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*"Accelerating the Development on
Environmental Friendly Infrastructure"*

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WELCOME MESSAGE

Dear Colleagues,

In this opportunity of the 2nd International Seminar on Infrastructure Development (ISID 2014), on behalf of the Organization Committees, we would like to welcome all of you to attend this prestigious conference in Balikpapan, East Kalimantan.

The ISID 2014 compiles 51 papers that have been submitted and accepted for presentation in plenary session and parallel technical session. The presentation is divided into several sessions, such as water resources, structural and material engineering, geotechnical and geo-environmental engineering, transportation and urban planning, and construction management. Invited speaker from well-known universities and government officials will present their technical and research papers.

We sincerely thanks to all member of the Scientific Committee who have contributed idea and time to support the organization of this seminar. We would like also to thank all our colleagues in the Organizing Committee that having given hard efforts to prepare this seminar.

Finally, we wish this seminar will have a great success; all participants will deepen their knowledge and experience during the technical sessions and will widen their networking with the colleagues in the same fields of research. I do hope you will have a sweet memory in Balikpapan.

Yours Sincerely,

Tri Harianto
Chairman

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WORKABILITY AND COMPRESSIVE STRENGTH OF SELF COMPACTING CONCRETE USING SEAWATER AS MIXING WATER

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ABSTRACT: Self Compacting Concrete (SCC) is one of concrete technology innovation which effective and efficient. SCC has properties of high fluidity and so that is able to flow through the reinforcement without any segregation of material and fill the spaces in the mold little or without compaction process. Workability of fresh concrete can be said as SCC if qualified filling ability, passing ability and segregation resistance.

The aim of this study was to determine the workability and compressive strength of the SCC using seawater as mixing water. Measurement of workability on fresh concrete used EFNARC standard which includes slump flow test, V-funnel and L-box. Compressive strength test of concrete used ASTM standard 39 / C 39M – 99. The test conducted at the age of 1, 3, 7, and 28 days. The results showed that the workability of fresh concrete using sea water as mixing water qualified as SCC. Compressive strength of SCC using seawater as mixing water had a high compressive strength at an early age compared with SCC using fresh water. This paper is a part of ongoing research studying about microstructure characteristics and the strength of SCC using sea water.

Keywords: Self compacting concrete, seawater, workability, compressive strength.

1. Introduction

Indonesia is the world's largest archipelagic state that consists over 7.9 million square kilometers of sea water and 18.000 islands. It makes many areas that have not qualified water as drinking water. In concrete construction, the use of sea water in mixing is always avoided. Whereas, as we know that concrete construction building in the region has possibly minimum or non-existent amount of fresh water, the using of sea water in mixing concrete and curing concrete is unavoidable. Beside that there are some areas where seawater is used as mixing water with or without intension. The demand of water is getting more and more increasing in both the improvement of infrastructure development and the life need. Therefore, saving fresh water is essential to do by utilizing sea water due to it is an abundant natural resource.

In this life cycle, the civil engineering world, especially on the developed countries have been thinking about the next challenge will be lessening the potential for clean water (fresh water) which can be used as mixing concrete. If the use of sea water on the concrete industry and infrastructure development is permitted, fresh water will be much saved.

Sea water contains of Sodium Chloride (NaCl), which gives the effect to the concrete. As what had been researched in the previous studies, the addition of NaCl to fresh concrete will form Friedel's salt crystals ($3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CaCl}_2 \cdot 10\text{H}_2\text{O}$) which is improve pH and alkalinity to be higher, so it will enable hydration of cement and also give more solid structure with smaller pores [13]. The using sea water as mixing water in the concrete are safe, which it has little influence on the strength and corrosion [9,10].

Sea water can be used as mixing water and concrete curing water which concrete cured in the air has hydration process doing bad than it many pores and cracks but otherwise if it cured in sea has hydration process doing great [16]. Sea water accelerated the early age strength development of concretes that were shown to increase for specimens mixed and cured in seawater at early ages up to 14 days [2, 14]. Sea water or water quality are not the factors that affect corrosion in concrete instead of the permeability of the concrete and the lack of concrete cover [5].

Self compacting concrete (SCC) was first developed in Japan. It is one solution to overcome the shortage of the skilled workers. Fresh SCC has high fluidity so that it is able to flow and fill the spaces in the mold with little or no vibration process. Beside that, SCC is one of the solutions to get concrete structures that have good durability [8].

SCC resistance to attack by sulfuric acid and chloride, which durability of SCC is better than conventional concrete (CC) [3]. Modulus of elasticity, creep and shrinkage of concrete SCC did not differ significantly with normal concrete and normal concrete and SCC after doing maintenance on up to 900 days in both marine and fresh water, there are not differences in mass and damage caused by sulfate [11, 12]. SCC permeability decreases with increasing strength and quantity as well as high-volume fly ash showed the chloride ion permeability was significantly lower than normal concrete [4].

