The Compressive Strength of Self-Compacting Concrete (SCC) with the Addition of Micro Synthetic Fibers and Sika ViscoCrete 3115 N Admixture

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Abstract. Self Compacting Concrete (SCC) was an innovation in concrete that could compact itself, with high flowability and workability. SCC did not require mechanical vibration in the placement process within formwork volumes. The purpose of this research was to determine the characteristics of SCC with the addition of the Viscocrete 3115N admixture and to determine the compressive strength of SCC with the addition of synthetic micro fiber variations of 0%; 0.20%; 0.25%; 0.30%. The materials used were sand from the Pinang River and a maximum size split of 20mm from Lahat, which had been tested and all materials met the requirements. The test results showed Slump Flow values of 70cm; 70cm; 69cm; 66cm, L-Box test values of 0.93; 0.90; 0.87; 0.85, V-Funnel test values of 7 seconds; 7 seconds; 8 seconds; 10 seconds, and compressive strength tests on cylindrical specimens (15x30) were conducted at 7 days, 14 days, and 28 days. The 28-day compressive strength values were BS 26.42 MPa; BSSS 0.20% 26.89 MPa; BSSS 0.25% 27.08 MPa; BSSS 0.30% 27.13 MPa. The percentage increase was 1.8%; 0.7%; 0.18%, with the most optimal increase occurring at 0.20% fiber content. Fiber content of 0.30% reduced the fresh concrete properties of SCC, but the values still met the requirements.

Keywords: Self Compacting Concrete (SCC), Viscocrete, synthetic micro fibers, compressive strength.

1 Introduction

In the modern era, development in the field of construction showed significant progress, with the use of new technologies and methods that were constantly being developed. One of them was the construction of mega projects in transportation, such as roads and bridges, water-related construction like reservoirs and irrigation systems, as well as the increasing construction of buildings in developed countries. Therefore, construction with high workability was needed to accelerate and simplify the development of these mega projects.

Construction development at this time mostly used concrete structures because they had several advantages compared to other construction structures. Among others, structural concrete had high strength, was economical in construction and maintenance, easy to

N. L. Husni et al. (eds.), *Proceedings of the 8th FIRST 2024 International Conference on Global Innovations (FIRST-ESCSI 2024)*, Advances in Engineering Research 261,
https://doi.org/10.2991/978-94-6463-678-9_7

maintenance, easy to shape using formwork, and easy to work with (workability). However, concrete had structural weaknesses, such as lower tensile strength than compressive strength, susceptibility to cracking, brittleness, and difficulty compacting in small spaces when using conventional concrete.

The use of concrete in the construction field mostly relied on conventional concrete. However, in some construction works, conventional concrete alone could not be used. Therefore, concrete was further developed by experts to meet these needs. Self Compacting Concrete (SCC) had high flowability, allowing it to flow and fill the formwork and compact itself. Based on the new innovation of Self Compacting Concrete (SCC), research development was carried out to determine the characteristics and compressive strength of Self Compacting Concrete (SCC) with the addition of synthetic micro fibers and the Sika Viscocrete additive.

1.1 Literature Review

Previous research served as a fundamental reference for conducting research and could become a new source of inspiration for further studies. Earlier research could expand and deepen the theories and methods that would be applied in future research. Types of fibers' effects on self-compacting concrete's new characteristics and flexural toughness (Abdullah M. Zeyed, 2020) [5]. According to the study's findings, adding fibers generally degraded the qualities of fresh concrete. When fibers H, M, S, P, and R were added to the concrete, the slump flow diameter dropped to 630, 640, 640, 610, and 650 mm, respectively, from 670 mm for SCC. When fiber types H, M, S, P, and R were added to the concrete at 28 days, the corresponding compressive strengths were 34.5, 33.9, 32.1, 36.9, 35.8, and 33.3 MPa.

