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Physical and Mechanical Properties of Self-Compacting Concrete (SCC) with Pineapple Leaf Fibre and Polypropylene

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Abstract. SCC is a high-performance concrete innovation that does not require vibrating equipment at the time of placement and compaction. The purpose of this study is analysis the ratio effect of fiber gain on physical and mechanical properties of SCC. This research uses fiber with fiber variation and content as additional material. The variation of fiber is pineapple leaf fiber and polypropylene with w/c is 0.3. The variation of fiber has length 12 mm with fiber content 0.2%, 0.3% and 0.4% of cement weight. Testing the physical properties or characteristics of SCC conducted in this study was slump flow, V-funnel and L-box. The testing of mechanical properties performed at the ages of 7 and 28 days for compressive and flexural strength. The addition of fiber showed the effect on physical and mechanical properties of SCC. Increasing the fiber content showed an increase in flexural strength accompanied by a decrease in the value of the diameter and time of fresh concrete. Maximum compressive strength was obtained with the use of 0.3% fiber content of 56.28 and 58.04 MPa for pineapple leaf fiber and polypropylene at the ages of 28 days. The 0.4% fiber content provided a maximum flexural strength of 7.76 and 8.16 MPa for pineapple leaf fiber and polypropylene at the ages of 28 days.

1. Introduction

Concrete with a minimum vibration usage at the time of compaction has been used in Europe since the early 1970s. In Europe this concrete was used in construction work for Sweden transportation in the mid-1990s. SCC is a high-performance concrete innovation that does not require vibrating equipment at the time of placement and compaction. SCC can flow with its own weight, filling the entire mold and can obtain solid structures even on very tight reinforcement [1]. According to [2] and [3], Self-Compacting Concrete (SCC) or self-leveling concrete is a composite of various constituent materials that produce a concrete with good segregation resistance, has a good flowability with a certain viscosity.

SCC is one of high performance concrete innovations. SCC does not perform very well in resisting tensile strength that cause cracks in concrete. As a result of the deficiency of the concrete, the fiber is used as an additional material in the composition of the SCC mixture. In construction world, the use of fiber as one of the reinforcement materials has been used since the early 19th century. The use of



fibers can improve mechanical properties such as tensile strength and flexural of concrete in a construction element. In addition, the use of fiber can also reduce the early cracks caused by the loading and heat hydration.

Fiber is used as one of the brittle reinforcing materials of concrete. Reinforced concrete with fiber or also called Fiber Reinforced Concrete (FRC) is used as the constituent material to increase the compressive strength, flexural and tensile strength of concrete [4].

According to [5], since 1960 has begun efforts by researchers to develop concrete from conventional concrete to culminate in the development of reinforced concrete with fiber. The use of fiber can be used as an additional material that serves to improve the stability of SCC in preventing premature cracking of plastic concrete shrinkage or the plastic shrinkage properties of concrete. The use of fiber can decrease the characteristic of flowability and passing ability in SCC, so there are must be the requirement of type, length and optimal quantity to give a good characteristic on fresh and hardened concrete [1].

ACI grouped fibers such as Synthetic Fiber Reinforced Concrete (SNFRC) and Natural fiber reinforced concrete (NFRC). SNFRC is the use of synthetic fiber as a reinforcing material of concrete. According to [6], synthetic fibers are a type of artificial fiber derived from research developed in the textile and petrochemical industries. SNFRC is a fiber derived from organic polymers. The types of fibers that have been tested and become a mixture of concrete are acrylic, aramid, carbon, nylon, polyester, polyethylene and polypropylene. According to [7], polypropylene fibers are divided into three types based on fiber length is monofilament, microfilament and fibrillated which each fiber types have different fiber properties.

NFRC or reinforced concrete with natural fiber is the use of natural fiber as an additive material for reinforcing concrete. Natural fibers that can be used as concrete reinforcement materials are pineapple leaf, coconut, sisal, jute, banana and other fibers. The use of natural fiber as a reinforcement material of concrete due to the abundance of plants used as material for the production process or consumption directly besides the relatively cheap fiber prices make natural fibers are also in demand as an additional material of concrete.

According to [8], the addition of fiber can increase strength and reduce crack and also plastic shrinkage properties in concrete. Pineapple Leaf Fiber (PALF) is a natural fiber that can be used as a concrete reinforcing material known as Pineapple Leaf Fiber Reinforced Concrete (PALFRC). Natural fibers are relatively cheaper than other synthetic fibers so they are widely used as a reinforcing material substitute of synthetic fibers [9].

Pineapple Leaf Fiber obtained from pineapple leaves fiber cut to the desired size, washed, dried and used for composites. Based on research [10], Pineapple Leaf Fiber has a high enough cellulose content of 70-80% and low to lignin levels is 5-12%. Pineapple leaf fiber has a tensile strength ranging from 413-1627 MPa and a modulus of 34.5 to 82.51 GPa.

