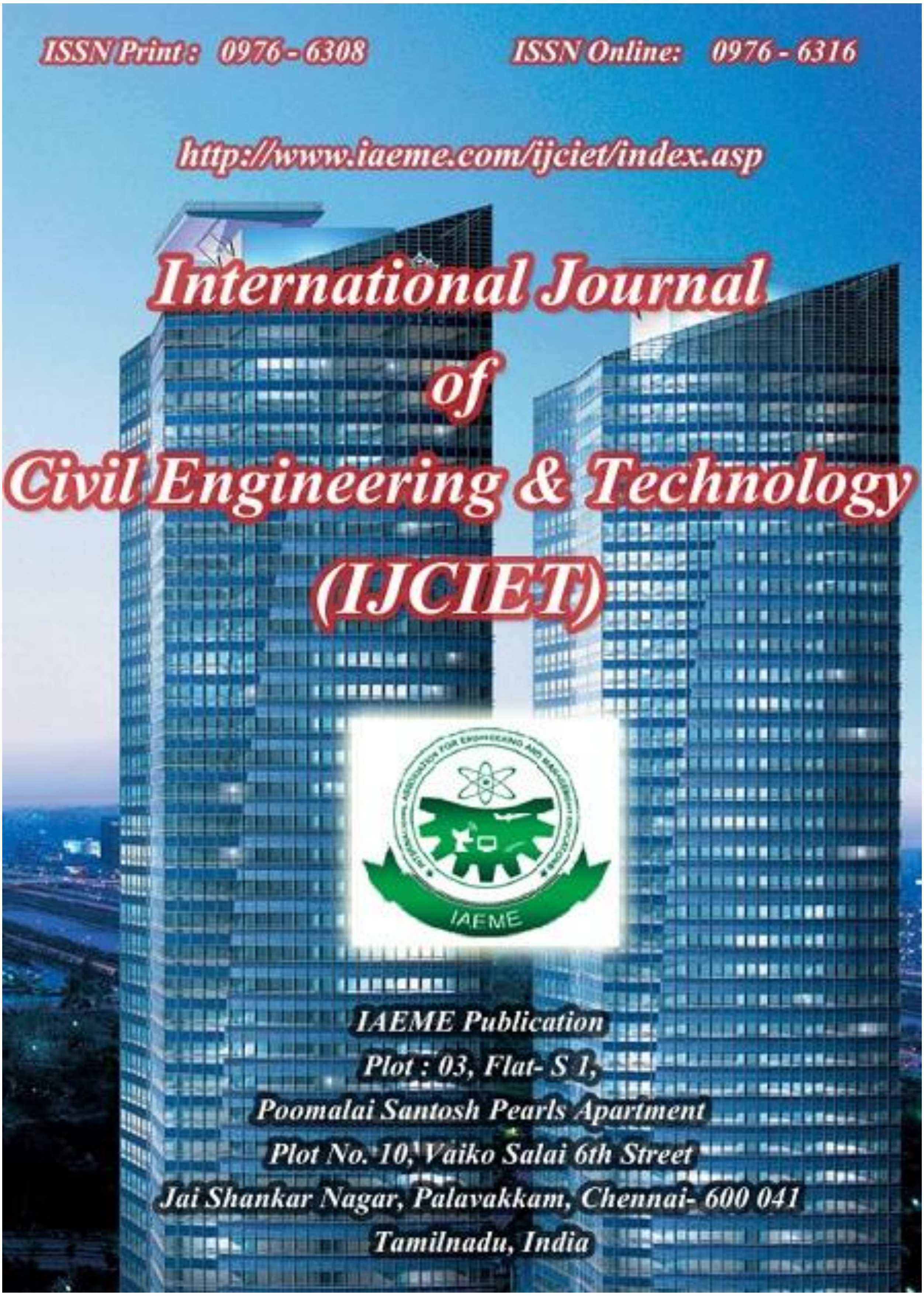
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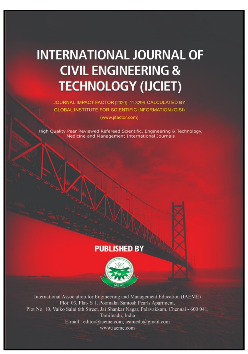

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Volume 9, Issue 9, September 2018 , Articles Published : 207

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Haider Abaid Salomy Al-Amar (https://iaeme.com/Home/author_details/21499) ; Amer Atyah Laftah Al-khalidi (https://iaeme.com/Home/author_details/21500)

Article Id : IJCIET_09_09_051 (https://iaeme.com/Home/article_id/IJCIET_09_09_051), Pages : 508-520

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Article Id : IJCIET_09_09_053 (https://iaeme.com/Home/article_id/IJCIET_09_09_053), Pages : 533-538

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Konstantin Siboro (https://iaeme.com/Home/author_details/21550) ; H. B. Tarmizi (https://iaeme.com/Home/author_details/21551) ; Sya`ad Afifuddin (https://iaeme.com/Home/author_details/21552) ; Rujiman (https://iaeme.com/Home/author_details/21553)

Article Id : IJCIET_09_09_054 (https://iaeme.com/Home/article_id/IJCIET_09_09_054), Pages : 539-547

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Article Id : IJCIET_09_09_056 (https://iaeme.com/Home/article_id/IJCIET_09_09_056), Pages : 556-568

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Article Id : IJCIET_09_09_057 (https://iaeme.com/Home/article_id/IJCIET_09_09_057), Pages : 569-584