Properties of Self Compacting Concrete's (SCC) Workability and Strength (Ibnu Fakrianto, Liana Herlina, 2023) [3]. According to the study's findings, the maximum compressive strength at 28 days was 52.08 MPa and the splitting tensile strength at 28 days was 3.16 MPa with a content of 1%. At 2% content, the concrete's slump flow diameter measured 70 cm. Superplasticizer increased the concrete's splitting tensile strength and compressive strength while also facilitating flow.

Evaluation of Hemp Fiber's Effect on Self Compacting Concrete's (SCC) Mechanical Properties (Hizkia Hernandez, Widodo Kushartomo, 2023) [4]. The findings of this study demonstrated that, up to a volume of 2%, the splitting tensile and flexural strengths of SCC made with hemp fibers increased. At the same time, the compressive strength and elastic modulus of SCC continued to decrease with the increase in the variation of hemp fibers compared to normal SCC. SCC was formed into cylindrical and beam shapes with variations of hemp fiber volume additions of 0%, 1%, 1.5%, 2%, and 2.5%. The number of samples produced included 6 cylinders and 3 beams for each variation of the hemp fiber volume used. The tests conducted included flexural strength, elastic modulus, splitting tensile strength, and compressive strength.

1.2 Self Compacting Concrete (SCC)

According to EFNARC (2005) [2], Self Compacting Concrete (SCC) was an innovation in concrete that could compact itself with a sufficiently high slump. In the placement process within formwork volumes and during compaction, SCC did not require direct compaction through vibration like normal concrete. Self Compacting Concrete (SCC) had high flowability, allowing it to flow and fill the formwork and compact itself.

SCC (Self Compacting Concrete) had high workability and flowability, good homogeneity, and could reduce permeability while having a high level of durability. The aggregates used in the production of SCC were relatively smaller, allowing it to flow on its own through tightly packed reinforcement. The production process of SCC required an admixture in the form of a superplasticizer, which functioned to reduce water content and enhance flowability. The use of superplasticizer allowed for a reduction in the water-cement ratio to a value of w/c = 0.3 or smaller.

1.3 Characteristics of Self Compacting Concrete (SCC)

Concrete that satisfies the following requirements may be categorized as Self Compacting Concrete (SCC) in accordance with the EFNARC Specification and Guidelines for Self-Compacting Concrete (2005) [2]: 1. Filling, passing, segregation resistance, and viscosity were the new characteristics of Self Compacting Concrete (SCC). 2. Self Compacting Concrete's (SCC) solid qualities were durability, strength, and shrinkage.

1.4 The advantages and disadvantages of Self Compacting Concrete (SCC).

According to EFNARC (2002) [1], Self Compacting Concrete (SCC) had advantages, including not requiring compaction or vibration with a vibrator because SCC could compact itself, resulting in a better concrete surface. It allowed for faster construction due to its ease of work, reduced labor on-site, which helped save labor costs, and provided greater design freedom as SCC was easy to shape. Additionally, it decreased noise levels at the project site due to the absence of vibration, and the work environment became safer and more watertight because of its low porosity.

Some disadvantages of using Self Compacting Concrete (SCC) included that the production of SCC was more expensive compared to conventional concrete. The construction of formwork had to be carefully considered because it could easily leak the SCC mixture, and the concrete should not experience segregation while still meeting the flowability requirements.

1.5 Testing Methods for Self Compacting Concrete (SCC)

Slump flow for filling ability, T-500 slump flow for filling ability, J-ring for passing ability, V-funnel for filling ability, V-funnel T5 minutes for segregation resistance, L-box for passing ability, U-box for passing ability, Fil-box for passing ability, GTM screen stability test for segregation resistance, and Orimet for filling ability were the ten testing methods used to ascertain the properties of SCC (Source: EFNARC, 2002) [1].

