 2008, which is ± 3 of the temperature at each measurement location.

Table 6 Physycal and chemical parameters measurement results

Location	*Temperature (˚C)*	*pH*	*Brightness(cm)*	*DO (mg/l)*	*Conductivity(µs/cm)*	*TDS (mg/l)*	*Turbidity (NTU)*
Pendem	28,4	7,7	14,5	6,8	335	711	221
Bumiayu	24,6	7,3	49	6,2	369	701	106
Sengguruh	27,6	7,3	26	6,1	392	811	51,6
Kademangan	31,3	6,9	33	6,5	366	805	42,7
Mojoroto	28,5	7,1	37	5,1	383	819	39,7
Meritjan	28,6	6,9	27	5,4	380	769	32
Waru Turi	29	6,5	25	3,6	391	814	30,6
Kertosono	28,9	7,1	13	5,7	378	535	50,8
Pagerluyung	28,3	7,5	25	6,7	333	826	35,4
Rata-rata	28,36	7,1	27,7	5,8	370	755	67,76

pH or acidity of the water describes hydroxide ions concentration in water, which in all sampling point measurement met the standard. pH tends to decrease from upstream to downstream (Effendi, 2003) and affected by temperature, photosynthesis, respiration, dissolved oxygen and the presence of ions in the water.

Brightness is one of physical parameters inversely correlating with turbidity in the water. The range of brightness ranged from 39 – 54 cm. Brightness tends to decrease from upstream to downstream, whereas turbidity occurred the other way around. Turbidity is generally caused by particles suspended in water (Effendi, 2003).

Dissolved oxygen is a parameter that describes oxygen content in water. DO ranged from 3.6 to 6.8 mg / L, making point 5 the only location did not met the stream standard. This might occur due to high organic content. Trash floating in the river was found in this location along with water hyacinth plants, indicating high organic content (Ratnani, et al., 2010).

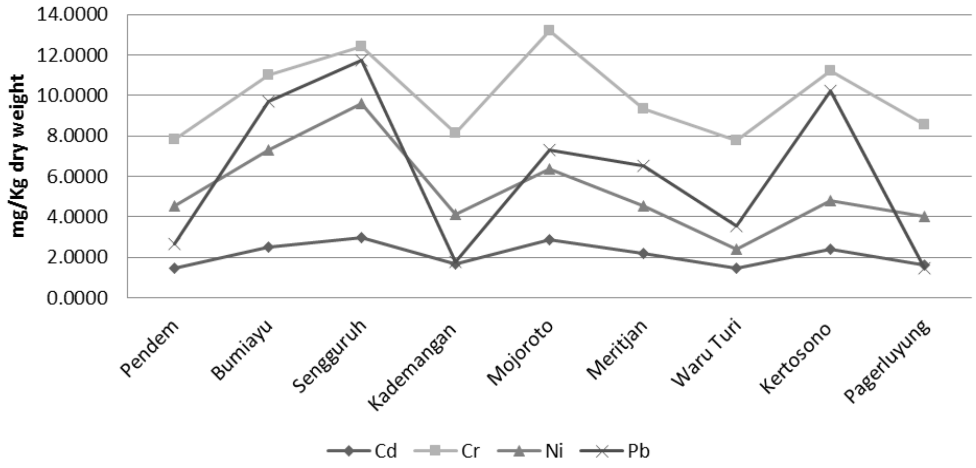
Conductivity shows ability of water to deliver electric current due to presence of dissolved ionized minerals, ranged from 333-392 µs / cm. Location 9, which is an upstream area, had the highest condutivity. Having prior background data from

East Java EPA, conductivity values in this study were still around the measurement results from East Java EPA data.

