UCT JOURNAL OF RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY 2019(04)

Available online at http://journals.researchub.org

The effect of twisted polymer fibers on the physical and mechanical properties of C35 concrete

Muhammad Tanveer Majid*

COMSATS University Islamabad, Vehari Campus, Pakistan

ARTICLE INFO

Article history:
Received 15 June. 2019
Accepted 13 Aug 2019
Published 16 Sept. 2019

Keywords:
Concrete, Forta fiber, compressive test, bending test, tensile test, modulus of elasticity.

ABSTRACT

Concrete as the most used material, is known as an integral part of construction. So far, many studies have been done in the field of improving the quality of concrete that most of them have examined change in concrete mix design; however, the use of additives and also replacing commonly used materials in concrete with new materials always has been considered. Today, different fibers, especially Forta fibers, are used. In this study, experiments on Forta fiber- reinforced concrete are described. The concrete mixing design and Forta fiber properties are also briefly described. The comparison between the results of the tests showed that Forta fiber- reinforced concretes have more bending strength and modulus of elasticity than normal and ordinary concretes.

1. INTRODUCTION

In today's advanced world and with the advances in various scientific fields, the concrete industry has also evolved. Special concrete production is also a result of these improvements, which, in addition to reducing the dead load of the building, reduces the force applied to the structure by the earthquake acceleration and, if destroyed, also reduces the weight of the resulting debris and today it is called the concrete of the century. According to their specific properties, these types of concrete have different applications, which are distinguished by their specific gravity and compressive strength [3]. Cement mortar and concrete made from Portland cement is one of the most widely used construction materials in the world. They have brittle behavior and some significant disadvantages, such as poor ductility and cracking, and poor performance. Also, their tensile and bending strengths are relatively low compared to their compressive strengths. Many efforts have been made to convert cement into building materials with desirable physical and mechanical properties.

1.1. Forta fibers

By 2013, FORTA, a Pennsylvania-based company in the US, has been manufacturing and selling various types of concrete and asphalt reinforcing fibers for thirty-five years. Since 1978, Forta has manufactured, developed and promoted a complete set of reinforced concrete fibers that have been used in a wide variety of applications. Concrete fibers are used to remove heat-reinforced concrete in concrete such as: steel deck ceilings, industrial floors, landscaping, parking lots, concrete pavements, shotcrete, concrete prefabricated parts (intended research), bridge decks, etc. These fibers reduce shrinkage of fresh and hard concrete, increase shock resistance, increase fatigue resistance and increase concrete hardness.

Forta fiber consists of two different structures with different materials. One part of it is composed of thin twisted strands, whose material is copolymer and the other part is made up of a network of thin pure polypropylene filaments. The grid section prevents the creation and expansion of thicker, shallow cracks in the concrete and the twisted strands section, after opening into the concrete structure, plays both a role in preventing primary cracks and secondary cracks and hardened concrete.

The long history of using fibers in brittle materials goes back at least 3500 years ago, when a type of straw-reinforced brick was used to build 57-meter-high hills near Baghdad.

Polymer fibers are commonly used for reinforcement in lightweight concrete. Polymer fibers can be produced in both filamentous and pollen form. The fibers are chemically inert and highly stable in the alkaline concrete environment and are resistant to cracking due to plastic shrinkage. The use of polymer fibers, in addition to improving the tensile strength and bending strength, toughness and ductility, also clearly improves the impact and fracture resistance.

*Corresponding author: admin@urdunama.org
DOI: https://doi.org/10.24200/jrset.vol7iss04pp11-15

Committee 544 of the American Concrete institute (ACI) released its first report on fiber concrete in 1973, which has been reviewed in recent years [1].

Bing Chen et al. investigated the properties of lightweight concrete containing EPS reinforced steel. They argued that steel fibers increase the tensile strength of concrete and improve its shrinkage [2].

Korshy et al. investigated the properties of high strength concrete by adding steel fibers. Experimental results showed that with increasing steel fibers, the tensile strength increased linearly and the rate of increase was higher in the first 7 days [4, 5, 6].