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Kariaman Sinaga (https://iaeme.com/Home/author_details/63226) ; Suwardi Lubis (https://iaeme.com/Home/author_details/21638) ; Marlon Sihombing (https://iaeme.com/Home/author_details/10105) ; Ritha F Dalimunthe (https://iaeme.com/Home/author_details/21639)

Article Id : IJCIET_09_09_058 (https://iaeme.com/Home/article_id/IJCIET_09_09_058), Pages : 585-599

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Article Id : IJCIET_09_09_060 (https://iaeme.com/Home/article_id/IJCIET_09_09_060), Pages : 615-627

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Fivi Rahmatus Sofiyah (https://iaeme.com/Home/author_details/63241) ; Yulinda (https://iaeme.com/Home/author_details/13332) ; Iskandar Muda (https://iaeme.com/Home/author_details/17567)

Article Id : IJCIET_09_09_062 (https://iaeme.com/Home/article_id/IJCIET_09_09_062), Pages : 642-657

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Article Id : IJCIET_09_09_063 (https://iaeme.com/Home/article_id/IJCIET_09_09_063), Pages : 658-665

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Article Id : IJCIET_09_09_064 (https://iaeme.com/Home/article_id/IJCIET_09_09_064), Pages : 666-680

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Ami Dilham (https://iaeme.com/Home/author_details/63245) ; Fivi Rahmatus Sofiyah (https://iaeme.com/Home/author_details/21788) ; Iskandar Muda (https://iaeme.com/Home/author_details/21789)

Article Id : IJCIET_09_09_065 (https://iaeme.com/Home/article_id/IJCIET_09_09_065), Pages : 681-695

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Erlina (https://iaeme.com/Home/author_details/62891) ; Zainal Abidin Tarigan (https://iaeme.com/Home/author_details/21815) ; Sri Mulyani (https://iaeme.com/Home/author_details/21816) ; Azhar Maksum (https://iaeme.com/Home/author_details/21817) ; Iskandar Muda (https://iaeme.com/Home/author_details/17567)

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Dina Limbong Pamuttu (https://iaeme.com/Home/author_details/21838) ; Hairulla (https://iaeme.com/Home/author_details/21694)

Article Id : IJCIET_09_09_067 (https://iaeme.com/Home/article_id/IJCIET_09_09_067), Pages : 708-712

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Suyadi (https://iaeme.com/Home/author_details/21848) ; Hairulla (https://iaeme.com/Home/author_details/21694)

Article Id : IJCIET_09_09_068 (https://iaeme.com/Home/article_id/IJCIET_09_09_068), Pages : 713-718

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Pepe Massimiliano (https://iaeme.com/Home/author_details/21882)

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Article Id : IJCIET_09_09_071 (https://iaeme.com/Home/article_id/IJCIET_09_09_071), Pages : 746-758

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Dhangar Laxmi Balappa (https://iaeme.com/Home/author_details/21920) ; Venu Malagavelli (https://iaeme.com/Home/author_details/20951)

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Article Id : IJCIET_09_09_074 (https://iaeme.com/Home/article_id/IJCIET_09_09_074), Pages : 774-781

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Article Id : IJCIET_09_09_076 (https://iaeme.com/Home/article_id/IJCIET_09_09_076), Pages : 792-798

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Kennedy Okokpujie (https://iaeme.com/Home/author_details/5927) ; Etinosa Noma-Osaghae (https://iaeme.com/Home/author_details/5605) ; Odusami Modupe (https://iaeme.com/Home/author_details/22027) ; Samuel John (https://iaeme.com/Home/author_details/22028) ; Oluga Oluwatosin (https://iaeme.com/Home/author_details/22029)

Article Id : IJCIET_09_09_077 (https://iaeme.com/Home/article_id/IJCIET_09_09_077), Pages : 799-809

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Published On : September 27,2018

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Kennedy Okokpujie (https://iaeme.com/Home/author_details/5927) ; Chukwu Emmanuel (https://iaeme.com/Home/author_details/22037) ; Etinosa Noma-Osaghae (https://iaeme.com/Home/author_details/5605) ; Modupe Odusanmi (https://iaeme.com/Home/author_details/22038) ; Imhade P. Okokpujie (https://iaeme.com/Home/author_details/22039)

Article Id : IJCIET_09_09_078 (https://iaeme.com/Home/article_id/IJCIET_09_09_078), Pages : 810-831

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Published On : September 27,2018

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Ahmed A. Alalikhan (https://iaeme.com/Home/author_details/22057) ; Mohsen A. Habelalmateen (https://iaeme.com/Home/author_details/22058) ; Alaa M. Alhabbobi (https://iaeme.com/Home/author_details/22059)

Article Id : IJCIET_09_09_079 (https://iaeme.com/Home/article_id/IJCIET_09_09_079), Pages : 832-841

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THE EFFECT OF W/C AND RICE HUSK ASH (RHA) ON MECHANICAL PROPERTIES OF SELF-COMPACTING CONCRETE (SCC)

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ABSTRACT

One of the innovations in the world concrete industry development is Self Compacting Concrete (SCC), which is known as concrete that can compact by itself. The material used in SCC differs from conventional concrete, for example, the reduction of amount and passing size 10 mm for coarse aggregate, the addition of fine aggregate amount, and the addition of quartz sand with grain size 50 - 650 µm to reduce hydration heat and increase the flow ability and workability on fresh concrete mixtures. In addition, chemical admixture with high-range water reducer (HRWR) type is used to reduce the water use and mineral admixture is also used in the form of rice husk ash as a substitution material for cement use. SCC is expected to reduce the cement use in concrete mixtures which is not environment friendly. This study used variations of w/c = 0.275, w/c = 0.300, and w/c = 0.325 and the rice husk ash by 0%, 5%, 10%, and 15% of the cement use. Flow ability test, and workability test were performed using test equipments such as slump cone test, V-funnel, and L-box to know the SCC criteria. After that, the concrete compressive strength test was performed at age 3, 7, 14, and 28 days with cylindrical samples with size 100x200 mm. The higher use of rice husk ash causes the value of flow ability and workability tends to decrease and the decrease of concrete density. The result of compressive strength test at age 28 days of SCC-10-0.275 mixture showed a significant increase of compressive strength of 70.528 MPa and the minimum compressive strength was 46.679 MPa for mixture SCC-15-0.325.