In according with the above issues, the authors are interested to research the use of sea water using concrete technology effectively and efficiently This paper is a part of ongoing research studying about microstructure characteristics and the strength of SCC using sea water.

2. Concrete of Materials

Mixing water used in the SCC are sea water and fresh water as a comparison. In addition to the water used as mixing water, is also used to cure concrete. Sea water has a specific gravity of 1.01 and pH 8.

2.1. Cement

In this study, the SCC design does not use filler, but instead uses Portland Composite Cement (PCC), which the PCC containing of fly ash.

2.2. Water

This study uses seawater as mixing water in the SCC. In addition, the researchers made of SCC using fresh water as a comparison. In addition to the water used as mixing water, it is also used to cure concrete. Sea water have specific gravity 1.01 and pH 8.

2.3. Aggregate

This study used crushed stone with a maximum size of 20 mm and fine aggregate with a maximum size of 4.75. The aggregate is local materials. The specific gravity of crushed stone and sand are 2.62 and 2.57, respectacly.

2.4. Admixtures

Superplasticizer is used A-3115 ViscoCrete. A ViscoCrete-3115 is a third-generation superpasticizer.

3. Mix Design of SCC

In the design of SCC, the proportion of materials used method The European Federation of Specialist Chemicals and Concrete Constructions Systems [6, 7]. In the design used 1.1 ratio volume of water/cement.

The proportion of mix design in detail can be seen in Table 1

Table 1. Mix design concrete (in 1 m³)

Seawater (kg)	Cement (kg)	Sand (kg)	Crushed Stone (kg)	Superplasticiser (kg)
203.99	601.36	770.04	785.21	6.01

4. Method of Experiment

Before the mixing, all materials and tools that will be used are prepared. Mixing process is done in three stages. First, fine sand and coarse aggregate (saturated surface dry and water) are mixed together for about 1 minute. Second, enter into a cement mixer containing aggregate, approximately 1-2 minutes. Third, After dry mixing homogeneously, then enter the water was mixed with a mixer superplasticizer and about 2-3 minutes and see the mix to ensure a homogeneous mixture. Then the mixture is ready to use a test known workability with slump flow and T50, V funnel and L-Box. After knowing and meet the requirements of SCC is then inserted into the cylinder size of 10 x 20 mm. Samples made a total of 24 cylinders for each of the 3 samples in 1 (one variation of age or water mixing). Compressive strength test were conducted at the age of 1, 3, 7, and 28 days.

For the compressive strength test used a cylindrical specimen with a size of 10 mm x 20 mm. Compressive strength testing performed at the age of 1, 3, 7, and 28 days. Compressive strength testing method follows the ASTM test standard 39 / C 39M – 99 [1]. Tool Universal Testing Machine (UTM) is used to test the compressive strength by providing static monotonic uniaxial compressive load at an average speed of 0.14 to 0.34 MPa /sec. Compressive strength can be calculated by equation 1.

$$f_c = \frac{P}{A} \quad (1)$$

Where f_c = Compressive strength (MPa), P = load maximum P (N), and area surface A (mm²)

Based on Specifications and guidelines for SCC, the workability of fresh concrete can be said SCC if it meets the requirements of the filling ability, passing ability and segregation resistance. Based on the method EFNARC [6, 7], fresh concrete measurements performed in this study are as follows:

4.1. Slump flow and T500

The slump flow and T500 time tests to assess the flow ability and the flow velocity of SCC in the absence of obstacle. The results are an indication of the filling ability of SCC. The T500time is also a measure of the flow velocity and the viscosity of the SCC. This test used a plate. See figure 1.

The fresh concrete is poured into a cone as used for slump test of conventional concrete. When the cone is withdrawn upwards the time from commencing upward movement of the cone to when the concrete has flowed to a diameter of 500 mm is measured; this is the T500 time. The largest diameter of the flow spread of the concrete and the diameter of the spread at right angles to it are then measure Dan d the mean is the slump flow [6, 7]

Figure 1 Plate and Slump cone

4.2. V-funnel test

The V-funnel test is used to assess the viscosity and filling ability of self compacting concrete. It shows in Figure 2. V-funnel, made to the dimensions (tolerance ± 1 mm) in figure 2, equipped with watertight gate at its base. it shall be made from metal, the surfaces shall be smooth.

Clean the funnel and bottom gate, the dampen all the inside surface including the gate. Close the gate and pour the sample of concrete into the funnel, without any agitation or rod ding, then strike off the top with the straight edge so that the concrete is flush with the top of the funnel. Place the container under the funnel in order to retain the concrete to be passed. After a delay of (10 ± 2) s from filling the funnel, open the gate and measure the time t_v , to 0.1s, from opening the gate to when it is possible to see vertically through the funnel into the container below for the first time. t_v is the V-funnel flow time [6, 7]

Figure 2. V-Funnel

4.3. L-box

The L-box test is used to assess the passing ability of self compacting concrete to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking. There are two variations; the two bar test and the three bar test. The three bar test simulates more congested reinforcement. This research is used to the two bar test. The L-box test as shown in Figure 3.

