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Performance Study of Self - Compacting Concrete (SCC) as a Rigid Pavement

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Abstract. *Self Compacted Concrete (SCC) is a mixture of concrete that can flow and compact itself without the presence of compaction assistance with vibratory equipment as in normal concrete in general, not experience segregation and bleeding. The study aims to design the SCC normal concrete mixture composition by applying 0,4 by the cement water ratio to design, the addition of fly ash as a substitute for some cement with a percentage of 15%, fly ash by weight of cement. The added admixtures in concrete mixes are Superplasticizer Master Glenium Sky 8851 and Viscosity Modifying Admixtures (VMA) Master Matrix 110. The optimum percentage of the added material is obtained based on the results of the trial mixes is order to know whether by the applying concrete meets. To find out whether the concrete produced meets the requirements of self-compacting concrete (SCC), and then the for workability, segregation, and flowability testing was done using the slump, L Box tests and V-funnel tests. The results showed that the optimum percentage that meets the requirements of by the superplasticizer (SPA) and viscosity modifying admixtures (VMA), are 0,65 liter (4,53 kg) and 1,75 liter (5,53 kg) by the cement weight with the slump flow test of 65,7 cm (require: 65-80 cm) with the V-funnel test of 7,3 second (require: 3-15 second) and the L-box test is obtained a ratio between H2/H1 of 0,856 (require: 0,8-1,0). The compressive strengths of the self-compacting concrete are measured at the ages of 3, 7, 14, 21, 28 56, and 90 days by cube specimens testing. The tensile strength tests of concrete using a slab specimen of concrete are done at the ages of 3,7,14,21,28,56 and 90 days. the of compressive strength test result at the age of 28 days for the conventional normal concrete of and normal SCC strength without fly Ash at 25,33 MPa and 25,15 MPa. For SCC concrete using fly ash I obtained the effect of the optimum fly ash at a rate of 15% of the weight of cement. The flexural strength test results of SCC concrete and conventional concrete at 28 days are 4.564 MPa and 4.625 MPa respectively. However, the strength of SCC concrete at 90 days still increased, namely 32.40 MPa and 4,891 MPa for the compressive strength and yield strength of concrete respectively.*

Keywords: *self-compacted concrete, superplasticizer, viscosity modifying admixtures, compression strength, flexible strength*

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I. Introduction

The need for infrastructure continues to increase along with economic and technological advances, especially in the field of transport infrastructure, this can be seen with the construction of the MRT, toll roads, and flyovers in Indonesia. Especially in the construction of toll roads that are rampant in order to facilitate accommodation and support the regional economy. The toll road uses high quality concrete material in its manufacture as a rigid pavement. High-strength concrete has more compressive strength than normal concrete. High-quality concrete has a low fas value. A low fas value will have a high compressive strength but will reduce the workability of the concrete (Arifin, 2018).

Concrete is one of the construction materials that are widely used for buildings. In general, the concrete used in the field is normal concrete, in addition to making it quite easy and generally does not require admixtures. Normal concrete is also considered more economical than other construction materials such as steel. However, often in the field, due to unskilled workers, there are difficulties in casting such as concrete blankets that are too thin, curved concrete, the distance between reinforcement that is too tight, uneven distribution of coarse aggregate in concrete, incomplete compaction and so on, so that the concrete is segregated, there are air cavities in the concrete (Novianti and Syavira Putri 2019).

High-quality concrete has low workability, therefore road construction work requires a tool in the form of a vibrator so that the mixture can occupy all space, of course, this hampers the work because of the need for additional labor for vibrators. It is now widely developed SCC concrete where, SCC concrete is concrete that has high fluidity properties so that it is able to flow and fill the spaces in the mould without the compaction process. In addition, it is well known that the manufacture of SCC concrete has improved both concrete technology and work safety and health conditions to eliminate mechanical compaction at construction sites. Other advantages such as labour safety and time savings can be improved. While in terms of quality, SCC concrete has many advantages, namely it can reduce the permeability of concrete so that the concrete surface becomes smoother and more homogeneous. (Nurtanto 2019).

