THE INVESTIGATION OF BASALT AND GLASS FIBERS ON THE BEHAVIOR OF REINFORCED CONCRETE BEAMS

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Abstract - This paper presents an experimental study aimed at determining the compressive, tensile and flexural behavior of concrete members containing different percentages of Basalt Fiber (BF) and Glass Fiber (GF). The diameter of BF and GF are 12-30 µm and 13µm respectively, both BF and GF are hooked ends deformed with 12 mm length. The mixtures contain the combination of BF and GF fibers. Control beam is without fiber, BF0.5 is (0.5 % BF), BF1 is (1 % BF), BF1.5 is (1.5 % BF), BF0.25GF0.75 is (0.25 % BF and 0.75 % GF), GF0.25BF0.75 is (0.25 % GF and 0.75 % BF) and BF0.5GF0.5 is (0.5 % BF and 0.5 % GF). The total volume of fibers is constant at 1 % for the hybrid fiber reinforced concrete beams. All mixtures are designed for high strength concrete (30 MPa). From the test results, it is observed that there is no significant effect of fiber inclusion on the compressive strength of concrete moreover BF concrete usually has higher tensile strength than GF. According to standards 28 days after casting fiber reinforced concrete beams are tested by two point loading. The flexural strength of beams are increasing with the increase of BF content in a gradual fashion but no such change was observed for GF reinforced concrete.

Keywords - Basalt Fiber (BF), Glass Fiber (GF), Compressive Strength, Tensile Strength, Flexural Strength.

I. INTRODUCTION

In civil engineering construction, concrete is a major construction material used in all over the world. These construction materials have inherently brittle in nature and have some of the dramatic demerits such as poor deformability of concrete and weak crack resisting properties. Tensile strength parameter and flexural strength are relatively low as compared to their compressive strength. Fibers are used to improve these factors. GFRC has been used extensively to produce light-weight and thin architectural elements. Basalt and glass fiber have high modulus, high elongation, and primarily these produce strong composite. The purpose of the experimental work presented in this paper is to compare the flexural and mechanical behavior of concrete reinforced with BF and hybrid BF-GF. Moreover, a study on the load-deflection behavior of fiber Reinforced Concrete (RC) beams are done.

II. LITERATURE REVIEW

Fiber reinforced concrete is a new constructional material established through broad research and progress during the last two decades. A variety of studies have focused on the properties and applications of fiber RC. It has been found that the addition of fibers to concrete can improve the tensile and shear strength, fracture toughness, crack resistance and energy dissipation capacity of concrete structures. Chandramouli et al (2010) conducted studies on GFRC and reported 15–20 % increase in flexural and splitting tensile strength and 20–25 % increase in compressive strength. A similar trend was observed by Tassew and Lubell (2014) where the flexural strength of ceramic concrete increased with increase in the GF volume fraction irrespective of the mix composition or fiber length. The flexural toughness, compression toughness index and shear toughness of ceramic concrete showed a considerable increase with an increase in the fiber content which was true regardless of the type of matrix or fiber length. Jon sung Sim et.al, (2005) investigated the applicability of the BF as a strengthening material for structural concrete members through various experimental work for durability, mechanical properties, and flexural strengthening. The BF used in this study was manufactured in Russia and exhibited the tensile strength of 1000 MPa, which was about 30 % of the carbon and 60 % of the high strength glass (S-glass) fiber. When the fibers were immersed in an alkali solution, the basalt and glass fibers lost their volumes and strengths with reaction product on the surface but the carbon fiber did not show significant strength reduction. From the accelerated weathering test, the BF was found to provide better resistance than the GF. Very few researches are present in the literature on the hybrid effect of GF and BF in RC beams.

III. EXPERIMENTAL TEST AND RESULTS

3.1 MATERIALS AND MIXTURE PROPORTIONS

The mix proportions of concretes prepared for this study are presented in Table 1. The water to cement ratio of the concretes is kept constant at 0.48 for all mixes. To obtain a desired level of workability in the was used at varying dosages. In the concrete mix design, coarse aggregate (crushed gravel and maximum size are 10 mm), fine aggregate (fine sand

and size interval is 0-4 mm), CEM I 32.5R Portland cement was used as cementitious materials.

concrete mixtures	Cement (kg/m^3)	Water (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate (kg/m^3)	Fiber content by volume %		SP (kg/m^3)	Density (kg/m^3)
					GF	BF		
Control	400	192	1110	600	0	0	1.80	2398
BF0.5					0	0.5	3.1	2320
BF1.00					0	1.00	3.45	2260
BF1.50					0	1.5	3.80	2130
BF0.50 GF0.5					0.5	0.5	3.55	2413
BF0.25 GF0.75					0.75	0.25	3.45	2419
BF0.75 GF0.25					0.25	0.75	3.63	2397

Table.1 Mix proportions of concrete mixtures

The RC beams were cast and tested under two point loading, using a different percentage of fibers. All specimens with the identical size of 1500 x 150 x 200 mm. All beams have identical reinforcement details including longitudinal reinforcement two 10 mm diameter bars were used at the bottom of each beam, two 8 mm at the top of each beam and stirrups reinforcement of 5 mm diameter at 100 mm spacing center to center as shown in Fig.1 with specimen details.