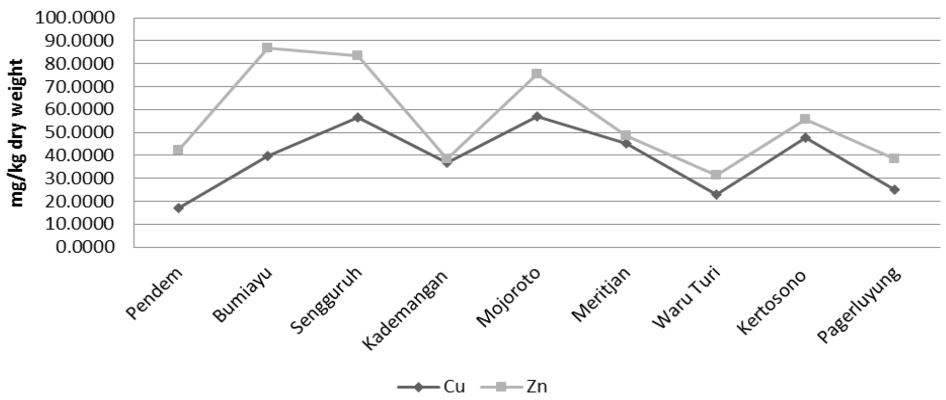
3.3 Heavy Metal in Sediment

Heavy metal content in sediment is shown in **Figures 3a** and **3b**. In **Figure 3a**, cadmium in sediments fluctuated and has range 1.46 to 2.99 mg/kg dry weight, making cadmium at all sampling location exceed the sediment quality standard. The highest cadmium content in sediment sample was on Sengguruh and Mojoroto. Sengguruh receives the water flow from Lesti river, creating possibility of contaminant accumulation and cadmium content from paper and plastic industries. According to Bond & Straub (1974) in Alturkmani (2009), wastewater of paper industry contains cadmium. High cadmium concentrations in Mojoroto might occur due to tofu, sugar and cigarettes industry. Concentrations of chromium and lead ranged from 7.84 to 13.2 mg/kg dry weight for Cr and 1.44 to 11.72 mg/kg dry weight for Pb, which in all sampling location was below the standard. Despite their relatively low concentration, the highest chromium concentration was found in Mojoroto while lead in Sengguruh. Based on references in **Table 1,** lead content was found in cigarette industry, while chromium and lead was found in sugar and paper industry, and there were paper and plastic industries in Sengguruh.

Nickel concentration in all sediment sampling location met the standard, and has ranged from 2.39 to 9.6 mg / kg dry weight with Sengguruh as the highest nickel concentration among all samples. This might occur not only because Sengguruh received waterflow from Lesti river, but also there were paper and plastic industries around.



(a)



(b)

Figure 3 Concentration of Heavy Metals In Sediments (a) Cd, Cr, Ni, Pb and (b) Cu & Zn

Copper in sediment samples at all sampling points ranged from 16.94 to 56.67 mg/kg dry weight, making Bumiayu, Sengguruh, Kademangan, Mojoroto, Meritjan and Kertosono exceeded the quality standard of copper in sediment. Sengguruh had the highest copper concentration, which might occur due to accumulation of contaminants from Lesti and the surrounding paper and textile industries.

Zinc concentration in all sampling point varied from 31.415 to 86.945 mg / kg dry weight. Despite lower zinc concentration in all sampling point compared to sediment quality standard, Bumiayu sediment sample had the highest Zn content, which might occur due its dense residential population and industries around. Domestic waste and wastewater is known to be the cause of high zinc content.

Pendem had industrial activity, but heavy metal content had been detected. Pendem is located in Batu, which is famous for agribusiness activities, that use pesticides or fertilizers in production activities. According to Bond & Straub (1974), pesticides and fertilizers contains cadmium.