1.6 Materials Comprising Self Compacting Concrete (SCC)

In the mixture of Self Compacting Concrete (SCC), there were various constituent materials, including coarse aggregates, fine aggregates, cement, water, and an additive known as an Air Entraining Agent (AEA). In this study, Sika's Viscocrete 3115 N was used as an additive, along with the addition of micro synthetic fibers. The constituent materials of Self Compacting Concrete (SCC) in this research included coarse aggregates in the form of crushed stone or split, while the fine aggregates could be natural sand, processed sand, or a combination of both. Portland cement was a hydraulic binding material produced from grinding, along with Portland cement clinker and gypsum with one or more inorganic materials, or from the mixing of Portland cement powder with powder from other inorganic materials. Water was a very important base material in the concrete mixture, and the amount of water used in Self Compacting Concrete (SCC) was less than that in conventional concrete. The addition of micro synthetic fibers served to improve the structural properties of the concrete; the fibers were mechanical in nature, meaning they would not react chemically with other concrete mixture materials. The fibers helped bind and unify the concrete mixture after the initial setting with the cement paste, making the concrete stronger and more stable in supporting loads due to the interlocking action of the fibers.

2 Methodology

2.1 The Scope of Research

The research was conducted in the material testing laboratory of Politeknik Negeri Sriwijaya Palembang.

2.2 The Data Collection

In this research, the samples used came from local materials available in South Sumatra. These materials included sand from the Sungai Pinang Plaju, coarse aggregates from Lahat with a size of 1-2, Portland Pozzolana Cement (PPC) from PT. Semen Baturaja, the admixture was Viscocrete 3115 N from PT. Sika Indonesia, the micro synthetic fibers used were from CV. KimiaidJGC, and the water came from PDAM Tirta Musi in Palembang City.

2.3 Data Analysis

It was necessary to perform standard material tests, such as: a. sieve analysis of coarse and fine aggregates; b. testing for silt and moisture content; c. testing for coarse and fine aggregate specific gravity; and d. testing for bulk density of coarse and fine aggregates. The test samples used in this study were cylindrical specimens with dimensions of 15 cm by 30 cm. Normal Concrete, SCC with a fiber content of 0%, and SCC with fiber contents of 0.20%, 0.25%, and 0.30% were among the research samples created.

3 Result and Discussion

3.1 Pengujian Material

From the results of the fine aggregate sieve analysis tests conducted in the Civil Engineering Laboratory, the material testing results could be seen in Table 1.

Table 1. The results of the fine aggregate sieve analysis test

Opening Size (mm)	Retained weight	Weight	% cumulative	
	(gram)	(%)	Retained	Passing
4,75	40,5	4,05	4,05	95,95
2,36	94,1	9,41	13,46	86,54
1,18	222,9	22,29	35,75	64,25
0,6	264,5	26,45	62,20	37,80
0,3	263,5	26,35	88,55	11,45
0,15	103,6	10,36	98,91	1,09
0,075	2,1	0,21	99,12	0,88
Pan	8,8	0,88	100	0,00
Total	1000	100	302,92	-

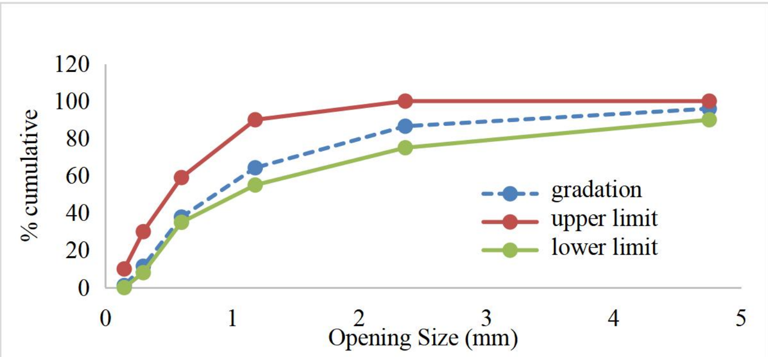

Fig. 1. Grading of fine aggregate zone II

The results of the fine aggregate sieve analysis tests showed a fine aggregate modulus value of 3.03. This value met the requirements for concrete materials according to SNI S-04-1989-F, where the fine aggregate modulus value ranged from 1.50 to 3.80 with particle variation according to the grading standard. The percentage of passing weight from the test results and the minimum and maximum limits of fine aggregate grading were also obtained.