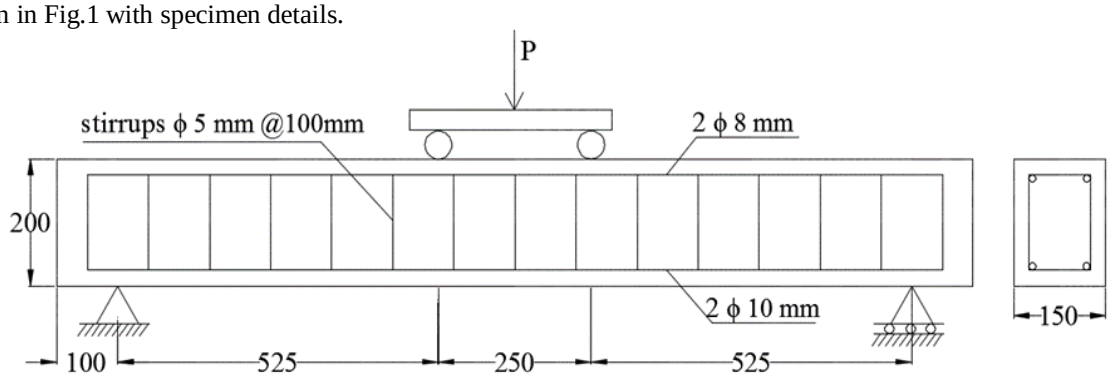


Figure 1: Loading and geometry of tested beam (all dimension in mm).

Cylinders and cubes specimen with BF and GF are casted to study their effect on the properties of concrete. Detailed properties and the pictures of the GF, BF used in this study are presented in Table 2 and Figure 2. After casting, the samples were cured at room temperature for 24 h. After demolding, all samples were kept in saturated water till testing day.

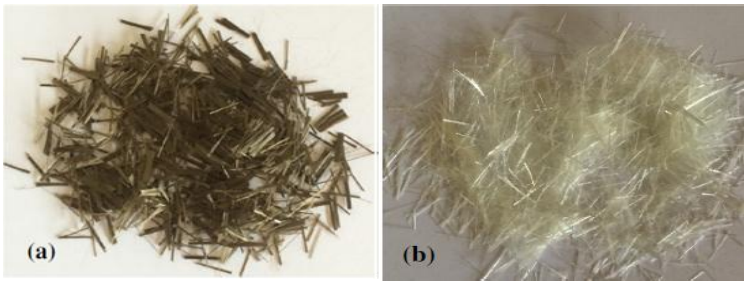


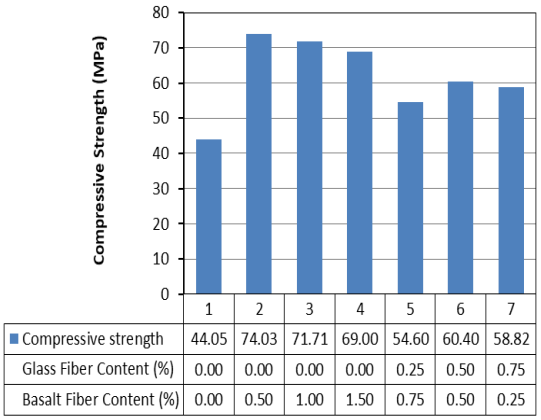
Figure 2: The fibers used in the study (a) basalt fiber and (b) glass fiber.

Fiber type	Length (mm)	Diameter (µm)	Modulus of elasticity (GPa)	Elongation (%)	Tensile strength (MPa)	Density (g/cm^3)
Glass	12	13	77	2.56	3400	2.6
Basalt	12	13-20	89	3.15	4100-4800	2.8

Table 2 Properties of glass and basalt fiber

3.2 COMPRESSIVE STRENGTH TEST

Compressive strength test is done according to EN 12390-3 [13], on cube specimens with dimensions of 100×100×100 mm. Three specimens were tested for each mixture and average was reported in this paper. Figure 3, presents the compressive strength test results of concrete mixes.



