COMPRESSIVE STRENGTH AND SLUMP FLOW OF SELF COMPACTING CONCRETE USES FRESH WATER AND SEA WATER

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ABSTRACT

SCC concrete has high fluidity that is able to flow and to pass without segregation of reinforcement material and fill the spaces in the mould with little or no compaction process, resulting in a more impermeable concrete. This paper discusses the effect of sea water as mixing water on workability of the fresh state of the SCC (slump flow test and T50) as well as an increase the compressive strength of the SCC using sea water and fresh water as a comparison. Test of Slump flow and T50 using standard EFNARC. The compressive strength was tested using ASTM standard 39 / C 39M - 99. Tests were conducted at ages 1, 3, 7, 28 and 90 days. The results showed that the slump flow of SCC using sea water is smaller than that using the freshwater SCC. SCC uses sea water has an excellent workability, segregation and aggregate does not seem equitable. The increase in compressive strength in SCC uses sea water has differences with SCC using fresh water at the age of 1, 3, 7, 28 and 90 days by 11%, 9%, 3%, 0% and 0%. The increase in compressive strength of concrete SCC uses sea water very quickly at the early age at the age of 1 and 3 days compared with an increase in the compressive strength of concrete SCC uses fresh water. The increase in compressive strength SCC uses sea water at the age of 1 to 28 days is greater than the SCC that uses fresh water, but otherwise at the age of 90 days.

Keyword: self compacting concrete, sea water, fresh water, compressive strength, slump flow.

1. INTRODUCTION

Indonesia is an archipelagic so many areas that the quality of the water source does not qualify as a drinking water. Development of concrete constructions in areas that are likely quantity of water / fresh minimal / no, then the sea water is unavoidable in concrete mixing and maintenance. According to Otsuki, *et al* (2012) that in the near future, water will be very difficult to obtain and limited. Also reveals that the present time, there are some areas where sea water or sand containing chloride has been used as water / ingredients mixing with or without intention [10].

In this life cycle, the civil engineering world, especially in developed countries have been thinking about the next challenge will be lessening the potential for water / fresh water that can be used as an ingredient concrete mixing. If the use of seawater in infrastructure construction and concrete industries are permitted, will be a lot of stored fresh water. As Otsuki *et al*. (2012) stated that the safe use of sea water as mixing water in concrete [9]. Additionally, the study by Tjaronge *et al* (2013, 2014), using seawater as mixing water and water-cured concrete. From the results of the study stated that the sea water can be used as mixing water ([14], [15]).

The durability of high concrete construction need good compaction, where compaction is performed by trained skilled labour. The decreasing-skilled labour force in the world of construction of resulted in concrete sometimes is not compacted properly as lowering the quality of the construction work. As proposed by Okamura and Ouchy (2003), one of the solutions to obtain a concrete structure that has good durability is to use the Self-compacting concrete (SCC). It was first developed in Japan in the middle of 1980s. It began to be used in of concrete constructions in the early the 1990s. It was a solution on a durable concrete structure that is tied to the ability of the job construction. It was able to solidify his own, which can flow into every corner of the mould, because the weight of its own and without the need of vibrator. It is an innovative concept in concrete technology that is effective and efficient. SCC character has a high fluidity property so as to flow and fill the spaces in the mould with little / nothing of compaction process. This can reduce the processing time of compaction due to the high level of liquidity, so the SCC is able to be easily removed and taken through a pump to a high level in the casting storey building as well as the structures that have a very dense reinforcement [9].

Dense concrete has good durability as by Al-Tamimi and Sonebi (2003) have investigated the SCC durability against sulphuric acid and chloride with the result that the SCC durability better than conventional concrete (CC) [3]. Persson, B. (2001, 2003), modulus of elasticity, creep (creep) and shrinkage (shrinkage) of concrete SCC did not differ significantly with normal concrete. Normal concrete and SCC treated up to 900 days at sea and fresh water, with the result that no mass difference and the damage caused by sulphate [10]. Furthermore, Dinakar, P. *et al* (2008) SCC permeability decreases with increasing strength. Quantity and high volume fly ash shows the chloride ion permeability was significantly lower than normal concrete [4].

The research on utilization of seawater using technology of SCC is very appropriate, because the SCC technology combines with sea water, the sea water used for fresh water saving without diminishing strength and durability of concrete. This paper discusses the 1) SCC workability (slump flow and T50) and 2) The increase in the compressive strength of the SCC until the age of 90 days.

