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Study of Self Compacting Concrete performance with addition of nylon fiber

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Abstract. Self Compacting Concrete (SCC) is a plastic concrete that is easy to flow because of its own weight, fulfils all the desired concrete molds, and has the properties to compose itself. Very suitable applied to conventional concrete construction work that has a large specific gravity and compaction or vibration of concrete is needed. The purpose of compaction itself is to minimize the air trapped in fresh concrete, hence the concrete becomes homogeneous and voids do not occur. To increase the flexural strength of concrete, the addition of nylon fibers can be a solution. Nylon fiber is a material with polymer fibers that have fiber, film and plastic properties. The objective of this study is to evaluate the compressive strength and modulus of elasticity, tensile strength and flexural strength of concrete with the addition of nylon fiber. The percentage of nylon fiber addition of 0.5% and 1% of the weight of cement with a diameter of 0.35 mm and 0.65 mm and a length of 15 mm and 20 mm. With the addition of 1% nylon fiber, compressive strength increases 126% in variation of 0.65 mm diameter and L = 15 mm, tensile strength increases 56.27% in variations diameter of 0.65 mm and a fiber length of 20 mm and flexural strength increases 5.390% in variations a diameter 0.65 mm in the length of 20 mm. The diameter, length and volume of the addition of nylon fibers affect the concrete mechanical behavior. It is proven that the greater the diameter of the nylon and the percentage of the addition of nylon can increase the strength of concrete.

1. Introduction

The rapid development in the construction industry has caused the demand for concrete to increase, so that concrete work plays an important role. This can be seen clearly in every construction that is built, such as tall buildings, housing, airports, roads, bridges, dams, port docks, and irrigation channels and other buildings always need concrete work, both as primary needs and as elements of supporting materials.

Conventional concrete construction work which has a large specific gravity and compaction or vibration of concrete is absolutely necessary. The purpose of compaction itself is to minimize the air trapped in fresh concrete, hence the concrete becomes homogeneous and voids do not occur. However, to get high quality concrete by still using conventional work usually requires more energy and costs. Therefore, various kinds of innovations have been carried out to obtain high quality concrete that is environmentally friendly and economical. To improve the quality of concrete, one solution is the addition of nylon fiber. Nylon fiber is a material with polymer fibers that have the properties of fibers, films and plastics. Nylon is formed by a group associated with a repeat hydrocarbon unit of varying length in a polymer having a specific gravity of 1.15. According to Gonzalo [1] reinforced concrete with irradiated nylon fiber, the increased strength of concrete caused by radiation fiber depends on the percentage of fiber applied and the fiber content in the concrete. The best percentage is 2% nylon fiber. In Tjaronge's research [2], making their own concrete compaction, the process of compacting concrete is no longer needed. According to Supartono there are several ways to improve concrete performance [3], including reducing the porosity of the material by reducing the amount of water in the concrete mixture, adding active minerals such as Silica Fume, Copper Slag, or fly ash, adding fiber in the concrete mixture, and Self Compacting Concrete.

SCC is a concrete that when it is still in the form of fresh concrete is able to flow through the reinforcement (passing ability criteria) and fills the entire space in the mold in a solid manner without the need for manual compaction or mechanical vibration (criteria filling ability). To obtain concrete that is able to flow without material separation (segregation resistance), a high range water reducer or superplasticzer is used. The superplasticzer improves the consistency of the cement paste and makes the cement paste envelope and bind the aggregate tightly, so that the concrete is able to flow without material abrasion.The objective of this study is to evaluate the compressive strength, split tensile strength, flexural strength, and modulus of elasticity in concrete with the addition of Nylon fiber.

2. Methods

The specimens were cylindrical concrete specimens with diameter of 10 cm and height of 20 cm and a beam with dimension of 10 cm x 10 cm x 40 cm. The number of specimen and types of testing can be seen in Table 1.

Table1. Sample variation.

Type of Testing	Sample	Age of Testing	Variation 0,5% Ø=0.65mm L=15 mm	L=20 mm	Ø=0,35mm L=15 Mm	L=20 Mm	1% Ø=0.65mm L=15 mm	L=20 mm	Ø=0,35mm L=15 Mm	L=20 mm	Normal Concrete	Total
Unit	Cm	Day										
Compressive Strength and Modulus of Elasticity	Cylinder (10x 20)	7	3	3	3	3	3	3	3	3	3	27
		14	3	3	3	3	3	3	3	3	3	27
		28	3	3	3	3	3	3	3	3	3	27
Tensile strength	Silinder (10x20)	28	3	3	3	3	3	3	3	3	3	27
Flexural Strength	Beam (10x10x40)	28	3	3	3	3	3	3	3	3	3	27
Total												162

The mix design method used is The European Federation Of Specialist Construction Chemicals and Concrete Systems (EFNARC) [4]. The target slump flow is 550 mm, in which the slump flow test is carried out using the Abrams cone. After making the test specimen, the next procedure is the treatment of the test specimen by immersed in fresh water at room temperature.