The use of SCC concrete in road construction will facilitate the work because SCC concrete has high workability, therefore the addition of a superplasticizer is needed in its manufacture. The use of superplasticizer in SCC concrete increases the workability of fresh concrete with not much effect on the compressive strength value of the concrete. (Cahyaka, 2018).

The constituent materials of SCC concrete as a rigid pavement for roads are very important because they will affect the strength, feasibility, and durability of the road. In principle, to get concrete with good quality is greatly influenced by the quality of the constituent materials, namely fine aggregate (sand), coarse aggregate, fly ash, cement, and water, as well as the way of working. SCC concrete as a rigid pavement consists of fine, coarse, and filler aggregates. The material is washed river sand with a fineness modulus of 2.66, specific gravity of 2.58, and water absorption of 1.7%. Coarse aggregate with a maximum nominal size of 12.5 mm and specific gravity absorption of 1.1% and 2.67, respectively. Fly ash is a substitute for cement or sand that affects concrete, the use of fly ash for SCC concrete as a rigid pavement. (Nurtanto 2019).

II. Literature Review

2.1 Self Compacting Concrete

SCC As early as 1983 the issue of concrete durability became a major topic in the construction field in Japan. To produce concrete with good durability, adequate compaction by skilled workers is required. The reduction of skilled labor in the construction field in Japan caused the quality of construction work to decrease as well. Okumura found a solution to the decline in the quality of concrete work by using SCC concrete (Okamura,1983).

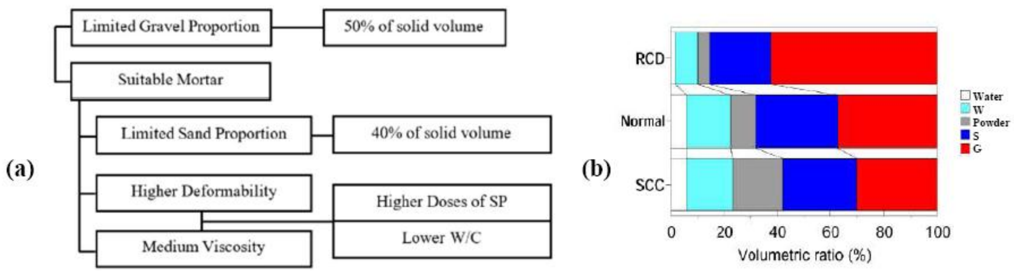

Figure 1 (a) SCC concrete mix composition **(b)** Comparison of materials SCC concrete mix and normal concrete (Okamura and Ouchi, 2003)

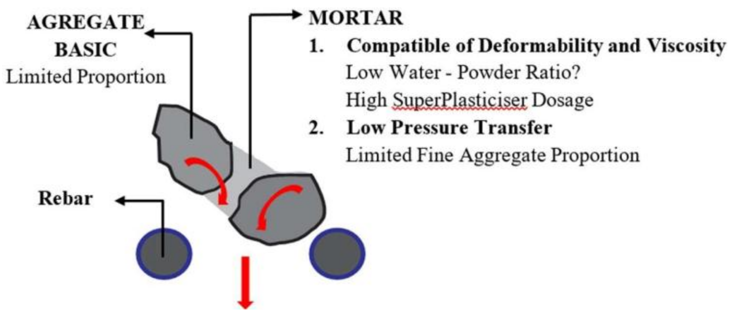

Figure 2 Compaction mechanism of self compacting concrete (Okamura and Ouchi, 2003). (Okamura dan Ouchi, 2003)

III. Research Methodology

The research of SCC normal concrete as rigid pavement is an experimental research conducted at the Laboratory of Structures and Building Materials, Faculty of Engineering, Tadulako University. The research includes material testing, mix design, observation of the physical properties of SCC concrete as rigid pavement both when it is fresh and when it has hardened, testing SCC concrete as rigid pavement in the form of slump flow test, L-Box test and V funnel test in the state of fresh concrete and when it has hardened in the form of testing the compressive strength and split tensile strength of concrete. In the design of the mixture, several variations of Superplasticizer/VMA will be used and can be analyzed after the test data is obtained, to obtain the optimum percentage of the use of Superplasticizer/VMA.