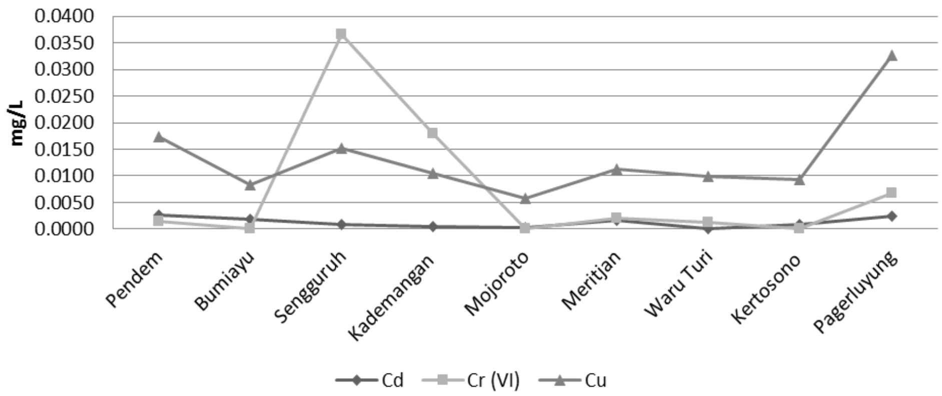
Lowest concentration for almost all heavy metals in this study were at the Waru Turi, despite several industries located in this area. This relatively low heavy metal content in sediment may occur can be because of its rough texture sediment. According to Parera (2004), heavy metal affinity in between sediment and its environment decreases when the sediment has coarse-textured and/or similar to sand, and will increase on silky texture sediment that resembles mud.

3.4 Heavy Metal in Water

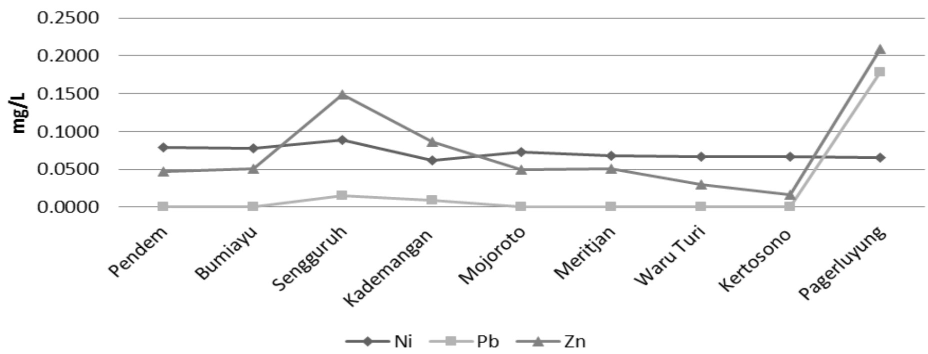
Heavy metal in water analysis results are shown in **Figure 4**. It appeared that cadmium and hexavalent chromium in the water had detectable range-0.0026 mg / L and undetected-0.0367 mg / L, which is below the standard. The highest cadmium concentration was at Pendem, famously known for its agrobusiness activities. According to Bond & Straub (1974), contained cadmium in pesticides / fertilizers. The highest hexavalent chromium content was found at Sengguruh point, which had paper and plastic industry.

Figure 4a shows copper concentration ranged from 0.0058-0.0327 mg/L. Pagerluyung was the only location exceeding the quality standard,that might occur because of the agricultural areas. Agriculture areas in Indonesia generally use pesticides for production process, which containes heavy metals such as copper (Bond & Straub, 1974).

Figure 4b shows that nickel ranged from 0.062-0.089 mg/L. Stream standard for nickel has not been set in the East Java Provincial Regulation No. 2/2008. Nickel content in water samples was measured quite high compared to other parameters, whereas the highest concentrations of nickel were in Sengguruh. Paper and plastic industry operated around the area, creating possibility for nickel contamination (Bond & Straub, 1974).