2.1. Sample testing

2.1.1. Compressive Strength using SNI method 1974:2011 [5]. The testing was carried out after specimen reaches the age of 7.14, and 28 days. Concrete compressive strength can be calculated by the formula equation (1)

$$f_c = \frac{P}{A} \quad (1)$$

where fc = compressive stress of concrete (N/mm^2), P = maximum load (kg), A = Cross-sectional area that receives a load(cm^2).

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2.1.2. Tensile Strength using SNI method 2491: 2014 ***[6].*** This test is done by giving tensile stress to the concrete indirectly. The specimen used was a cylinder that was laid down and pressed so that the tensile stress on the concrete occurred. The tensile strength can be calculated by the following formula equation 2:

$$f'ct = \frac{2P}{\pi LD} \tag{2}$$

Where f'ct= tensile strength (Mpa), P = maximum load (N), L= specimen length (mm), D= specimen diameter (mm)

2.1.3. Modulus elasticity of concrete (Ec). The modulus of elasticity of concrete can be determined based on normal concrete weight Wc and concrete compressive strength fc ', by equation 3:

$$E_c = (W_c)^{1,5}\, 0,043. \sqrt{fc'} \tag{3}$$

with W_c = 1500~2500 kg/m^3

2.1.4. Flexural strength using SNI method 4431:2011 ***[7].*** flexural strength testing is carried out using a Universal Testing Machine (UTM) machine with a capacity of 1000 kN. Figure 1 show concrete flexural strength testing, then the concrete flexural strength is calculated according to equation 4 as follows.

$$f_L = \frac{P.L}{b.h^2} \tag{4}$$

where f_L : Flexural Strength (MPa), P : highest load read on the test machine (ton), L : Distance (mm), b: wide cross-section broken horizontal direction (mm), h : wide cross-section broken vertical direction (mm).

Figure 1. Flexural strength testing.

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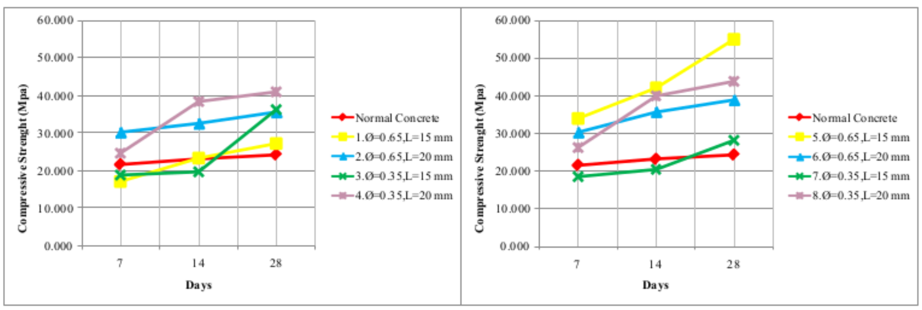
3. Results and discussion

In the study Ansar, the effect of adding nylon fibers on lightweight concrete with gas technology can increase the compressive strength, split strength, and modulus of elasticity [8]. The addition of nylon fibers by 0.25%, 0.5%, 0.75%, 1% to the concrete volume, increasing the compressive strength value by 7.62%, 15.48%, 31.54%, 50.37% respectively to lightweight concrete without fiber. The tensile strength is up to 46.04% at 1% fiber content, and the modulus of elasticity is increased to 63.18%.Thesame results were obtained in this study as below.

3.1. The compressive strength of SCC

In Figure 2 with a variation of 0.5% of the nylon fiber shows the highest compressive strength value in variation 2 with Ø = 0.65mm and L = 20 mm at 40.97 MPa. Whereas for the addition of 1% nylon fiber, variation 5 with Ø = 0.65mm; L = 15 mm increased the highest compressive strength that is equal to 54.93 MPa. The addition of nylon fibers by 0.5% and 1% can increase the compressive strength of 68.75% and 126.26%, respectively.

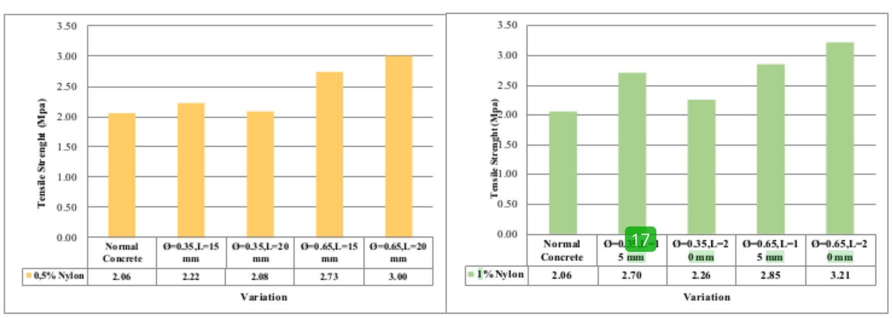


(a) 0.5% Nylon (b)1% Nylon

Figure 2. Compressive strength of SCC with nylon fiber.