2. RESEARCH METHODS

A. Materials

Materials used in the study is Portland Composite Cement (PCC), fresh water, sea water, crushed stone, sand and super plasticizer.

B. The design

The design SCC used the method of The European Federation of Specialist Chemicals and Concrete Constructions Systems (EFNARC [7], [8]). Water-cement ratio of 0.35 is used in the design. Super plasticizer used amounted to 1% of the Powder. Proportion of mixing used ratio of cement, sand, gravel, water to cement weight, they were 1: 1:28: 1:31: 0:35, respectively.

C. The experimental

All the ingredients were mixed with 3 stages. First, fine sand and coarse aggregate (Saturated Surface Dry (SSD)) mixed together for ± 1 min. Second, the cement is inserted into the machine concrete mixer containing aggregate; the mixing is done about 1-2 minutes. Third, after a homogeneous mixture, the water was mixed super plasticizer incorporated into the concrete, and mixing about 2-3 minutes and the mixture is considered in concrete mixer to ensure a homogeneous mixture. Then the mixture is ready to be tested slump flow and T50. After the measurements and observations, where it meets the requirements of the SCC is then inserted into the cylinder size of 10 x 20 mm. The sample is made of 15 cylinders for each of the 3 samples. The test specimen is tested performed before treatment for 1, 3, 7, 28 and 90 days.

Test of Slump flow and T50 is the test to determine the viscosity of SCC without any obstructions. By knowing the workability and slump flow indication filling ability of SCC can be known. The T50 time is also a measure of flow rate and viscosity of the SCC. This test uses the slump cone and plate as shown in Figure -1. The middle of the plate, there should be a line of 500 mm diameter circle has a centre that coincides with the midpoint of the plate.

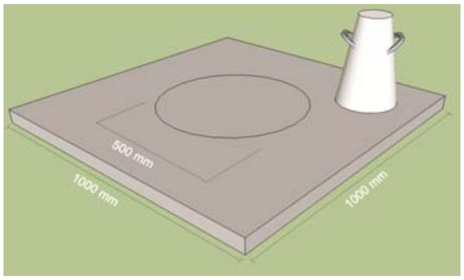

Figure-1. Plate and Slump Cone.

Fresh concrete is poured into the slump cone as used for conventional concrete slump test. T50 is measured when the slump cone is pulled up, the time of start upward movement until the concrete has flowed to a diameter of 500 mm. The largest diameter of the spread concrete flow and the diameter of the spread is then measured and d mean, that's the slump flow value.

Compressive strength test, a cylindrical specimen with a size of 10 mm x 20 mm. Compressive strength testing done at age of 1, 3, 7, 28 and 90 days. Tool Universal Testing Machine (UTM) is used for testing the compressive strength by providing static uniaxial monotonic loading press. Compressive strength testing method follows the ASTM test standard 39 / C 39M - 99 [1].

3. RESULT AND DISCUSSIONS

A. Workability

This research, workability both the fresh state of SCC using fresh water or sea water qualifies as SCC. The test results on the workability of fresh concrete can be seen in Figure-2 and Figure-3, that the slump flow the fresh state of SCC that uses fresh water is higher than the SCC uses sea water. In contrast to the SCC value freshwater T50 smaller than the SCC seawater. Value slump flow and T50 satisfy the standards EFNARC (650-800 mm, 2-5 second ([6], [7]): dashed line in Figure-2 and Figure-3). Difference average value slump flow between SCC uses seawater and freshwater was 6.09%. The difference between average values of the SCC T50 uses sea water to fresh water was 26.66%.

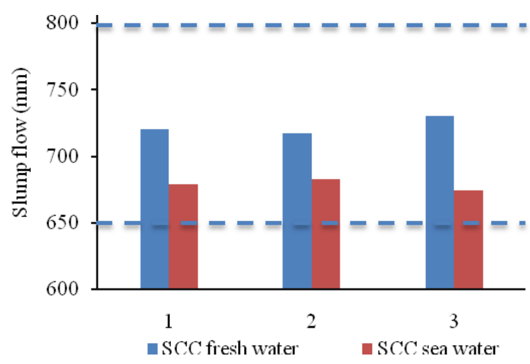

Figure-2. Slump flow the fresh state of SCC.