These fibers are manufactured by Forta American Company and distributed exclusively in Iran.

1.2. Numerical model

To investigate the effect of fiber on concrete behavior, a laboratory program was developed. Compressive, bending, tensile and elastic modulus tests were performed on specimens with different amounts of fiber. The following is a description of the characteristics of the samples and tests as well as the results obtained from them. Figure 1 illustrates the fabricated samples.

Figure 1. Laboratory samples

Table 1 shows the specifications of the laboratory samples in which we have 5 groups.

Table 1. Sample Specifications

Sample size (Lit)	Slump (cm)	Fiber weight percent	Fiber (kg/m^3)	SP/C	Water to cement W/C	Coarse-grained sand (kg/m^3)	Fine-grained sand (kg/m^3)	Gravel	Cement	Group
100	22	0	0	0.005	0.4	480	200	1120	350	S1
100	15	0.0086	2	0.005	0.4	480	200	1120	250	S2
100	7	0.0173	4	0.005	0.4	480	200	1120	350	S3
100	2	0.0260	6	0.005	0.4	480	200	1120	350	S4
100	1	0.0347	8	0.005	0.4	480	200	1120	350	S5

1.3. Experiments

In this section, we examine two bending and elasticity tests and discuss their results.

A) Bending test

In this experiment, the standard ASTM C293-79 method is used to determine the bending strength of concrete using simple beam and mid-point loading. For this purpose, the amount of intermediate concentrated force is gradually added with the help of the hydraulic jack of the device and the midpoint displacement of the beam is measured.

In the figure below, the tested samples are shown.

