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Evaluation of structural failure resistance of glass fiber reinforced concrete beams

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ABSTRACT

Glass fiber reinforced concrete (GFRC) is a composite material that is widely used in construction due to its high strength and durability. GFRC is made by adding glass fibers to the concrete mix, which increases the tensile strength of the material. This paper evlautes the shear resistance (SR) of sliced glass fiber (30 mm) GFRC beams. The shear resistance of GFRC beams can be significantly improved by adding glass fibers to the concrete mix. However, further research is needed to fully understand the shear behavior of GFRC and to optimize its design for maximum shear resistance. The result indicates that shear fracture glass fiber is a better alternative for increasing a shear resistance input mechanism.

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1. INTRODUCTION

Glass fiber reinforced concrete (GFRC) is a composite material that is widely used in construction due to its high strength and durability. Adding glass fiber (GF) to the concrete mix increases the tensile strength of the GFRC material. However, researchers need to evaluate the shear behavior of GFRC beams because the shear resistance of GFRC is not well understood [1]–[7].

Several studies have been conducted to assess the shear resistance of GFRC beams. A study conducted by [8] examined the shear behavior of GFRC beams with varying fiber contents. The findings demonstrated that incorporating GF into the concrete mixture substantially enhanced the beams' shear resistance. The researchers also discovered that the beams' shear strength exhibited a positive correlation with the fiber content, up to a specific threshold, beyond which it exhibited a decline.

Another study conducted by [9], [10] evaluated the shear behavior of GFRC beams with different fiber orientations. The results showed that the orientation of the fibers had a significant effect on the shear resistance of the beams. The authors found that beams with fibers oriented at 45 degrees to the longitudinal axis had higher shear resistance compared to beams with fibers oriented at 90 degrees. In addition to fiber content and orientation, other factors that can affect the shear resistance of GFRC beams include the type of fibers used, the aspect ratio of the fibers, and the curing conditions. Therefore, it is important to consider these factors when designing GFRC beams for shear resistance [7], [11], [12].

The depth and width of the notch in GFRC beams can also affect shear resistance. A deeper and wider notch can reduce shear resistance as it weakens the beam at that point. The geometry of the specimen, such as the length-to-width ratio, can also affect shear resistance. Shorter and wider specimens generally have higher shear resistance compared to longer and narrower ones [13], [14]. The variables employed in this study and their mechanical attributes of GFRC, are discussed in section 2.

GFRC is a composite material that has gained popularity in construction due to its high strength and durability. Adding GF to the concrete mix increases the tensile strength of the material, making it suitable for use in applications where high strength is required. However, researchers have conducted several studies to evaluate the shear behavior of GFRC beams due to the limited understanding of GFRC's shear resistance.

These GFRCs can improve the shear resistance of the concrete by increasing its tensile strength and preventing cracking. The fibers can also improve the overall durability and toughness of the concrete [15]–[19]. The type and amount of fiber used can affect the shear resistance of the concrete. For example, steel fibers can provide high strength and stiffness, while synthetic fibers can improve toughness and durability. The amount of fiber used can also affect the shear resistance, with higher fiber content generally resulting in higher shear strength. The orientation of the fibers can also affect shear resistance. Orienting fibers perpendicular to the shear plane can significantly improve shear strength [20]–[22]. In addition to fiber reinforcement, other factors, such as mix design, curing, and testing methods, can also affect the shear resistance of fiber-reinforced concrete. Proper attention to these factors is essential for designing and constructing safe and effective concrete structures [23], [24]. However, GF may not be suitable for all types of concrete structures due to its low impact resistance and susceptibility to the alkali-silica reaction. Proper consideration of these factors is necessary when using GF as reinforcement in concrete [25]–[29].

Manufacturers may produce fibers with larger or smaller diameters depending on the specific application requirements. However, some manufacturers may produce fibers with larger or smaller diameters, depending on the specific application requirements. The length of the fibers can also vary, with longer fibers typically providing better reinforcement properties [30]–[32]. The paper is structured as follows: section 2 discusses the method, describing the research chronology and flowchart of the study. Section 3 provides a discussion on results and discussions describing the results obtained, and section 4 concludes the study.

2. METHOD

In this research, we adopted the standard laboratory testing method for measuring the structural failure resistance of GFRC. A beam is loaded in a three-point bending test until failure. We measure the load and deflection throughout the test and calculate the shear strength of the beam based on the maximum load and the dimensions of the beam. This method is widely used in the construction industry to evaluate the performance of GFRC and ensure it meets the required standards for strength and durability. Figure 1 presents the experimental test for shear resistance of GFRC.