Key words: Self compacting concrete, V-funnel, L-box, rice husk ash, flow ability

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1. INTRODUCTION

Concrete is one of the most commonly used construction materials in various construction works, it is undeniable that all aspects in constructions world are related to concrete. In the manufacture of concrete, it is generally used some materials that mixed together, so that it can be concrete. The mixture of conventional concrete is from cement, water, fine aggregate, and coarse aggregate. In the 1980s in Japan, SCC was produced at the University of Tokyo in collaboration with leading contractors for concrete manufacturing. Concrete is designed to flow through very small reinforcement gaps without any bleeding and segregation. Superplasticizer becomes an additional material for the concrete to get a high slump [1, 2, 3]. SCC is described as a self-placing concrete, and self-leveling concrete, which is part of SCC [4, 5].

SCC is a high performance concrete that can compact by self-weight and fill all the voids without segregation, excessive bleeding or any other separation of materials, without the need of vibrator. SCC characteristics are filling ability, passing ability, and segregation resistance [6, 7, 8].

In this study, SCC concrete was made using water, cement, fine aggregate, coarse aggregate, superplasticizer and addition of rice husk ash. Rice husk ash is a type of mineral additive that has silica elements that resembles cement. Rice husk is the outer cover of the rice plant grain with a high concentration of silica about more than 80-85% [9, 10]. Rice husk ash (RHA) is obtained from the residue of the rice husk combustion from rice mill, Buyung Putra Pangan Inc., which is located in South Sumatera province. The expectation of cement use being substituted by rice husk ash is that it can be more environments friendly and able to make concrete that can do the compaction by itself, which can increase the ease of work, especially in concrete industry.

SCC can compact by its self-weight and fill every corner of the formwork in confined reinforcements. SCC consists of ingredients like cement, aggregates, water, and admixtures. However, for good workability, optimum dosage of superplasticizer admixture is used to reduce the water content. Superplasticizer helps decreases the w/c ratio to increase the segregation resistance [11].

The key properties of SCC are filling ability, passing ability, and segregation resistance. Filling ability is the property to flow through the formwork and fill all the spaces. Passing ability is the property to flow without any blocking. The segregation resistance is the property of SCC to maintain a uniform composition hence the paste and the aggregate bind together [12]

2. MATERIAL AND METHOD

This study was conducted with variations of rice husk ash use by 5%, 10%, and 15% as the substitution of cement use and variations of w/c 0.275, 0.300, and 0.325. Fine aggregate and coarse aggregate test used the ASTM standards and SCC workability test used the EFNARC standards. The materials used are as follows cement, water, fine aggregate, coarse aggregate, superplasticizer, and rice husk ash.

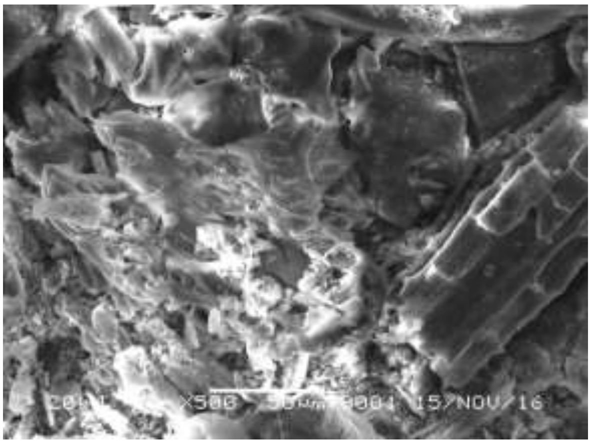

Figure 1 SEM of RHA

Table 1 Chemical composition of RHA

No.	Contents	Weight (%)
1	Silicon Dioxide (SiO_2)	94.68
2	Aluminum Oxide (Al_2O_3)	0.24
3	Iron (III) Oxide (Fe_2O_3)	0.80
4	Calcium Oxide (CaO)	1.77
5	Magnesium Oxide (MgO)	0.00
6	Sulfur Trioxide (SO_3)	0.43
7	LOI	2.80

Table 2 Mix proportion of 1 m^3 SCC

Mix	OPC (kg)	RHA (kg)	FA (kg)		CA (kg)	Water (kg)
			1	2		
SCC-0-0.275	600	0	246	540	823	165
SCC-0-0.300	600	0	246	540	823	180
SCC-0-0.325	600	0	246	540	823	195
SCC-5-0.275	570	30	246	540	823	165
SCC-5-0.300	570	30	246	540	823	180
SCC-5-0.325	570	30	246	540	823	195
SCC-10-0.275	540	60	246	540	823	165
SCC-10-0.300	540	60	246	540	823	180
SCC-10-0.325	540	60	246	540	823	195
SCC-15-0.275	510	90	246	540	823	165
SCC-15-0.300	510	90	246	540	823	180
SCC-15-0.325	510	90	246	540	823	195