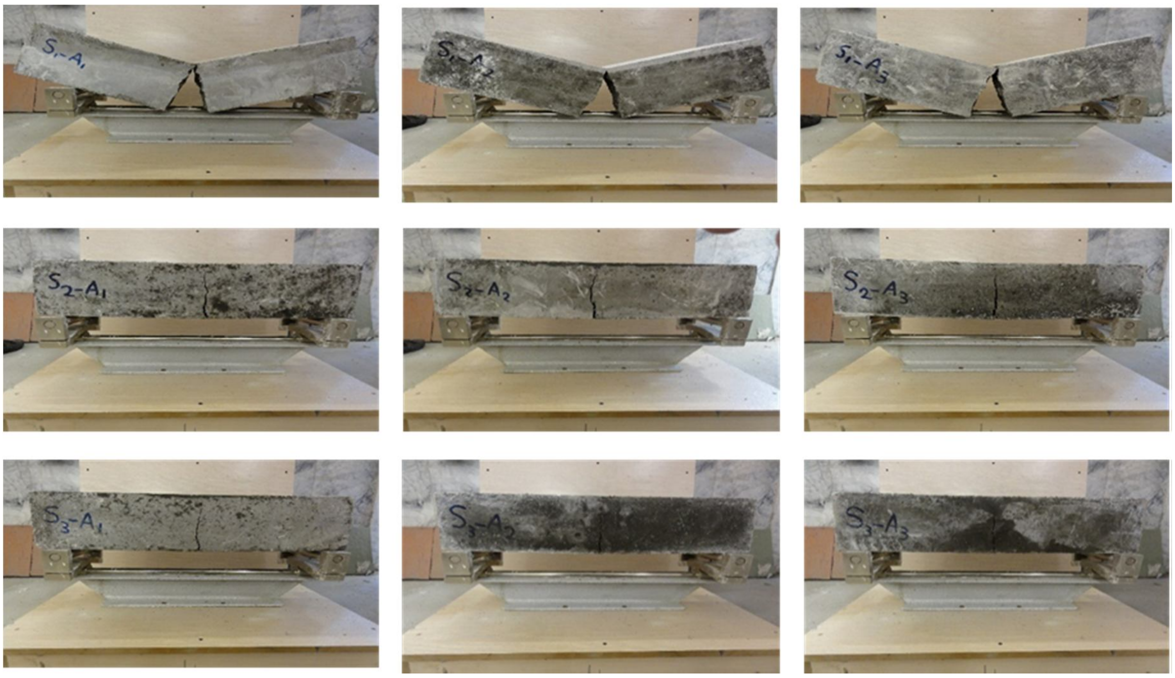

Figure 2. The results of bending test samples

Table 2. The results of bending test

Group	Sample name	Dimensions	Final load	Rupture modulus	Mean rupture modulus
		(cm×cm×cm)	(kg)	(MPa)	(MPa)
S1	S1-A1	15x15x65	2900	7.07	7.04
($0\frac{kg}{m^3}$)	S1-A2	15x15x65	2920	7.13	
	S1-A3	15x15x65	2840	6.93	
S2	S2-A1	15x15x65	3150	7.69	7.62
($2\frac{kg}{m^3}$)	S2-A2	15x15x65	3100	7.56	
	S2-A3	15x15x65	3120	7.61	
S3	S3-A1	15x15x65	3150	7.68	7.67
($4\frac{kg}{m^3}$)	S3-A2	15x15x65	3120	7.61	
	S3-A3	15x15x65	3160	7.72	
S4	S4-A1	15x15x65	3210	7.83	7.76
($6\frac{kg}{m^3}$)	S4-A2	15x15x65	3180	7.76	
	S4-A3	15x15x65	3150	7.68	
S5	S5-A1	15x15x65	2860	6.98	7.01
($8\frac{kg}{m^3}$)	S5-A2	15x15x65	2770	6.76	
	S5-A3	15x15x65	2980	7.27	

Many researchers believe that increasing the fiber's weight and its length to diameter ratio increases the area under the force-displacement curve. The reason that increasing the fiber weight parameters and the length to diameter ratio improves the bending properties is that the number of fibers in the concrete volume increases for a given fiber length. It is natural that if the fibers are of proper orientation and size at the fracture surface, their effect on bending properties is greater. In this test, bending strength increases with increasing fiber content up to 6 kg / m3 up, but in the sample with fiber of 6 kg / m3 up (S5 sample), bending strength is reduced. This was due to a decrease in fiber number along the fracture surface as well as a decrease in specific gravity and an increase in the porosity level in samples with high fiber content (sample S5 in this experiment).

B) The modulus of elasticity test

Concrete cylinders are used to obtain the modulus of elasticity of concrete samples. Cylindrical specimens are placed in the measuring apparatus and axial force is applied to them.

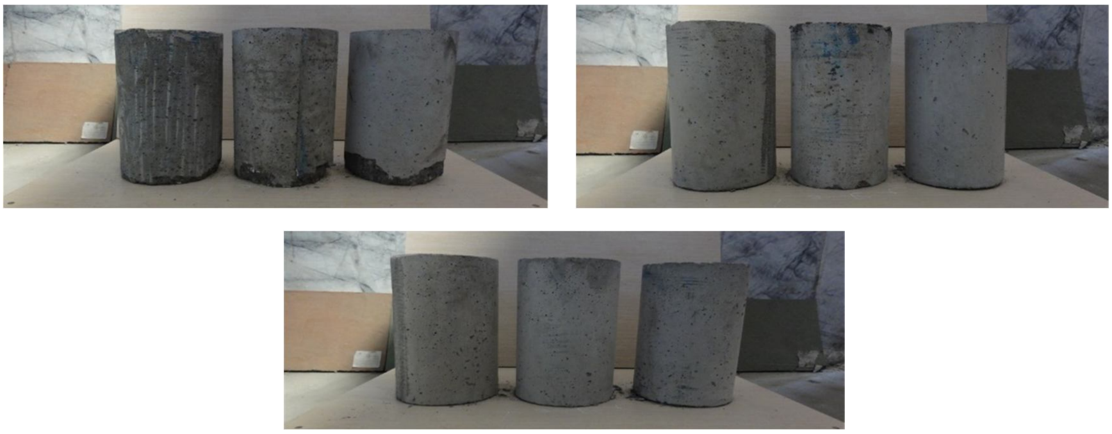

Figure 3. Some specimens after testing the modulus of elasticity

The following table shows the results obtained from the samples under modulus of elasticity test.