2. Methodology

This research used an experimental method. The variations of fiber used are pineapple leaf fiber and polypropylene with the composition 0.2%, 0.3% and 0.4% of the cement weight. The tests of physical properties or characteristics of SCC in the form of slump flow, V-funnel and L-box test. Testing of mechanical properties were compressive strength and flexural strength at the ages of 7 and 28 days. The cement material used in this research was OPC type 1. The pineapple leaf fiber was used from Blitar, East Java and cut with length 12 mm. The pineapple leaf fiber has an average fiber diameter of 192.353 μm . Figure 1 shows the results of SEM testing of pineapple leaf fiber diameter. The length of polypropylene was 12 mm. The coarse aggregate was used from Merak with a maximum aggregate size of 10 mm. The first fine aggregate was used from Bekasi with size ranges 50 - 650 μm . The second fine aggregate was used natural sand of Tanjung Raja in accordance with ASTM standard of fine aggregate grain size ranges from 0.125 - 4 mm. Superplasticizer was used in this research is superplasticizer type F. The composition of superplasticizer is 1,500 - 2,000 mL per 100 kg of cement weight. The mix composition of SCC was based on [1] and [6]. The mixed composition of SCC with

variation and fiber composition can be seen in Table 1. Based on Table 1 variations of non-fiber, pineapple leaf fiber and polypropylene are shown on the N, DN and P labels. The numbers 0.2, 0.3 and 0.4 on the label indicate the fiber use of fiber content in each fiber variation of 0.2%, 0.3% and 0.4% of cement weight. The composition of the mixture used is uniform with the value of the ratio of cement water or w/c of 0.3. The sample was printed in a cylindrical formwork with size 10 cm x 20 cm for testing of compressive strength and beam formwork with size 10 cm x 10 cm x 35 cm for testing of flexural strength.

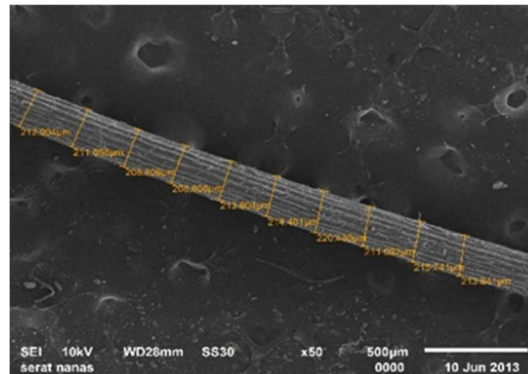


Figure 1. Diameter of pineapple leaf fiber

Table 1. Mix composition of SCC

Label	OPC (kg/m ³)	Water (kg/m ³)	Coarse aggregate (kg/m ³)	Fine aggregate (kg/m ³)	
				I	II
N	600	180	830	246	540
DN-0.2	600	180	830	246	540
DN-0.3	600	180	830	246	540
DN-0.4	600	180	830	246	540
P-0.2	600	180	830	246	540
P-0.3	600	180	830	246	540
P-0.4	600	180	830	246	540

3. Result and Discussion

3.1. Slump Flow

Slump flow testing was used to know the properties of filling ability and flow ability in the form of fresh concrete. This tested provided an overview of fresh concrete capability in flowing. The value of the slump flow test shown in Figure 2 was obtained from the average measurement of the diameter of fresh-split diameter with the variation and composition or content of pineapple leaves and polypropylene in four directions of perpendicular distribution. Based on the results of slump flow testing there was a difference in the diameter of the distribution ranged from 595 - 720 mm. Maximum slump flow value was obtained on SCC with label N which non-fiber variation with diameter 720 mm, while minimum values were at DN-0.4% with 595 mm for pineapple leaf fiber and P-0.4% with 620 mm for polypropylene fiber.

3.2. V-Funnel Test

The V-funnel testing was performed to determine the time of streamed of fresh concrete by the use of V-funnel testing in the form of a reversed triangle prism. The value of the V-funnel test resulted from the calculation of the duration of the falling fresh concrete from the funnel at open until fresh concrete exits from the V-funnel test apparatus. Figure 3 shows the value of V-funnel test results. Based on the

value of V-funnel test results obtained the fastest jetting time with the N label was the composition of SCC without additional fiber with a time of 6.93 seconds, while the label DN-0.4% shows the time of late streaming of 14.89 seconds. The time span of DN labeling with the used of pineapple leaf fiber was between 10.14 - 14.89 seconds and label P with the used of polypropylene fiber between 9.25 - 13.56 seconds. Figure 3 shows that increasing composition of the pineapple leaf fiber and polypropylene made the test results become slower. The viscosity of fresh concrete become higher due to the used of variations of the fiber content which allows the fibers in fresh concrete to clot and block the rate flowability in fresh concrete.