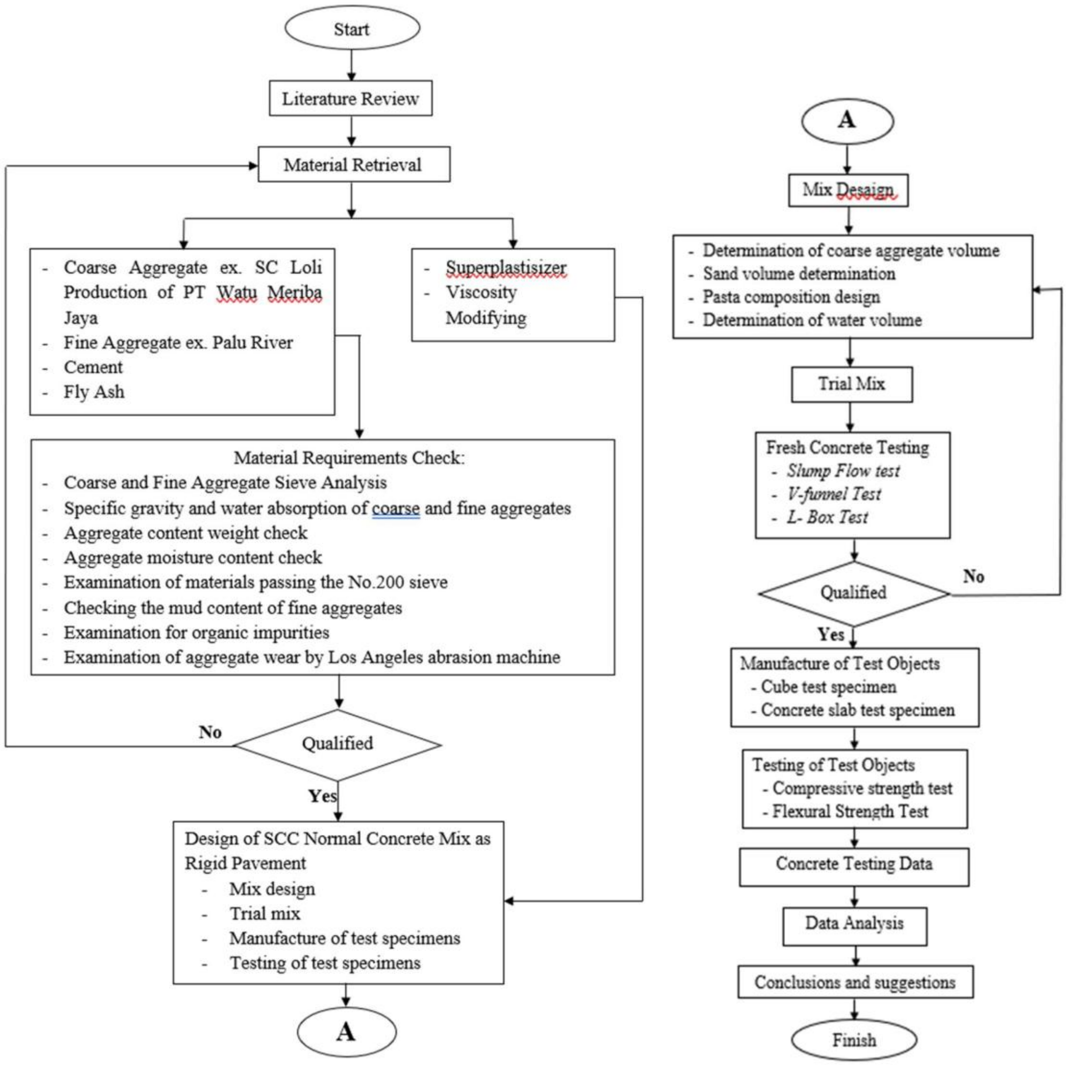

Figure 3 Research Flowchart

IV. Result and Discussion

4.1 Calculation of 1 m3 Conventional Concrete Mix Proportions

Table 2 Optimum mix proportions of conventional concrete

Description	Cement	*fly Ash*	Water	Sand	Gravel
Fly Ash 15%	348.50	61.50	205	618	1,147