Table 2. The results of the coarse aggregate sieve analysis test

Opening Size (mm)	Retained Weight		% cumulative	
	(gram)	(%)	Retained	Passing
50,8	0	0	0	100
38,1	0	0	0	100
19	82	4,10	4	96
9,5	1292,4	64,62	69	31
4,75	619,7	30,99	99,71	0,295
2,36	0,9	0,05	99,75	0,250
1,18	0,2	0,010	99,76	0,240
0,6	0,3	0,015	99,78	0,225
0,3	0,5	0,025	99,80	0,200

The fine aggregate modulus value of 6.71 was obtained, and this value met the maximum specification set by SNI 03-1968-1990 of 8.

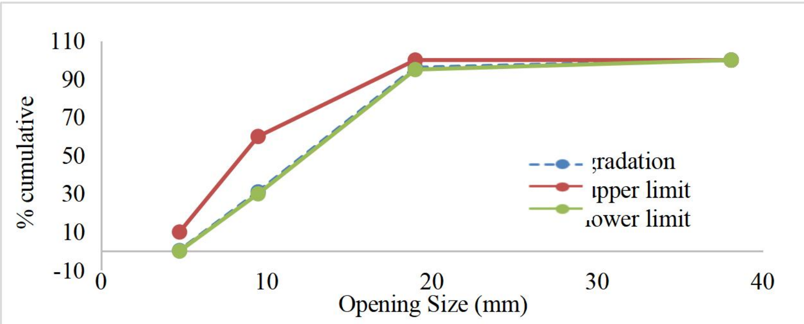

Fig. 2. Grading of split with a maximum size of 20mm

The physical properties of the aggregate were tested based on SNI procedures to determine whether the materials to be used met the standards.

Table 3. Recap of the physical properties aggregate test results

Type of test	Fine Agregates		Coarse Agregates	Unit
Fine aggregate modulus	3,03	6,71	-	3,03
Dry specific weight	2,47	2,48	-	2,47
SSD specific weight	2,52	2,55	-	2,52
Absorption	2,2	2,93	%	2,2
Moisture content	2,64	1,98	%	2,64
Slurry content	3,53	0,89	%	3,53

Loose bulk density	1,25	1,27	gr/cm^3	1,25
Solid bulk density	1,40	1,42	gr/cm^3	1,40

The concrete mix was a combination of its constituent materials. The characteristics and properties of the materials influenced the concrete planning. The concrete mix design aimed to determine the composition or proportion of the constituent materials. The concrete design in this study was prepared with a concrete quality of F'c 25 MPa..

Table 4. The comparison of the mix design between normal concrete and SCC $1M^3$

Mix Design	Normal Concrete	SCC
The quality of concrete	Fc 25	Fc 25
Cement	460 kg/m^3	430 kg/m^3
Water-cement ratio	0,5	0,3
Flow/slump flow	±8	550mm-800mm
Viscocrete	-	1,5%
Percentage of fine aggregate	35%	52%
Percentage of coarse aggregate	65%	48%
Grading of sand	Zone 2	Zone 2
Cement	PCC Type 1	PCC Type 1

3.2 Slump Flow Test Analysis

The slump test analysis was conducted to determine the flowability of SCC by measuring the spread value of fresh concrete.