Figure 3. L-Box Test

The L-box has a level horizontal base and closes the gate between the vertical and horizontal sections. Pour the concrete from the container into the filling hopper of the L-box and allow standing for (60 ± 10) s. Record any segregation and then raise the gate so that the concrete flows into the horizontal section of the box. When movement has ceased, measure the vertical distance, at the end of the horizontal section of the L box, between the top of the concrete and the top of the horizontal section of the box at three positions equally spaced across the width of the box. By difference with the height of the horizontal section of the box, these three measurements are used to calculate the mean depth of concrete as H_2 mm. The same procedure is used to calculate the depth of concrete immediately behind the gate as H_1 mm [6, 7].

5. Result and Discussion

5.1. Workability test of SCC

In this study, workability of concrete using fresh water (SCC-FF) and concrete using sea water (SCC-SS) qualified as SCC. Test results on the workability of fresh concrete are shown in Table 2. From Table 2 shows that the slump flow and L-box on the fresh concrete SCC-FF were longer than SCC-SS. And the T500 and V-funnel value of SCC-FF were smaller than SCC-SS. Of the value of T500, SCC sea water has more time to until at the circle diameter of 500 cm. However, SCC workability of of fresh water and sea water SCC qualified as.

Table 2. Workability test result of SCC

Mix code	Slump flow	T500	V-Funnel	L-Box (H_2/H_1)
	(mm)	(sec)	(sec)	Ratio
SCC-fresh water (SCC-FF)	722.50	2.47	9.31	0.96
SCC-seawater (SCC-SS)	678.50	3.36	10.36	0.87
Criteria for SCC by EFNARC [8],[9]				
min	650 mm	2 sec	6 sec	0.8

max 800 mm 5 sec 12 sec 1.0

5.2. Compressive strength of SCC

From the research, the compressive strength of concrete using fresh water or sea water can be seen in Table 3.

Tabel 3. Compressive strength and age relationships

Age (day)	Compressive strength (MPa)		Difference Compressive strength (%)
	SCC-FF	SCC SS	
1	9.11	14.97	39.19
3	25.55	31.27	18.27
7	35.22	38.02	7.38
28	50.58	51.92	2.58

Figure 4. Compressive strength with age of SCC

Figure 5. Compressive strength difference of SCC

From Figure 4 shows that the compressive strength of concrete increase with increasing age. It occurs in both types of concrete. In addition, from the image is also seen clearly that the compressive strength of the SCC that uses sea water is higher than the SCC using fresh water.

Both concrete compressive strength differences can be seen in Figure 5. From figure 5, it is seen that the difference is very high compressive strength of concrete occurs at a young age the concrete age at the age of 1 and 3 days were 39.19% and 18.27%. In the next age increasingly small and almost the same compressive strength. Compressive strength of the SCC using sea water is higher because the possible influence of the salt content in the sea water accelerates the strength of concrete. The result agreed with the previous conducted by Falah M. W [14], the compressive strength of normal concrete were shown to increase for specimens mixed and cured in seawater at early ages up to 14 days. Also, the presence of chlorides accelerated the early age strength development of slag concrete up to about 7–14 days [2]. The compressive strength of mortar using sea water accelerates strength mortar. Differences compressive strength of mortar using sea water with mortar using aquades was high. It occurs at an early age mortar. At the age of 28 days, the strength of the mortar that uses sea water and aquades was almost the same [5]

Figure 6. f_{c28}/f_{cn} Ratio with age of SCC

From Figure 6 show that the f_{c28}/f_{cn} ratio at the age of 1 until 7 days, the SCC using sea water (SCC-SS) is higher than the SCC using fresh water (SCC-FF). And at an early age concrete is very high at the age of 1 and 3 days were 37.58% and 16.10%. That event is almost the same as the difference between the compressive strength of the SCC using fresh water (SCC-FF) with the SCC using sea water (SCC-SS).

6. Conclusions

- 1) Both SCC-FF and SCC-SS have workability qualified as SCC.
- 2) Slump flow of SCC-FF was higher than of SCC-SS, and conversely the value of T500 and V-funnel of SCC-SS is higher than the SCC-FF
- 3) At L-Box Test, H2/H1 ratio in concrete using fresh water better than the sea water.
- 4) Sea water has an effect on the strength of SCC-SS which accelerates strength of concrete at early age concrete of 1 and 3 day.

- 5) Difference the compressive strength / compressive strength at 28 days on concrete SCC-SS is high at the age of 1 and 3 days (early age) than with SCC-FF.

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