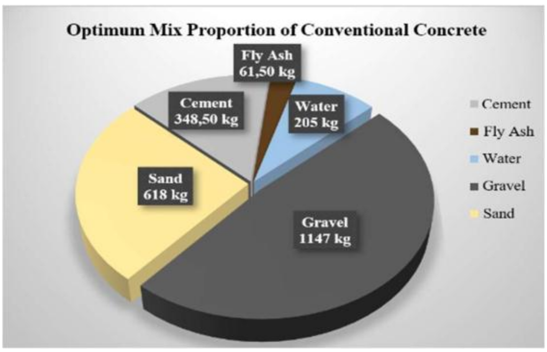

Figure 5 Optimum composition of materials in conventional concrete mix per cubic meter

4.3. Calculation of SCC Concrete Mix Proportion 1 m3

Table 5 SCC concrete mix proportions per 1 m3

Description	Cement	*fly Ash*	Water	Sand	Gravel	SPA	VMA
	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
SCC concrete	446.25	78.75	210	904.75	729.75	4.532	5.531

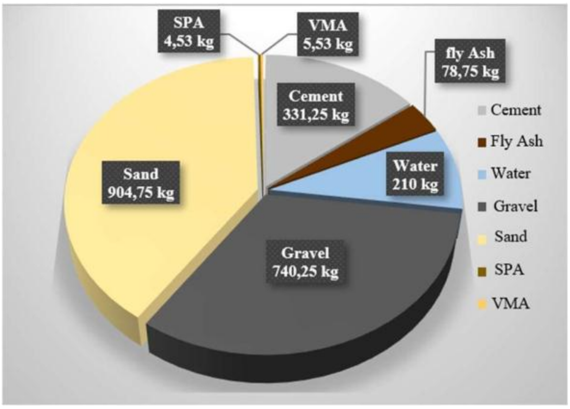

Figure 6 Material composition of one cubic meter of SCC concrete mix

4.4. SCC Concrete Testing Results and Test Piece Making

4.4.1 Testing Fresh SCC Concrete

- Slump Flow Test

Figure 7 Slump flow test

Table 6 Average value of fresh SCC concrete slump flow test results

Number	Description	*Slump Flow Value (cm) of SCC concrete*		
		D1	**D2**	**Daverage**
Sample 1	*Fly Ash* 15%	65.2	66.3	65.75
Sample 2	*Fly Ash* 15%	65.3	66.1	65.7

- V- funnel Test

Figure 8 V-funnel Test

Table 7 Average Value Results of the V-funnel Test

Number	*L - V- funnel value (6 -12 seconds)*			T Average (seconds)
	T1	T2	T3	
Sample 1	7.3	8.1	6.8	7.4
Sample 2	7.1	7.9	6.6	7.2

- L-Box Test

Figure 9 L-box Test

Table 8 Average value results of L-box testing of fresh SCC concrete

No.	*L - Box value of SCC concrete*					
	H1	H2	H1	H2	H1	H2
Sample 1	9.1	7.6	9.2	7.8	9	8.05
H2/H1	0.84		0.85		0.89	
Sample 2	9	7.5	9.1	7.7	9.1	8.02
H2/H1	0.83		0.85		0.88	

4.4.2 Manufacture of Test Objects

After testing fresh concrete and fulfilling the requirements, test specimens were made (Figure 10) for testing the strength of concrete. The test specimens used were concrete cubes and slabs for compressive strength and flexural strength tests, respectively.

Figure 10 Fabrication of concrete cubes and slabs

4.6. Testing Hard SCC Concrete

4.6.1. Testing the compressive strength of SCC concrete

Testing the compressive strength of concrete using cube test objects with a size of 150 x 150 x 150 mm. Concrete cube test objects made for each concrete mixture are 21 test objects for testing the compressive strength of concrete. Concrete compressive strength testing was carried out at the age of 3, 7, 14, 21, 28, 56, and 90 days for conventional concrete and normal SCC concrete. For each age of concrete compressive strength testing, 3 concrete cube test specimens were tested.