The cement used in this study was OPC (Ordinary Portland Cement) type I with cement fineness value of 340m^2/kg. Water used in this study was water of PDAM. Distilled water is water through the distillation process. The process of distillation was done by cooking water with a temperature of more than 100°C. The fine aggregate used was natural sand from Tanjung Raja. In accordance with ASTM standards, the used fine aggregate grain size ranged from 0.125 - 4 mm and quartz sand grain size ranged from 50 - 650 μm. The coarse aggregate used was the Merak split stone. The used coarse aggregate size was split stone with a maximum size of 10 mm. The superplasticizer used in this research is type F superplasticizer. The basic material of superplasticizer used is polycarboxylate ether (PCE). The use of superplasticizer was to raise the compressive strength and reduce the water cement ratio (w/c). RHA is a waste of rice husk combustion from PT. Buyung Putra Pangan. RHA was first filtered with a sieve size of 200 that resembles a cement grain size. The test result is shown on Table 1. SEM of RHA was tested at Pusat Survei Geologi Laboratory with 500x magnification. The result can be seen on Figure 1. The composition of SCC mixture that used can be seen in Table 2.

3. RESULT AND DISCUSION

3.1. Slump Flow

The value obtained in the slump flow test was obtained from four perpendicular directions, and then the data were averaged. Figure 2 shows that with the increase use of RHA, the slump flow diameter becomes smaller. This is because the volume and rate of water absorption in RHA in the mixture are high.

Figure 3 shows the results of the slump flow test based on the variations of w/c ratio. The higher value of w/c ratio, the diameter obtained from the slump flow test is larger, this is due to the increase of mortar volume because it contains high water content at high w/c ratio. Slump flow values ranged from 59 – 77 cm. The maximum slump flow value was found in the SCC-0-0.325 mixture, while the minimum slump flow value was in the SCC-15-0.275 mixture.

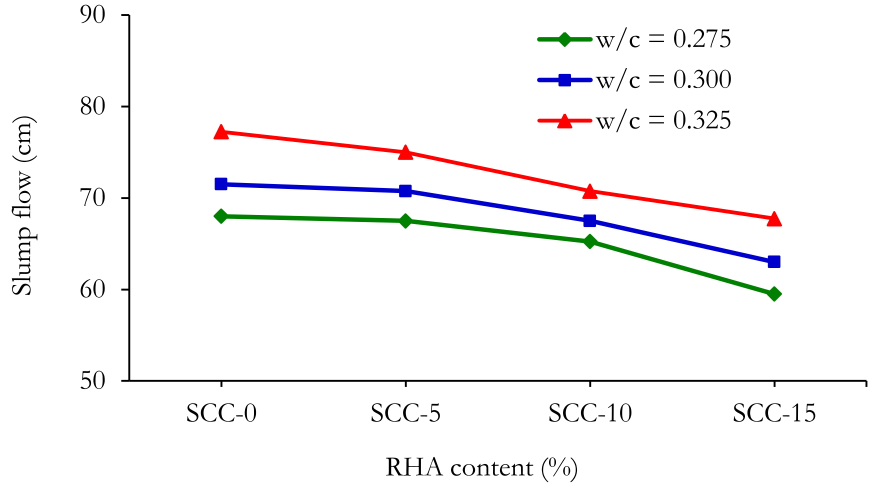

Figure 2 The effect of RHA content on slump flow

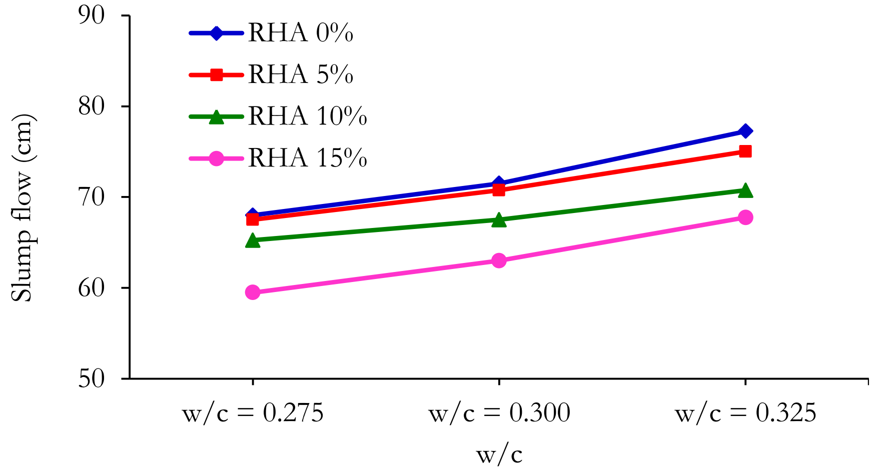

Figure 3 The effect of w/c ratio on slump flow

3.2. V-Funnel

V-funnel value was obtained from the result of time measurement required by fresh concrete mixture to flow from V-shaped tool. V-funnel test result can be seen in Figure 4 and Figure 5. Figure 4 is a result of a V-funnel test based on RHA that explains that the increase of RHA makes the V-funnel time becomes longer. The increase of RHA particles in the mixture causes the increase of fresh concrete viscosity. The maximum V-funnel value was in the SCC-15-0.275 mixture for 23.43 seconds, while the minimum V-funnel value was in the SCC-0-0.325 mixture for 4.88 seconds. Figure 5 explains that as the value of w/c ratio increases, the V-funnel time becomes faster. V-funnel values ranged from 4 - 23 seconds. The maximum V-funnel value was in the SCC-15-0.275 mixture for 23.43 seconds, while the minimum V-funnel value was in the SCC-0-0.325 mixture for 4.88 seconds.