(a)



(b)

Figure 4 Concentration of Heavy Metals in Water (a) for Cd, Cr (VI), Cu and (b) Ni, Pb, Zn

The concentration of lead and zinc in 9 locations ranged from undetected value to 0.178 mg / L (Pb) and 0.0162-0.2086 mg/L (Zn). Compared with the quality standard, cadmium content exceeded the standard at Pagerluyung, while for zinc the location that exceed quality standard were Bumiayu, Sengguruh, Kademangan, Mojoroto Meritjan & Pagerluyung. Pagerluyung water sample had the highest zinc content, which might occur because of the high agribusiness activity.

3.5 Water Pollution Index

Water Pollution Index was used to determine water quality status. Brantas River water pollution index at 5 points (Pendem, Sengguruh, Kademangan, Meritjan and Kertosono) for 5 years period is shown in **Table 7**. The data was sourced from East Java EPA from 2011-2015 and parameters used to calculate the index is temperature, pH, DO, TSS and several heavy metals (Cd, Cr^{6+}, Cu, Pb and Zn).

Table 7 Water pollution index in Brantas

Location/ Year	*2011*		*2012*		*2013*		*2014*		*2015*	
	IP	Category	IP	Category	IP	Category	IP	Category	IP	Category
Pendem	2.96	Lightly Polluted	3.00	Lightly Polluted	2.40	Lightly Polluted	2.55	Lightly Polluted	2.39	Lightly Polluted
Sengguruh	2.97	Lightly Polluted	3.13	Lightly Polluted	2.42	Lightly Polluted	2.39	Lightly Polluted	2.59	Lightly Polluted
Kademangan	2.96	Lightly Polluted	2.73	Lightly Polluted	2.40	Lightly Polluted	2.38	Lightly Polluted	2.39	Lightly Polluted
Meritjan	2.97	Lightly Polluted	2.74	Lightly Polluted	2.40	Lightly Polluted	2.40	Lightly Polluted	2.40	Lightly Polluted
Kertosono	2.98	Lightly Polluted	2.76	Lightly Polluted	2.74	Lightly Polluted	4.26	Lightly Polluted	2.98	Lightly Polluted
Average	2.97	Lightly Polluted	2.87	Lightly Polluted	2.47	Lightly Polluted	2.80	Lightly Polluted	2.55	Lightly Polluted

Calculations results was measured using equations pollution index based on Minister of Environment Decree No. 115 in 2003, and the result shows Brantas River categorized as lightly polluted river from 2011-2015.

4 CONCLUSION

Dominating industry around Brantas watershed varied from food industry, soybean, metal, cigarette to sugar industry. High industrial area density was found in Kademangan to Mojoroto for middle stream, and Kertosono to Pagerluyung for downstream of Brantas River.

Cadmium (Cd), hexavalent chromium (Cr VI) and nickel (Ni) content in water tend to decrease from upstream to downstream, while lead (Pb), copper (Cu) and zinc (Zn) had the opposite condition. Pagerluyung had worse water quality compared to other location based on exceeding copper, lead and zinc content compared to stream standard in East Java Provincial Regulation No 2 in 2008. Based on observation during this research, textile industries and agriculture area was found at around this sampling point. Pesticide use on agricultural land was one of the possibility of the cause, considering pesticide may contain heavy metals such as cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), copper (Cu) and zinc (Zn).

In sediment samples, heavy metal (Cd, Cr, Cu, Pb, Zn & Ni) tend to decrease from upstream to downstream. Cadmium concentration exceeded the standard at all sampling points, while copper concentrations exceeded in Bumiayu, Sengguruh, Kademangan, Mojoroto, Meritjan and Kertosono. Sengguruh and Mojoroto were found having worse contamination, because those location had the highest heavy metal concentration, namely cadmium, copper, chromium and lead.

Water quality index measurement using temperature, pH, DO, TSS, and several heavy metal (Cd, Cr^{6+}, Cu, Pb and Zn) parameters, referring to 5 monitoring points of East Java EPA; Pendem, Sengguruh, Kademangan, Meritjan and Kertosono, Brantas river was categorized as lightly polluted rivers from 2011 to 2015.

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