Table 3. Specimen characteristics and test result of elasticity modulus

Group	Group name	Dimensions	Final load	Final displacement	Rupture modulus	Mean rupture modulus
		(cm×cm×cm)	(ton)	(mm)	(MPa)	(MPa)
S1 ($0\frac{kg}{m^3}$)	S1-D1	15x30	30	0.173	29439.052	28514.265
	S1-A2	15x30	30	0.173	29439.052	
	S1-A3	15x30	30	0.191	26664.691	
S2 ($2\frac{kg}{m^3}$)	S2-A1	15x30	40	0.191	35552.921	32048.321
	S2-A2	15x30	40	0.208	32647.154	
	S2-A3	15x30	40	0.243	27944.889	
S3 ($4\frac{kg}{m^3}$)	S3-A1	15x30	40	0.208	32647.154	32672.315
	S3-A2	15x30	40	0.260	26117.723	
	S3-A3	15x30	40	0.173	39252.069	
S4 ($6\frac{kg}{m^3}$)	S4-A1	15x30	40	0.173	39252.069	3328.371
	S4-A2	15x30	40	0.243	27944.889	
	S4-A3	15x30	40	0.208	32647.154	
S5 ($8\frac{kg}{m^3}$)	S5-A1	15x30	40	0.260	26117.723	34873.954
	S5-A2	15x30	40	0.173	39252.069	
	S5-A3	15x30	40	0.173	39252.069	

As can be seen, similar to previous tests, the modulus of elasticity increases with increasing fiber content in concrete. By comparing the results of S1 and S2, it can be seen that the presence of fiber in concrete has a great effect on the modulus of elasticity.

2. CONCLUSION

1. In bending strength test it was observed that by increasing the amount of fiber up to 6 kg / m3 the bending strength increased gradually, but in the sample with fiber of 6 kg / m3 up (S5 sample), the bending strength decreased. The reason that increasing the fiber weight parameters and the length to diameter ratio improves the bending properties is that in this case the number of fiber in the concrete volume increases for a given fiber length. On the other hand, it is natural that if the fiber has a proper orientation and size at the fracture surface, its effect on bending properties is greater.
2. As the amount of fiber in the concrete increases, the modulus of elasticity also increases. Comparing the results of S1 and S2 samples, it can be seen that the presence of fiber in the concrete has a great effect on the modulus of elasticity. But the comparison of S2 and S5 samples shows that increasing fiber content from 2 to 8 kg / m3 has little effect on increasing this feature. Therefore, 2 kg / m3 of Forta fiber can be considered as a suitable percentage for reinforced concrete with it.

REFERENCES

[1] Aziz, M. A., Morphy, C. K. & Ramaswamy, S. D., Lightweight Concrete Using cork granules, Int. J. Lightweight Concrete, 1, No. 1, pp.29-23 (Lancaster, 1979).

[2] Darwish, F. A. Oliveira, T. M. Coura, C. G. Kitamura, S., Barbosa, M. T. G. Santos, W. "Influence of Fiber Ratio in the Size Effect", Proceedings, Int'l Conference Concrete: Construction's sustainable option, Dundee, UK, 2008, pp. 123-130.

[3] Mostofi Nejad, D., 2003, Concrete Mixing Technology and Design, Isfahan, Volume 6.

[4] Moufti, M.R., Sabtan, A.A., El-Mahdy, O.R., Shehata, W.M., "Assessment of the industrial utilization of scoria materials in central Harrat Rahat", Saudi Arabia, Engineering Geology 57 (2000) 155–162.

[5] Pohribnyi, V., Dovzhenko, O., Kuznietsova, I., & Usenko, D. (2015). The improved technique for calculating the concrete elements strength under local compression. In *MATEC Web of Conferences* (Vol. 230, p. 02025). EDP Sciences.

[6] Gao, Y., Liu, Z., Zeng, Q., Wang, T., Zhuang, Z., & Hwang, K. C. (2014). Theoretical and numerical prediction of crack path in the material with anisotropic fracture toughness. *Engineering Fracture Mechanics*, *180*, 330-347.