3.2. *Tensile strength of SCC*

In Figure 3, obtained SCC fiber concrete with the addition of nylon fiber has increased the tensile strength compared to the normal concrete. The optimal percentage increase in tensile strength of SCC concrete is obtained by adding 1% nylon fiber with a diameter of 0.65 mm and a fiber length of 20 mm with a value of 56.17%. Then the tensile strength value increases from the addition of 0.5% to 1% nylon fiber. Based on this, it can be said that the compressive strength and tensile strength values of SCC with the addition of fiber are affected by the percentage of fiber addition, fiber diameter, and fiber length.



(a) 0.5% Nylon b) 1% Nylon

Figure 3. Tensile strength of SCC.

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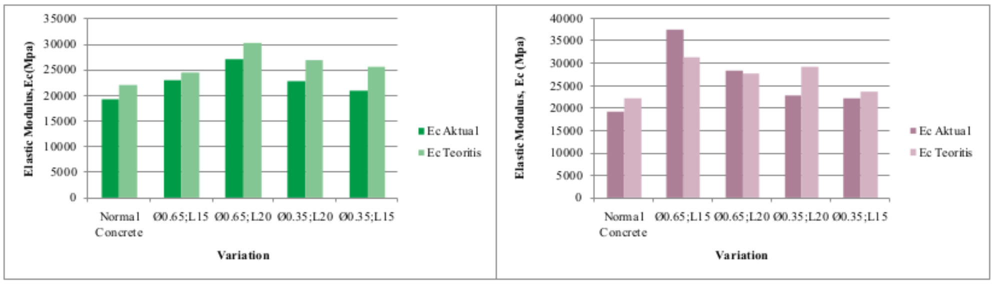
3.3. *Modulus of elasticity*

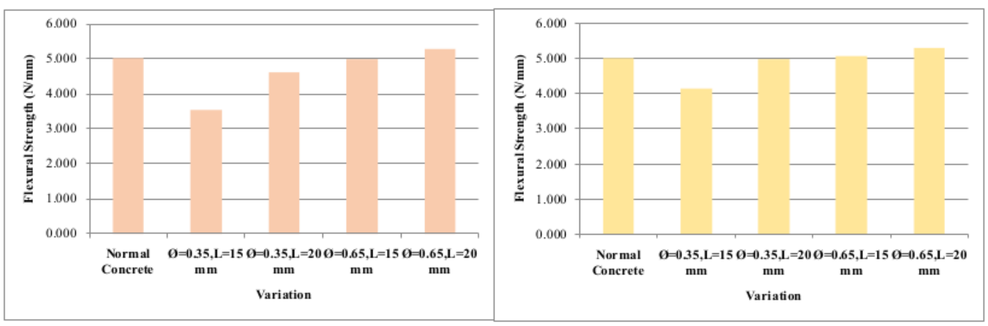
Figure 4 shows a comparison of the modulus of elasticity of experimental and theoretical values. Modulus of elasticity increases with increasing compressive strength, but the two variations do not show a trend related to the diameter and length of the fiber. The highest value is obtained from the addition of 0.5% nylon fiber with a diameter of 0.65 mm and a length of 20 mm, and addition of 1% nylon fiber with a diameter of 0.65 mm and a length of 15 mm.



(a) 0.5% Nylon (b) 1% Nylon

Figure 4. Modulus of elasticity SCC.

3.4. *Flexural strength*



(a) 0.5% Nylon (b) 1% Nylon

Figure 5. Average flexural strength at 28 Days.

Figure 5 shows the flexural strength of concrete in both variations of the addition of nylon fibers. The flexural strength for the addition of nylon fiber by 1% tends to be greater than the addition of 0.5% nylon fiber, where an increase of 1.134% for variations of nylon fiber with a diameter of 0.65 mm and a length of 15 mm, an increase of 5.39% with a diameter of nylon fiber 0.65 mm and a length of 20 m. Flexural strength with the addition of 1% nylon fiber 0.65 mm diameter shows better performance compared to 0.35 mm diameter. Similarly, the addition of fiber by 0.5%.

4. Conclusion

Based on the description above, it can be concluded that the performance of SCC concrete increases with the addition of nylon fiber. The increase in compressive strength, tensile strength and flexural strength is quite significant with the addition of 1% nylon fiber. SCC performance is also influenced by the diameter and length of the nylon fiber used. However, there has not yet been a trend of increasing SCC performance related to nylon fiber dimensions.

5. Acknowlegment

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