Figure 10 Testing the compressive strength of concrete

The compressive strength of 15% fly ash SCC concrete produced from testing at the age of 28 was 25.15 MPa. The compressive strength of SCC concrete at the age of 90 days is still increasing, which is 31.71 MPa. The complete SCC concrete compressive strength test results are presented in Table 9 and Table 10 below.

Table 9 Average value of SCC concrete compressive strength test results

Number	Description	Age (Days)	Compressive Strength of SCC Concrete (MPa)
1.	SCC Concrete	3	9.83
2.		7	16.47
3.		14	21.23
4.		21	23.76
5.		28	25.15
6.		56	27.56
7.		90	31.79

Table 10 Average value results of conventional normal concrete compressive strength testing

Number	Description	Age (Days)	Compressive Strength of SCC Concrete (MPa)
1.	Conventional Concrete	3	10.31
2.		7	16.71
3.		14	21.65
4.		21	23.88
5.		28	25.33
6.		56	31.18
7.		90	33.65

If the above data is presented in the form of a graph, the comparison between SCC concrete and conventional concrete will show an increase in compressive strength at each age of testing as shown in Figure 11 below.

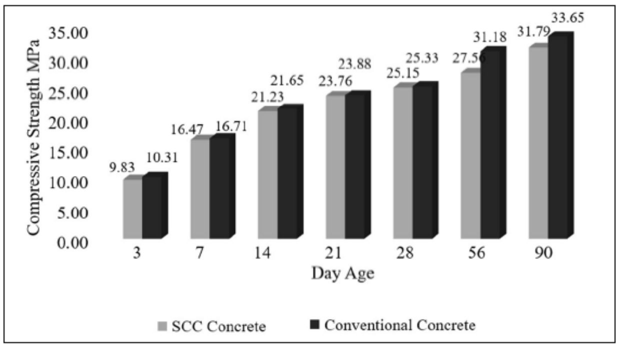

Figure 11 Strength testing graph of SCC concrete and conventional concrete with 15% Fly Ash

4.6.2. Flexural Strength Testing of SCC Concrete

(a) **(b)**

Figure 12 (a) Testing the flexural strength of concrete and (b) Samples of concrete flexural strength test results In testing the flexural strength of concrete, tested as much as

In testing the flexural strength of concrete, 3 specimens were tested at the age of 3, 7, 14, 21, 28, 56, and 90 days. The results of the SCC concrete flexural strength test are shown in Table 11 as follows.

Table 11 Average value of flexural strength testing of SCC concrete

Number	Description	Age (Days)	Flexural Strength Mpa
1	SCC Concrete with 15% Fly Ash	3	2.850
2		7	3.046
3		14	3.087
4		21	3.173
5		28	4.564
6		56	4.689
7		90	4.891

In addition to SCC concrete, this study also made concrete plate specimens for testing the flexural strength of conventional concrete which was used as a control value for the compressive strength of SCC concrete with 15% fly ash using the same material. The resulting compressive strength data for the conventional concrete is presented in Table 12 below.

Table 12 Results of Average Value of Conventional concrete flexural strength testing

No.	Uraian	Umur hari	Kuat Lentur Mpa
1	Beton Konvensional dengan *Fly Ash* 15%	3	3.012
2		7	3.272
3		14	3.445
4		21	3.565
5		28	4.625
6		56	4.932
7		90	5.281

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If the above data is presented in the form of a graph, the comparison between SCC concrete and conventional concrete will show an increase in flexural strength at each test age as shown in Figure 13 below.