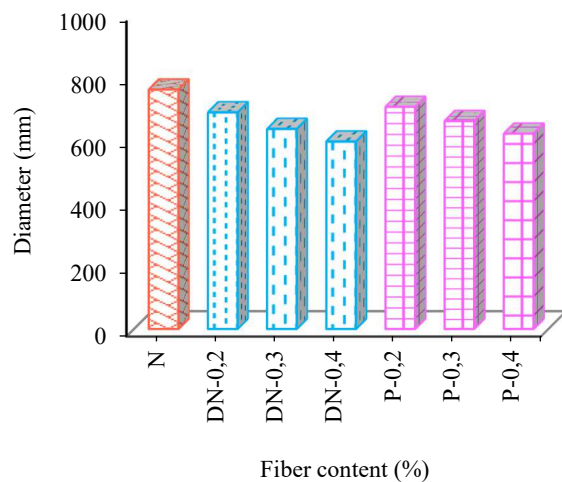


Figure 2. The result of slump flow test

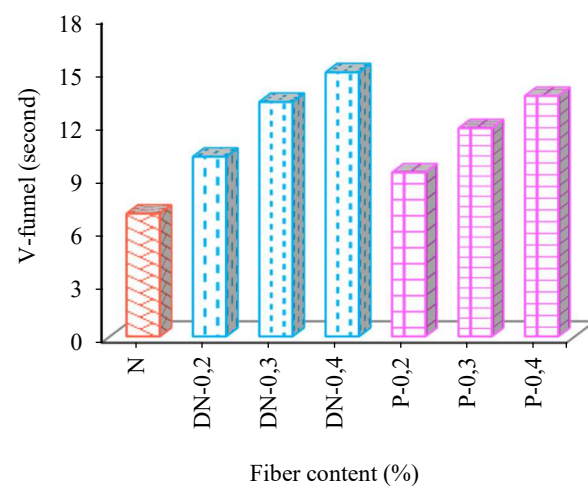


Figure 3. The result of V-funnel test

3.3. L-Box

L-box testing was performed by measuring the three base points and the end of the testing tool. L-box test results can be seen in Figure 4. This test conducted to determine the passing ability of SCC. Based on Figure 4 the values range of L-box is from 0.833 - 0.970. The highest L-box value ratio was obtained from normal SCC with label N 0.970. SCC with variations and contents of pineapple leaf fiber and polypropylene gave the highest ratio on label DN-0.2% equal to 0.892 and P-0.2% equal to 0.914. Figure 4 shows the increasing composition and fiber content of pineapple leaf fiber and polypropylene resulted smaller L-box ratio. This causes the ability to flow fresh concrete through the reinforcement or passing ability was reduced due to increased viscosity of concrete.

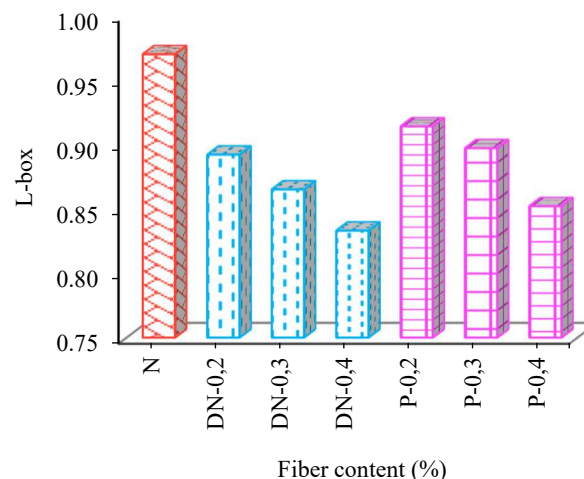


Figure 4. The result of L-box test

3.4. Compressive Strength

Testing of concrete compressive strength was performed at the ages of 7 and 28 days. The result of concrete compressive strength test was obtained from the average of 5 samples. The concrete compressive strength test was performed to compare the compressive strength value with composition and fiber content of pineapple leaf fiber and polypropylene. The results of compressive strength test at the ages of 7 and 28 days for variation and fiber content of pineapple leaf fiber and polypropylene can be seen in Table 2 and Figure 5.

The using of polypropylene fibers provides a higher compressive strength results compared to the use of pineapple leaf fibers. The used of 0.3% polypropylene fiber content gave a compressive strength value of 45.201 MPa where the compressive strength was higher than pineapple leaf fiber with a compressive strength of 44.342 MPa. The concretes compressive strength range with the addition of 0.2% - 0.4% fiber composition were 41.353 - 45.201 MPa. Compressive strength at the age of 7 days without fiber addition gave the lowest value of 39.436 MPa.