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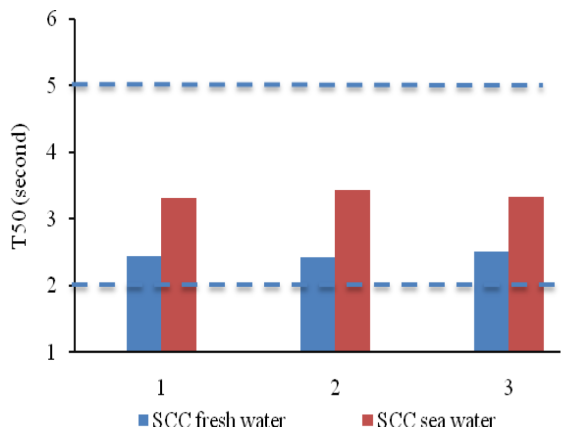

Figure-3. T50 on fresh state of SCC.

T50 value, the fresh state of SCC uses sea water has more time to get to the 50 cm diameter circle. Nevertheless, the slump flow in both SCC uses freshwater and seawater qualified as SCC. Thus in terms of workability of sea water can be used as mixing water in the SCC because qualified as SCC.

From observations the fresh state of SCC uses sea water, the slump flow shows that the deployment of the circular flow, crushed stone does not remain in the centre of the spreading flow after the rapture Abrams' cone. So SCC uses sea water has good workability because the fresh state of SCC looks homogeneous and there is no aggregate segregation and uneven. Although the fresh state of SCC uses sea water appear to be more viscous than the fresh state of SCC uses fresh water as can be seen in Figures 4 and 5.

Figure-4. Slump flow the fresh state of SCC uses fresh water.

Figure-5. Slump flow the fresh state of SCC uses sea water.

B. Improvement of Compressive strength of SCC

Figure-6 shows the compressive strength of the SCC uses sea water and fresh water, in which the compressive strength increased with age. Compressive strength of SCC uses sea water is higher than the compressive strength of the SCC uses fresh water until at the age of 90 days. As previous research by Erniati *et al.* (2013, 2014), that the compressive strength of both mortar and concrete that uses sea water are higher than the compressive strength of mortar and concrete uses distilled water/fresh water [5,6].

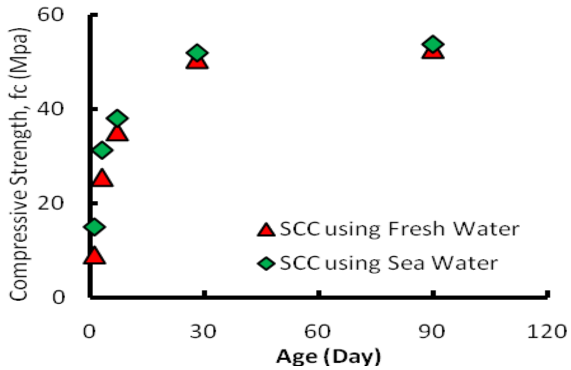

Figure-6. Compressive strength of SCC.

Improvement of compressive strength in SCC uses fresh water at the age of 1, 3, 7, 28 and 90 days were 18%, 50.5%, 69.6%, 100% and 104.2% of the SCC compressive strength at 28 days of 50.58 MPa. Improvement of compressive strength in SCC uses sea water at the age of 1, 3, 7, 28 and 90 days were 28.8%, 60.2%, 73.2%, 100%, and 103.5% of the SCC compressive strength at 28 days of 51.92 MPa. Thus differences in compressive strength increase in SCC that uses seawater to SCC uses freshwater at the age of 1, 3, 7, 28 and 90 days were 10.8%, 9.7%, 3.6%, 0% and 0.7%.

Improvement of compressive strength of SCC uses sea water appears that the rapid increase in compressive strength occurs at the early age at the age of 1 and 3 days. The possibility of the salt content in seawater accelerate the strength of concrete because the possibility of the formation of crystals that give concrete structure is more dense as the study previously by Pruckner, F and Gjorv, OE (2003) that the addition of sodium chloride in the fresh concrete will form crystals friedel' salt (3CaO. Al_2O_3. $CaCl_2$. $10H_2O$) that can improve higher pH, and alkalinity increases so will activate the hydration of cement paste as well as provide a more solid structure with pores smaller [13]. As well as a previous study by Aburawy, MM and Swamy, RN (2008), the presence of chloride accelerates the development of early age concrete strength slag until about 7-14 days [2].