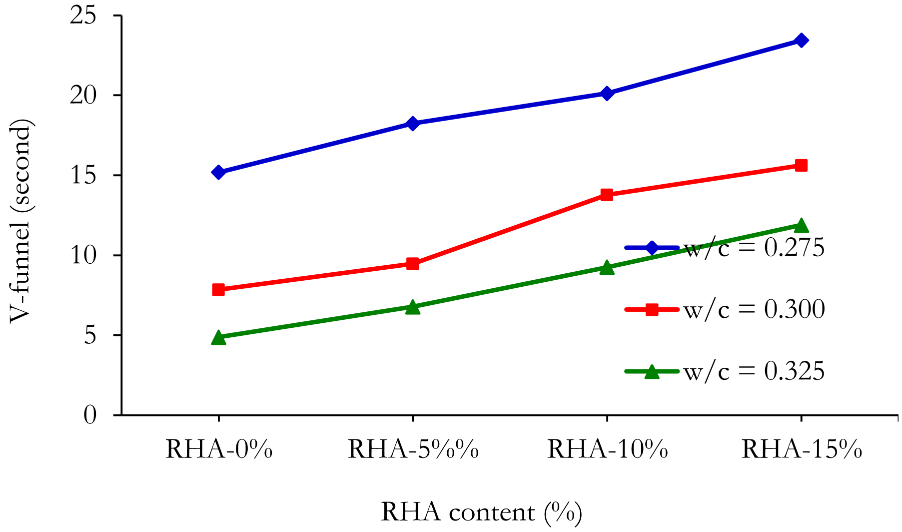

Figure 4 The effect of RHA content on V-funnel test

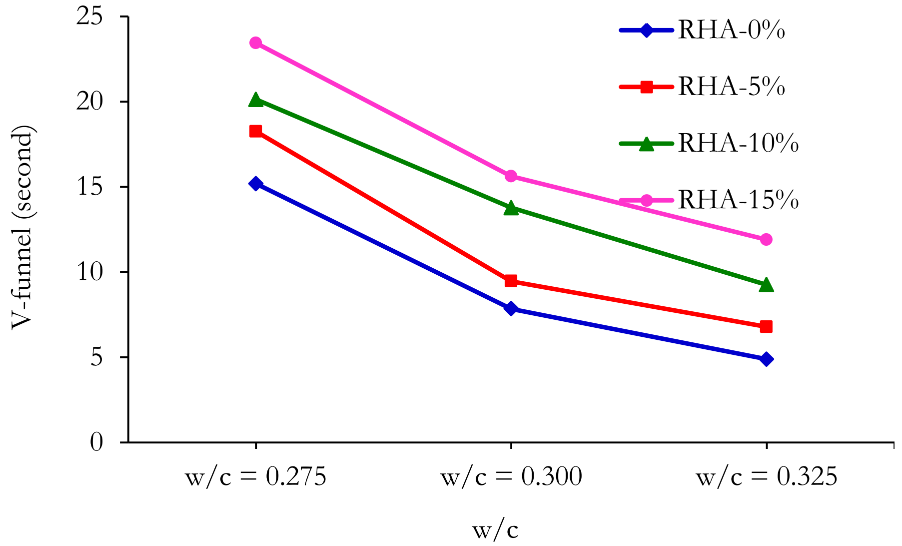

Figure 5 The effect of w/c on V-funnel test

3.3. L-Box

The L-box value is obtained from the comparison between the average of three-point measurement results from the base and the end of the L-box body. L-box test results can be seen in Figure 6 and Figure 7. Figure 6 explains that with increase of RHA, the L-box ratio becomes smaller. This is due to the increase of viscosity and the decrease of ability of fresh concrete to flow. The minimum value of H_2/H_1 ratio was found in the SCC-15-0.275 mixture of 0.78 and the maximum value of the H_2/H_1 ratio was found in the SCC-0-0.325 mixture. This shows that the higher use of RHA causes the decrease of the H_2/H_1 ratio as the increase of RHA particles in the mixture causes the viscosity of fresh concrete to increase. Figure 7 explains along with the increase of w/c ratio, it makes the L-box ratio becomes higher. The higher the w/c ratio makes the higher the L-box ratio, which is affected by the large amount of water that makes the concrete mixture faster to flow. The L-box value ranged from 0.77 to 1.00. The maximum value of L-box ratio was found in the mixture of SCC-0-0.325 with value of 1.00, while the minimum L-box ratio was in the SCC-0-15-0.275 mixture with value of 0.77.