	1	2	3	4	5	6	7
Compressive strength	44.05	74.03	71.71	69.00	54.60	60.40	58.82
Glass Fiber Content (%)	0.00	0.00	0.00	0.00	0.25	0.50	0.75
Basalt Fiber Content (%)	0.00	0.50	1.00	1.50	0.75	0.50	0.25

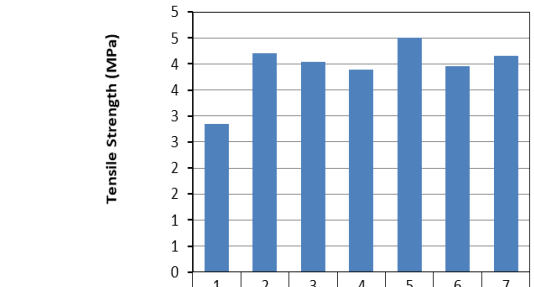
Figure 3: Compressive strength of mixtures containing GF and BF.

3.3 SPLITTING TENSILE STRENGTH TEST

The splitting tensile strength test was performed according to ASTM C496 [14] on three specimens of each mix. The size of cylinder used for this test was of diameter 150 mm and height 300 mm. For each mix, three cylinders were cast and cured for 28 days. The calculation was done by using the following formula.

$$T = \frac{2P}{\pi dl} \qquad (1)$$

Where T is the splitting tensile strength, d is the diameter of the sample, l is the sample length and P is the maximum applied load. Figs. 5 present the splitting tensile strength test results of concrete mixes.



	1	2	3	4	5	6	7
Compressive strength	2.85	4.20	4.04	3.90	4.50	3.96	4.16
Glass Fiber Content (%)	0.00	0.00	0.00	0.00	0.25	0.50	0.75
Basalt Fiber Content (%)	0.00	0.50	1.00	1.50	0.75	0.50	0.25

Figure 4: Tensile strength of mixtures containing GF and BF.

3.4 FLEXURAL STRENGTH TEST

The specimens were tested with two points loading accordance with ASTM C1018-92 [15], over an effective span of 1300 mm, and 525 mm shear span, the distance between loads being 250 mm. Each specimen was supported on roller assemblies and knife edges to allow longitudinal motion and rotation. Fig. 5 shows the test setup and instrumentations for the tested specimen. The specimens were tested at a loading rate of 1 mm of deflection in 1 min. The cracks of the specimens were mapped and test observations were recorded during loading and at the time of failure.



Figure 5: Test setup and instrumentations for tested specimen

The beams were observed visually during the test until the first crack has happened and the corresponding load was recorded. The first cracking load was also can be observed from the load–deflection curves. Fig 6, fig 7 shows the load–deflection curves.

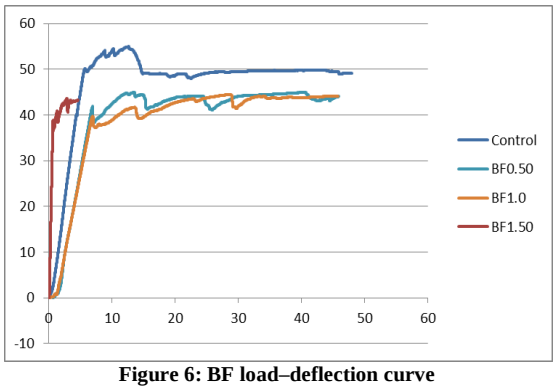


Figure 6: BF load–deflection curve

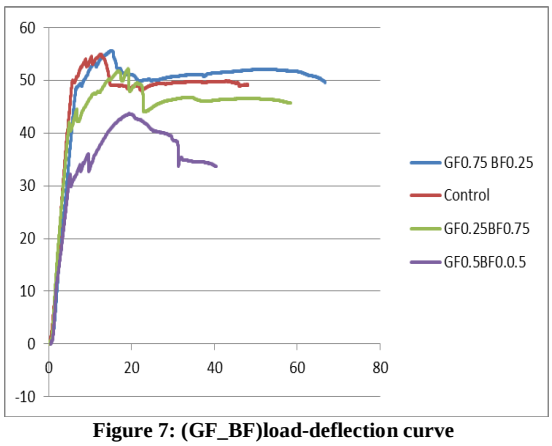


Figure 7: (GF_BF)load-deflection curve

CONCLUSION

This study presents experimental of fibers and hybrid fiber concrete mixtures and RC beams. The flexural and mechanical behavior of concrete reinforced with

fibers are compared. The crack pattern for all beams was failed in the flexural zone where the number of cracks increased. When Vertical cracks appeared during the initial load until the beams failed. Therefore, fibers are capable of avoiding a sudden and brittle concrete crushing owing to their capability of improving concrete toughness in compression

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