Table 5. SCC Concrete Slump Flow Testing

Specimen Code	Sika viscocrete content	Synthetic fiber content	Slump flow value	Description
BS	1,5 %	0 %	70 cm	Fulfilled
BSSS 0,20 %	1,5 %	0,20 %	70 cm	Fulfilled
BSSS 0,25 %	1,5 %	0,25 %	69 cm	Fulfilled
BSSS 0,30 %	1,5 %	0,30 %	66 cm	Fulfilled

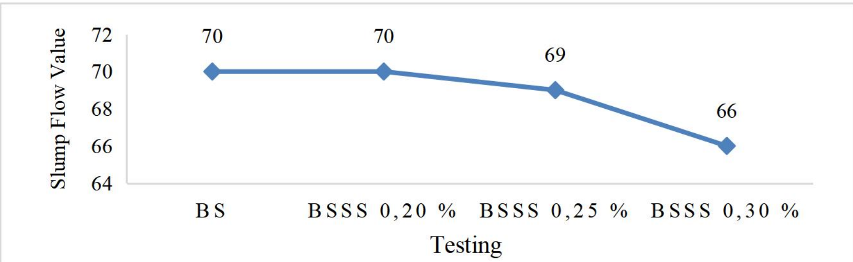

Fig. 3. Graph of slump flow testing

From the results of the slump flow test, it was known that the admixture Sika Viscocrete 3115 N with synthetic fibers showed that the more synthetic fibers were present in a concrete mixture, the smaller the diameter of the concrete flow spread became. However, at a fiber content of 0.30%, it still met the requirements for SCC concrete, which required a diameter of 550mm to 850mm.

3.3 L-Box Test Analysis

The L-Box test was used to evaluate the passing ability criteria of SCC concrete. The L-Box test identified the possibility of blocking during flow and measured the viscosity of fresh concrete.

Table 6. The results of the L-Box test for SCC concrete

Specimen Code	Sika viscocrete content	Synthetic fiber content	H2 (mm)	H1 (mm)	Value $PL = \frac{H2}{H1}$	Description
BS	1,5 %	0 %	95	102	0,93	Fulfilled
BSSS 0,20 %	1,5 %	0,20 %	90	100	0,90	Fulfilled
BSSS 0,25 %	1,5 %	0,25 %	89	102	0,87	Fulfilled
BSSS 0,30 %	1,5 %	0,30 %	85	100	0,85	Fulfilled

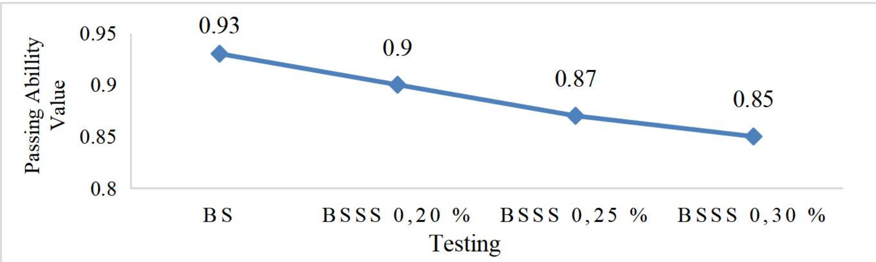

Fig. 4. Graph of L-Box Test Analysis

The ratio of passing ability (PL) achieved in the L-Box test could be seen from the results of the L-Box test in Table 7, which showed that the more synthetic fibers present in a mixture of admixture materials, the lower the PL value became.

3.4 V-Funnel Analysis

The V-Funnel test was used to measure the viscosity of SCC concrete and the resistance of concrete to segregation.