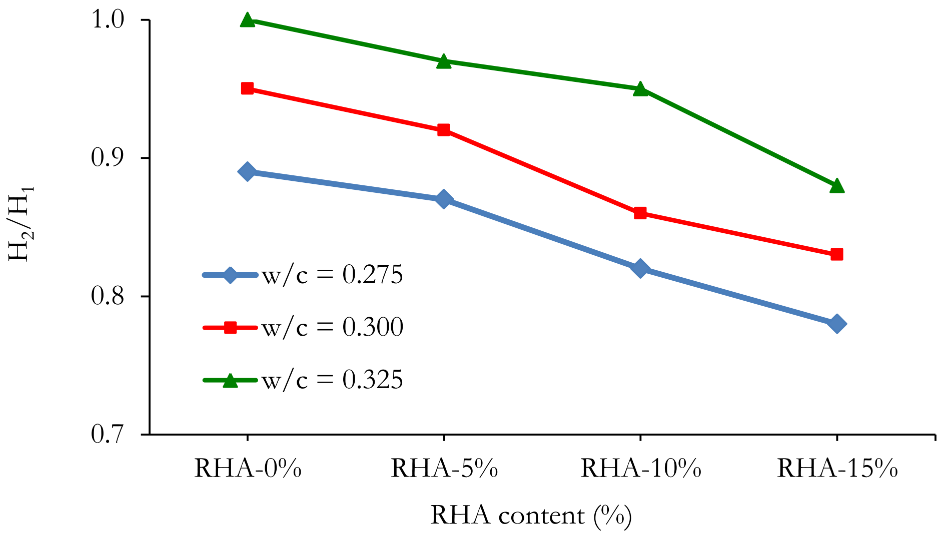

Figure 6 The effect of RHA on L-Box test

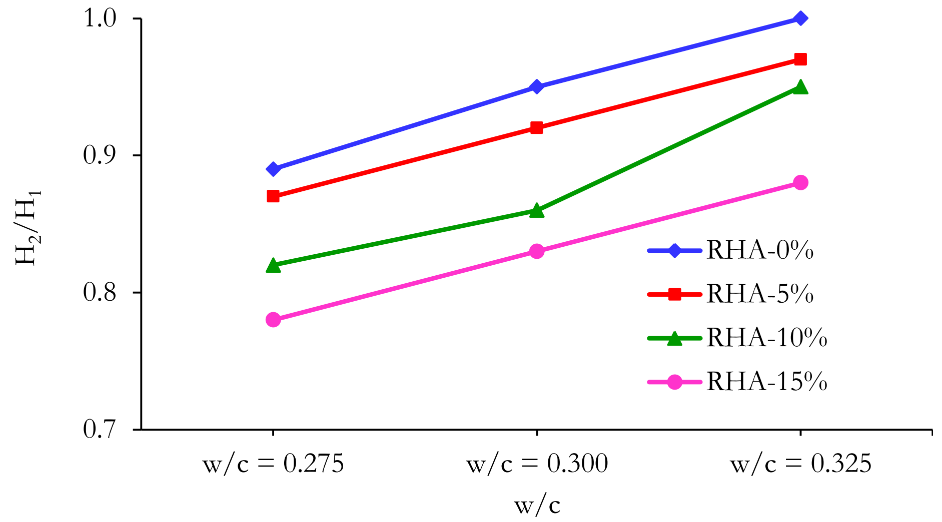

Figure 7 The effect of w/c on L-Box test

3.4. Compressive Strength

The results of hardened concrete test in this study were with concrete compressive strength tests at age 3, 7, 14, and 28 days. Figure 8 shows the compressive strength of SCC-0 concrete, without the addition of RHA at age 3, 7, 14, and 28 days. The minimum compressive strength of normal concrete was in the SCC mixture with w/c 0.325 for each concrete age, while the maximum compressive strength was in the mixture of SCC-0-0.275 aged 28 days with a compressive strength of 63.383 MPa. The increase of w/c ratio in the concrete mixture makes the decrease of compressive strength. Figure 8 shows the effect of concrete age on compressive strength results of SCC-0. The minimum compressive strength of normal concrete was in the SCC mixture with w/c 0.325 for each concrete age, while the maximum compressive strength was in the mixture of SCC-0-0.275 of age 28 days with a compressive strength of 63.383 MPa.

Figure 9 shows the effect of concrete age on the compressive strength of SCC-5. In the SCC test with RHA content of 5% as a substitution of cement, the result of maximum compressive strength in mixture with variation w/c = 0.275 was obtained. At age 3 days, the compressive strength was 32.664 MPa, age 7 days was 40.132 MPa, age 14 days was 57.245 MPa, and the maximum compressive strength was obtained at age 28 days of 68.280 MPa.