The result of compressive strength test at the age of 28 days with composition and variation of pineapple leaf fiber and polypropylene can be seen in Table 2. The compressive strength value of non-fiber concrete shows the lowest compressive strength value of 52.145 MPa. The range of compressive strength value at the age of 28 days concretes with different composition and fiber variations were 54.147 - 58.037 MPa.

The maximum compressive strength of concrete was obtained with the used of 0.3% fiber content for variation of pineapple leaf fiber and polypropylene with compressive strength of 56.275 and 58.037 MPa. The decreased of concrete compressive strength occurred with the addition of fiber content as much as 0.1% to 0.4%.

3.5. Flexural Strength

Flexural strength test was performed at the ages of 7 and 28 days concrete. Comparison and value of test results of SCC with pineapple leaf fiber and polypropylene at the ages of 7 days and 28 days are shown in Table 2 and Figure 6. Comparison of the flexural strength values from testing between variations and fiber compositions. Flexural strength values increased from concrete without variation of fiber to concrete with fiber variation and composition. Flexural strength values with variations and fiber compositions were obtained from the test results with range from 4.550-5.607 MPa. The maximum flexural strength values were obtained with the use of 0.4% fiber composition of 5.369 and 5.607 MPa for pineapple leaf fiber and polypropylene. The flexural strength at the age of 28 days increased with the addition of fiber content. Flexural strength at the age of 28 days with variation and fiber content has range from 7.518-8.302 MPa. The lowest flexural strength was found in concrete without the addition of fiber with value of 7.140 MPa. Concrete with variation of pineapple leaf fiber and polypropylene showed the maximum flexural strength on the used of 0.4% fiber content of 7.875 and 8.302 MPa.

Table 2. Compressive strength and flexural strength

Fiber	Fiber content (%)	Compressive strength (MPa)		Flexural strength (MPa)	
		7 days	28 days	7 days	28 days
Non-fiber	0.0	39.436	52.145	3.535	7.140
Pineapple leaf fiber	0.2	41.353	54.147	4.550	7.518
	0.3	44.342	56.275	4.837	7.763
	0.4	43.384	55.738	5.369	7.875
Polypropylene	0.2	42.214	55.814	4.802	7.952
	0.3	45.201	58.037	5.131	8.162
	0.4	44.818	57.889	5.607	8.302

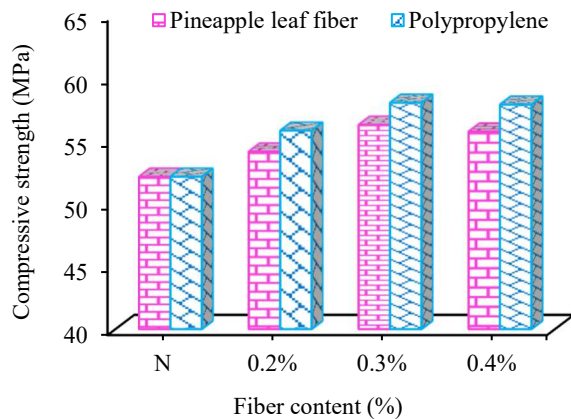


Figure 5. Compressive strength for age of 28 days

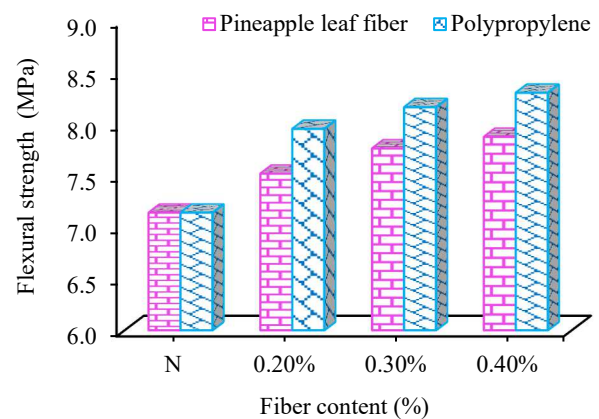


Figure 6. Flexural strength for age of 28 days

4. Conclusion

The optimum composition or content of pineapple leaf fiber and polypropylene were obtained by using 0.3% fiber content for compressive strength of SCC. Based on the results of slump flow testing, the more fiber composition used will make a smaller value of slump flow diameter. The results of the V-funnel test, the more fiber composition used will make the flow time generated longer. The highest compressive strength test at the ages of 7 and 28 days on pineapple leaf fiber were using 0.3% fiber content of 44.342 and 56.275 MPa. The results of the highest compressive strength test at the ages of 7 and 28 days on polypropylene fiber were using 0.3% fiber content of 54.147 and 58,037 MPa. The results of the highest flexural strength test at the ages of 7 and 28 days on pineapple leaf fiber were using 0.4% fiber content of 5.369 and 7.875 MPa

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