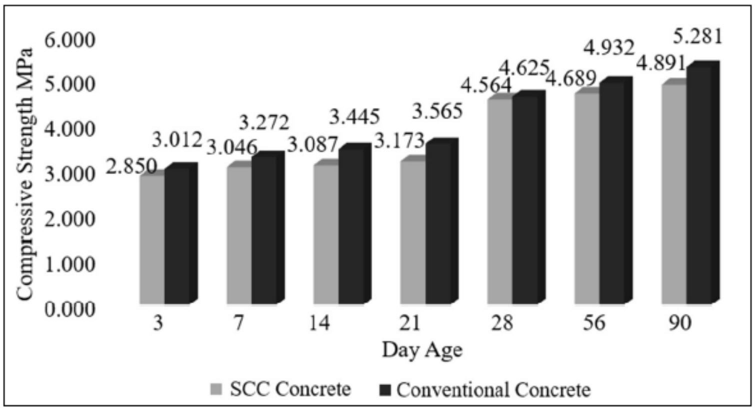

Figure 13 Comparison chart of SCC concrete flexural strength test results

Based on the results of the flexural strength test at the age of 28 days obtained as shown in Table 4.39 and Figure 4.32 above, the optimum percentage of the use of 15% fly ash with the test results of the flexural strength of SCC concrete of 4.404 MPa and Conventional concrete of 4.625 MPa.
In addition to the age of 28 days, the flexural strength of SCC concrete is also tested at other ages, namely 56 and 90 days with the results of the SCC concrete flexural strength test of 4.689 MPa and 4.891 MPa.

V. Conclusion and Recommendation

5.1 Conclusion

Based on the results and discussion, the authors draw the following conclusions:

i. The composition of the SCC concrete mixture with the cement water ratio used for conventional concrete is 0.5, obtaining a water composition of 205 kg, and the SCC concrete cement water factor is changed to 0.4 so as to obtain a water composition of 210 kg. The proportion of cement mixture was 348.50 kg and fly ash 61.50 kg for conventional concrete while SCC concrete obtained the proportion of cement 446.25 kg and fly ash 78.75kg. Conventional concrete uses a ratio of coarse and fine aggregate composition of 65% (1,147 kg) and 35% (618) respectively, while for SCC concrete it is 45% (904.75 kg) and 55% (729.75 kg) respectively. The superplasticizer and Viscosity Modifying Admixtures (VMA) in the SCC normal concrete mix obtained from the results were 0.65 liters (4.52 kg) and 1.75 liters (5.53 kg) respectively. In the case of fresh concrete with slump flow test, L-Box, and V-funnel test, the average value of the test results obtained, for the slump flow test was 65.75 cm, V-funnel was 7.4 seconds, and L-Box was 8.35 cm.

ii. From the results of testing and analysis, the average compressive strength for SCC concrete cubes and Conventional Concrete test specimens using 15% fly ash as a partial replacement of cement was obtained The results of the compressive strength test at the initial age of 28 days were 25.15 MPa then still experienced a reaction or increase at 56 days of 27.56 MPa and 90 days of 31.79 MPa, while for conventional concrete the compressive strength produced reached 25.33 MPa by experiencing the same reaction increase at 56 days of 31.18 MPa and 90 days of 33.65 MPa.

iii. From the results of testing and analysis, it is obtained that the average flexural strength for test specimens of SCC concrete plates and conventional concrete using 15% fly ash as a partial replacement of cement is obtained. The test result of flexural strength at the age of 28 days is 4.564 MPa, while for conventional concrete the flexural strength produced reaches 4.625 MPa. Testing the flexural strength of concrete which is based on (the Directorate General of Highways 2018) and (Department of Regional Settlements and Infrastructure 2003) where the flexural strength of concrete at the age of 28 days is 4.5 MPa and 2.44 MPa, then from the design results still meet the standards, so SCC concrete can be applied to the rigid pavement.

b. Recommendation

i. In future research, more attention should be paid to the condition of the material for the concrete mixture.

ii. In future research, it should be noted the mixing time on the rotation of the concrete mixer and the testing of fresh concrete SCC.

iii. Further research is needed to determine the percentage that can produce the maximum compressive strength of superplasticizer, VMA, and fly ash additives.

iv. Further research is needed to find out the most optimum percentage of fly ash used in normal SCC concrete mixes.

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