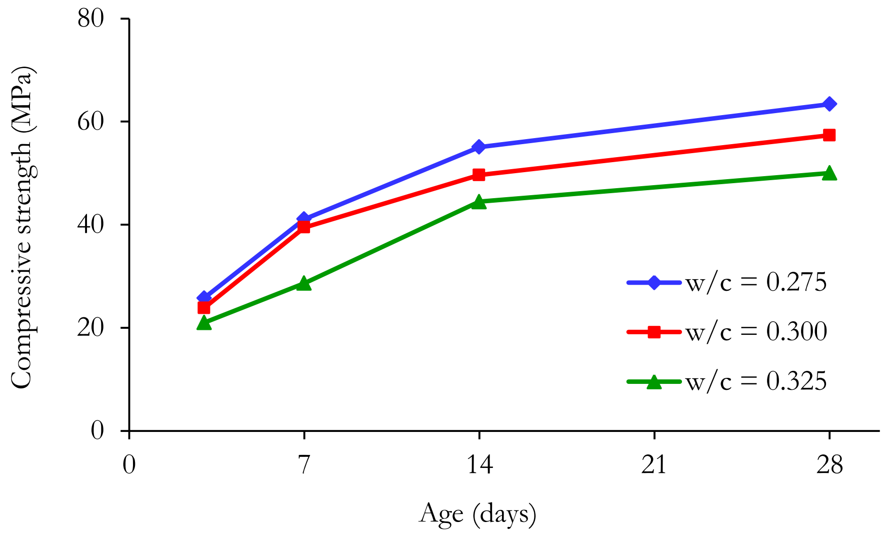

Figure 8. The compressive strength of RHA-0%

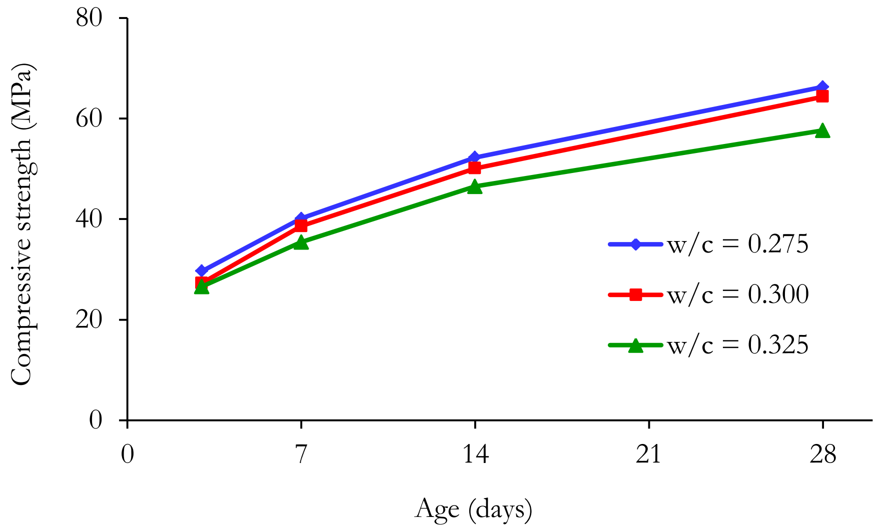

Figure 9 The compressive strength of RHA-5%

According to Figure 10, SCC test with RHA content of 10% as substitution of cement, the result of maximum compressive strength in mixture with variation w/c = 0.275 was obtained. At the age of 3 days, the compressive strength was 34.749 MPa, age 7 days was 48.284 MPa, age 14 days was 57.982 MPa, and the maximum compressive strength was obtained at age of 28 days of 70.588 MPa. Figure 11 shows the effect of concrete age on SCC-15 compressive strength results at age 3, 7, 14, and 28 days. Based on the result of 3 days compressive strength test, the maximum compressive strength in SCC-15-0.275 was 26.940 MPa and the minimum value 22.244 MPa at SCC-0-0.325. At age of 28 days was obtained the maximum compressive strength of 70.528 MPa for SCC-10-0.275 mixture and the minimum compressive strength of 47.679 MPa for SCC-15-0.325 mixture.

Figure 12 shows the effect of w/c on the 28 days concrete compressive strength results. The higher w/c ratio makes the compressive strength of the concrete decreases. It can be seen on concrete compressive strength results in SCC-0-0.275 mixture of 63.383 MPa greater than SCC-0-0.325 of 50.018 MPa with difference -13.356 MPa. Figure 13 shows the results of concrete compressive strength test at age 28 days with RHA content as substitution material from cement use. The maximum value of compressive strength on SCC-10-0.275 mixture was 70.528 MPa and the minimum value of 47.479 MPa on SCC-15-0.325 mixture. There was a significant increase in compressive strength from the use of RHA 5% and RHA 10% from SCC 0% and decrease of compressive strength in SCC with RHA 15%.