Table 7. The results of the V-Funnel test for SCC concrete

Specimen Code	Sika viscocrete content	Synthetic fiber content	Time	Description
BS	1,5 %	0 %	7 detik	Fulfilled
BSSS 0,20 %	1,5 %	0,20 %	7 detik	Fulfilled
BSSS 0,25 %	1,5 %	0,25 %	8 detik	Fulfilled
BSSS 0,30 %	1,5 %	0,30 %	10 detik	Fulfilled

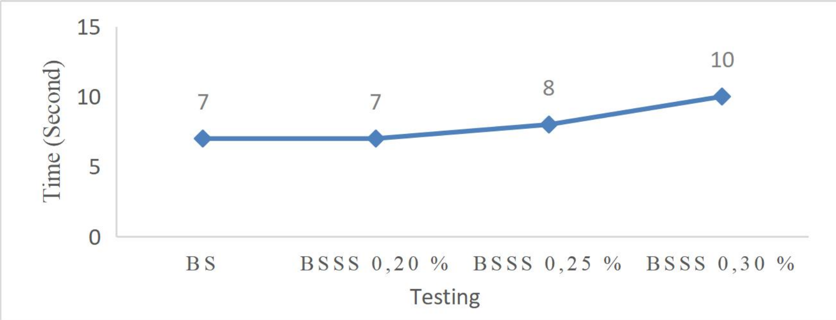

Fig. 5. Graph of V-Funnel Testing

The results of the v-funnel test indicated that as the amount of synthetic fiber increased, the time required to flow fresh SCC concrete through the v-funnel testing device became longer due to the reaction from the synthetic fiber.

3.5 The results of the average compressive strength test of concrete

After the test specimens were made and cured by immersion, the compressive strength tests of the concrete were conducted at 7 days, 14 days, and 28 days, with a total of 45 samples consisting of 5 mixture variations, each with 9 samples.

Table 8. The results of the average compressive strength of concrete

Specimen Code	Dates (Day)			Unit
	7	14	28	
BN	21,53	24,55	25,76	
BS	21,33	23,78	26,42	
BSSS 0,20 %	21,23	23,97	26,89	MPa
BSSS 0,25 %	21,42	24,06	27,08	
BSSS 0,30 %	21,51	24,63	27,13	

Regression analysis was used to determine the relationship between variables to obtain the validity of the data, indicating the level of accuracy of the data.

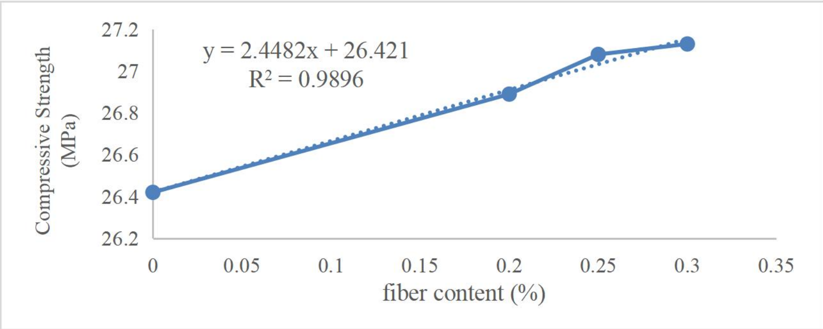

Fig. 6. Graph of the regression analysis of the compressive strength of SCC concrete at 28 days

The regression graph of the compressive strength of concrete at 28 days had the equation y = 2,4482x + 26,421 with an accuracy of R^2 = 0,9896, indicating that the validity of the data was 0.9896, with a very strong relationship.

4 Conclusion

The analysis indicated that in the characteristic testing of SCC concrete, the optimal values were found at fiber contents of 0% and 0.2%. After these levels, the characteristic values experienced a decrease, although the highest fiber content of 0.3% still met the criteria for SCC concrete. The percentage increases in compressive strength from the addition of fiber compared to SCC concrete without fiber were 1.8%, 2.4%, and 2.6%, respectively. Meanwhile, the percentage increases in compressive strength of SCC concrete with an addition of 0.05% for each test specimen were 1.8%, 0.7%, and 0.18%. The most optimal increase in compressive strength occurred in SCC concrete with a fiber content of 0.2%, while the lowest increase occurred at a fiber content of 0.3%.

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