C. The relationship between compressive strength and age of the SCC

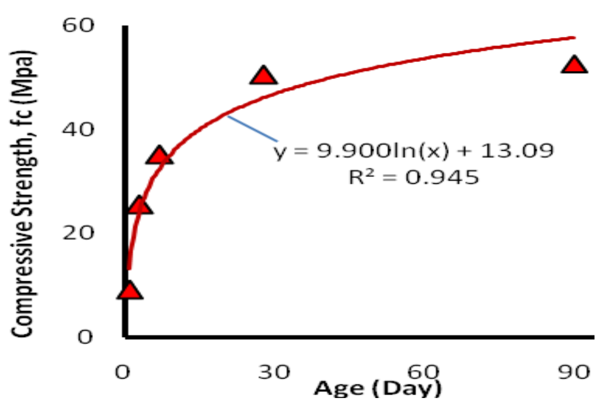

Figure-7. Relationship between compressive strength and age of SCC uses fresh water.

Figure-7 shows the non-linear regression equation, the relationship fc and age at SCC uses fresh water. The regression equation fc and age at SCC fresh water uses is y = 9.9 ln (x) +13.09, with a correlation value of r = 0.972 and the coefficient of determination R2 = 0.945. Relationship correlation value indicates a strong positive correlation, this means that the increasing age also increase the compressive strength. Based on the coefficient of determination, the mean age affects of 94.5% of compressive strength.

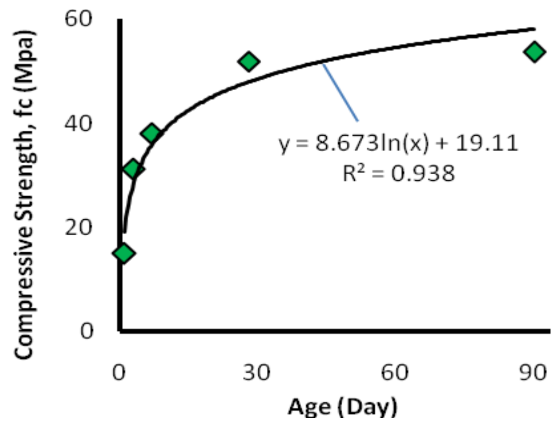

Figure-8. The relationship between compressive strength and age of SCC uses sea water.

Figure-8 shows the non-linear regression equation, the relationship fc and age at SCC uses sea water. Equation relationship between compressive strength and age for SCC uses sea water is y = 8.673 ln (x) +19.11. With a correlation value of r = 0969 and the coefficient of determination R2 = 0.938. Correlation value gave indicates relationship a strong positive correlation, that means the increasing age also increase the compressive strength. Based on the coefficient of determination, the mean age affects of 93.8% of compressive strength.

Slump flow on fresh state of SCC uses fresh water is higher than the slump flow of SCC uses sea water of 6.09%, and conversely T50 value of concrete using sea water is higher than the concrete using fresh water of 26.66%, but the slump flow on fresh state of SCC uses sea water to meet the standards as SCC. Fresh state of SCC uses sea water has good workability, where fresh state of SCC looks homogeneous and it is no segregation. Furthermore, the aggregate look evenly. The difference in the increase on compressive strength of SCC uses sea water with SCC uses fresh water at the age at 1, 3, 7, 28 and 90 days were 10.8%, 9.7%, 3.6%, 0% and 0.7%. Improvement of compressive strength of SCC uses sea water appears that the increase in high compressive strength on an early age that by the age at 1 and 3 days compared with an increase in the compressive strength of the SCC uses fresh water.

4. CONCLUSIONS

Slump flow on fresh state of SCC uses fresh water is higher than the slump flow of SCC uses sea water of 6.09%, and conversely T50 value of concrete using sea water is higher than the concrete using fresh water of 26.66%, but the slump flow on fresh state of SCC uses sea water to meet the standards as SCC. Fresh state of SCC uses sea water has good workability, where fresh state of SCC looks homogeneous and it is no segregation. Furthermore, the aggregate look evenly. The difference in the increase on compressive strength of SCC uses sea water with SCC uses fresh water at the age at 1, 3, 7, 28 and 90 days were 10.8%, 9.7%, 3.6%, 0% and 0.7%.

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