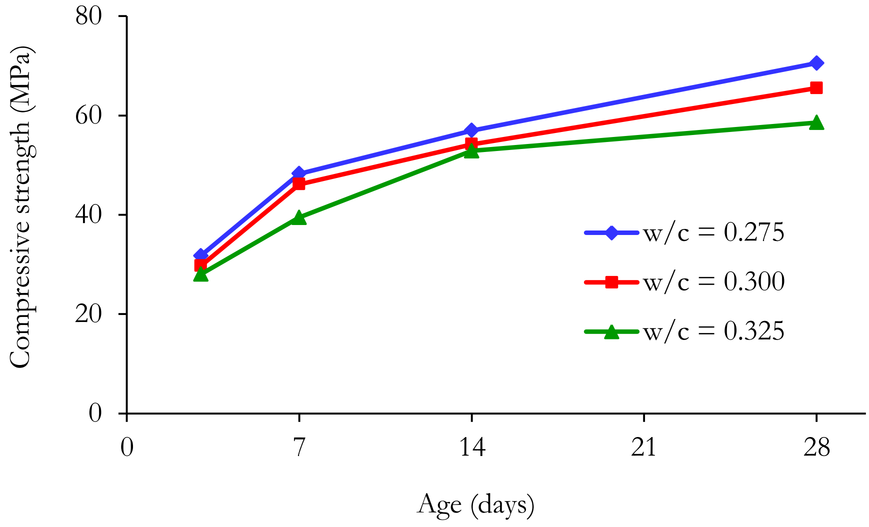

Figure 10 The compressive strength of RHA-10%

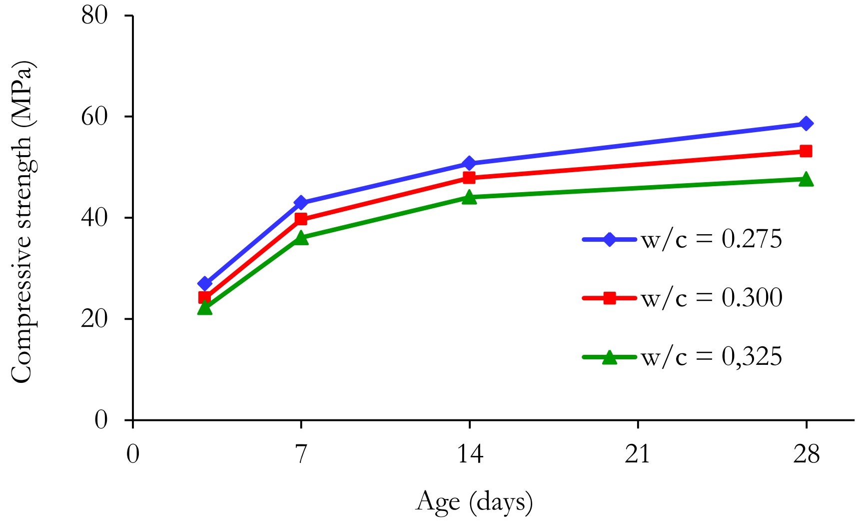

Figure 11 The compressive strength of RHA-15%

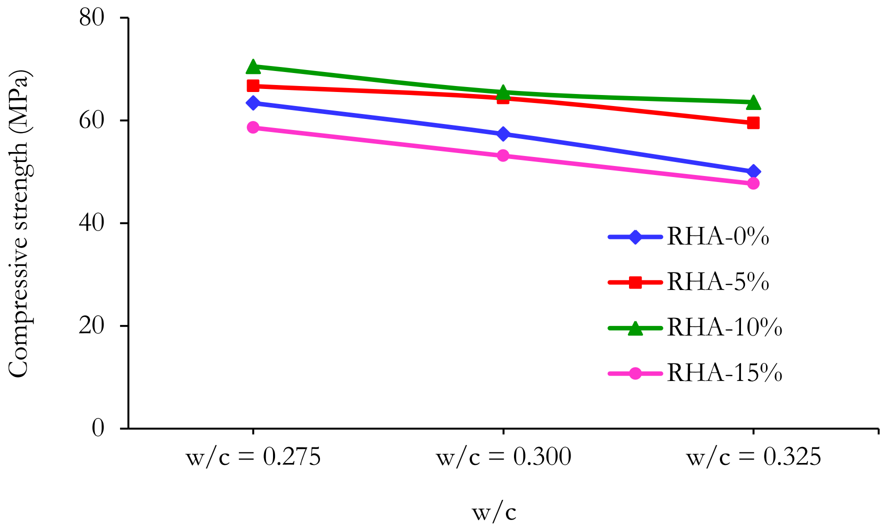

Figure 12 The effect of w/c on 28 days compressive strength

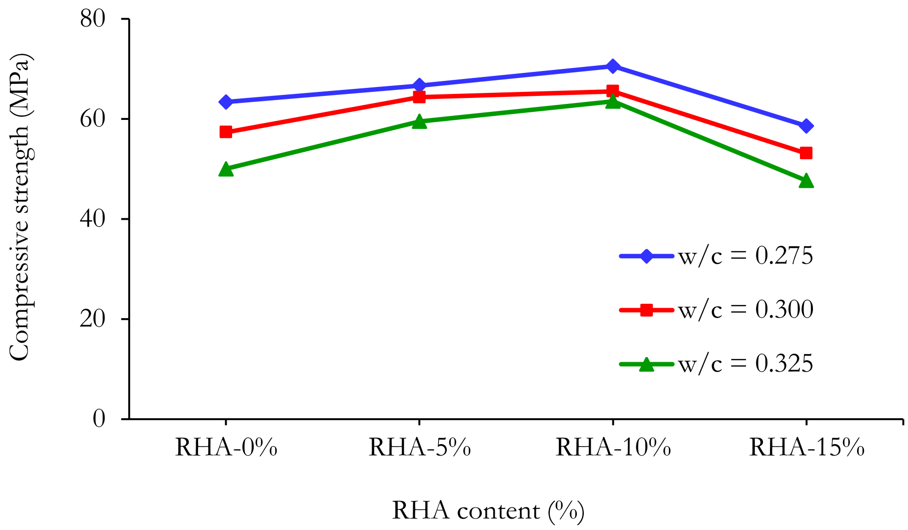

Figure 13 The compressive strength of 28 days concrete based on RHA content

4. CONCLUSIONS

The conclusions obtained from the study results are as follows:

- The maximum composition of the SCC mixture with the RHA substitution material shows the best performance in the mixture composition with a 10% substitution of RHA on the amount of cement used.
- The result of the slump flow test on fresh concrete shows a decrease in the diameter of fresh concrete along with the increase use of RHA. Slump flow test on fresh concrete showed the largest diameter at w/c = 0.325 with value of 77.25 cm and the smallest diameter at w/c = 0.275 with value of 59.50 cm.
- The result of the V-funnel test on fresh concrete shows the increase of flow time as RHA use increases. The V-funnel test on fresh concrete showed the fastest flow time at w/c = 0.325 with value of 4.88 seconds and the longest flow time at w/c = 0.275 with value of 23.43 seconds.

- The result of L-box test on fresh concrete shows a decrease ofH2/H1 ratio along with increase of RHA use. The L-box test on fresh concrete showed the largest H2/H1 ratio at w/c = 0.325 with value of 1.00 and the smallest H2/H1 ratio at w/c = 0.275 with value of 0.78.

- The result of the specific gravity test shows that for each variation w/c was obtained the density for SCC of 2.70 - 3.20 gram/cm^3.

The result of SCC compressive strength test at age 28 days with variation of SCC-10-0.275 and 10% RHA shows that there was a significant increase of concrete compressive strength. The result of the largest compressive strength value was 70.528 MPa for SCC-10-0.275 mixture and the minimum compressive strength was 47.679 MPa for SCC-15-0.325 mixture.

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