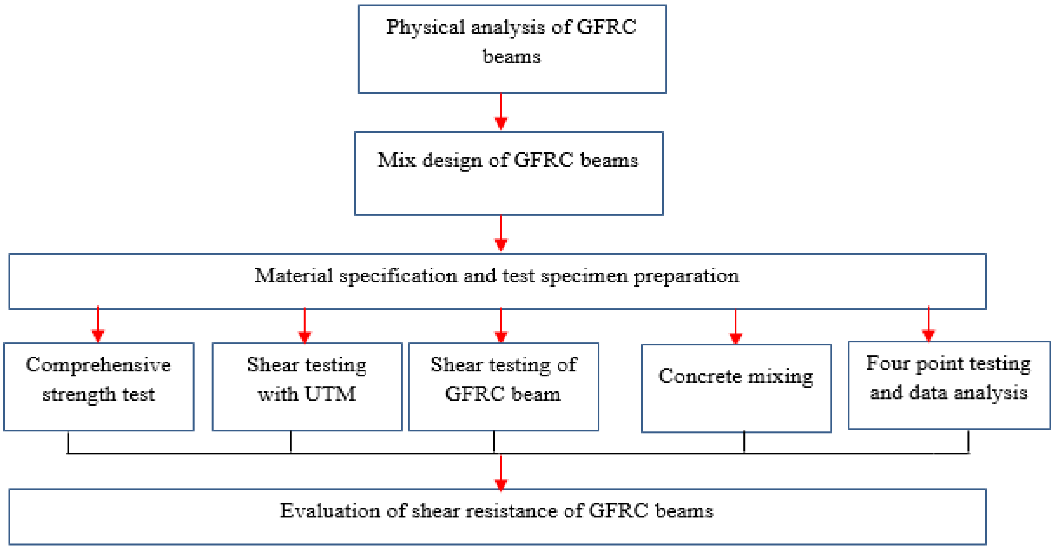

Figure 1. Experimental test for shear resistance of GFRC

3. RESULTS AND DISCUSSION

The experimental evaluation of this research verified twenty-four beam samples. The evaluation was carried out at the Debre Markos University Institute of Technology construction lab. The curative age of the examples was 28 days to achieve the compulsory strength. The filling setup was tested by a four-point structural universal testing machine (UTM). We analyzed the data for 24 concrete beams. In the analysis, the variation in the proportion of GF and the difference in the grade of concrete and its effect on structural failure resistance in the plane shear mode of loading have been assessed. The force-displacement responses of the samples demonstrate the shear performance of beam samples for different factors. Additionally, mode failure and crack route are also considered for succinct shear fracture results for plain and GFRC samples.

3.1. Shear load of GFRC and plain concrete samples

To assess the structural failure resistance of GFRC, final heaps have been considered. Then, the average maximum loads are determined for the evaluation metrics. Finally, the regular structural force of GFRC is greater than the regular structural force of basic concrete beams. For the C-20/25 grade of concrete, the structural failure of plain concrete beams has been experimentally determined at a normal load of 39.34 KN, while for the same assessment of concrete, the structural failure has been experimentally determined at extreme loads of 43.12 KN, 46.69 KN, and 50.29 KN by adding 0.5%, 1%, and 1.5% GF, respectively. For the C-40/50 grade of concrete, structural failure of basic concrete beams has been identified at a supreme typical value of 43.79 KN, while for the identical grade of concrete, structural failure has been detected at supreme typical values of 47.91 KN, 54.39 KN, and 53.23 KN with the addition of 0.5%, 1%, and 1.5% GF separately. The typical highest structural loads are shown in Table 1 and intensely show the effect of GF on a percentage increase in the average structural load resistance. Additionally, Figure 2 indicates the typical peak loads and percentages of GF C-20/25 and C-40/50 samples.

Table 1. The GFRC beams variation in %

Grade of concrete	GF (in %)	Peak load (average KN)	Percentage increase (%)
Glass	0.005 to 0.15	2500	1000 to 2600
C-20/25	0	39.34	------
	0.5	43.12	9.61
	1	46.69	18.69
	1.5	50.29	27.84
C-40/50	0	43.7933	-------
	0.5	47.91	9.39
	1	54.39	24.19
	1.5	53.23	21.56

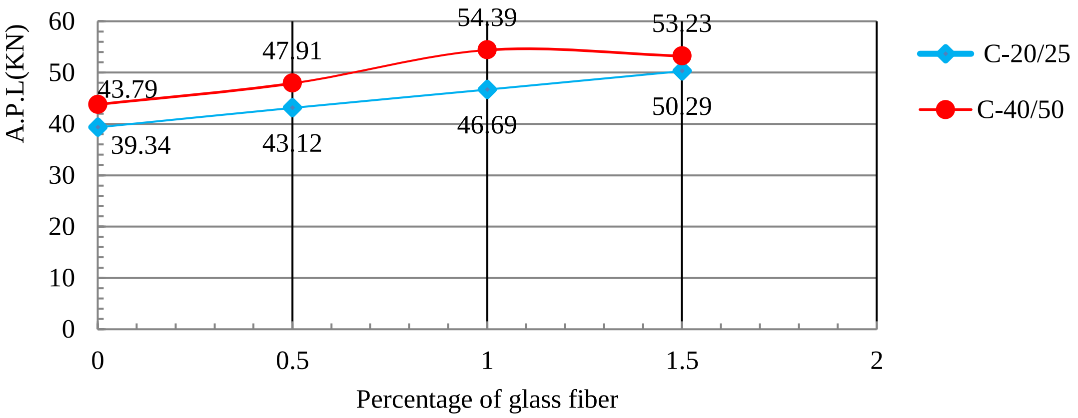

Figure 2. The peak load and of GF samples

In the C-20/25 beams, the structural load linearly increases for the GFRC, while for the C-40/50 beams, there is a decrease in the percentage of structural failure resistance at 1.5% of GF concrete compared to 1% of GF concrete. Although the percentage increase in structural failure resistance is reduced by 2.63% at 1.5%, beams compared with strength at 1% GF are still functioning relative to basic concrete beams with a similar grade of concrete. Figure 3 establishes the percentage of GFRC and the percentage increase in load.

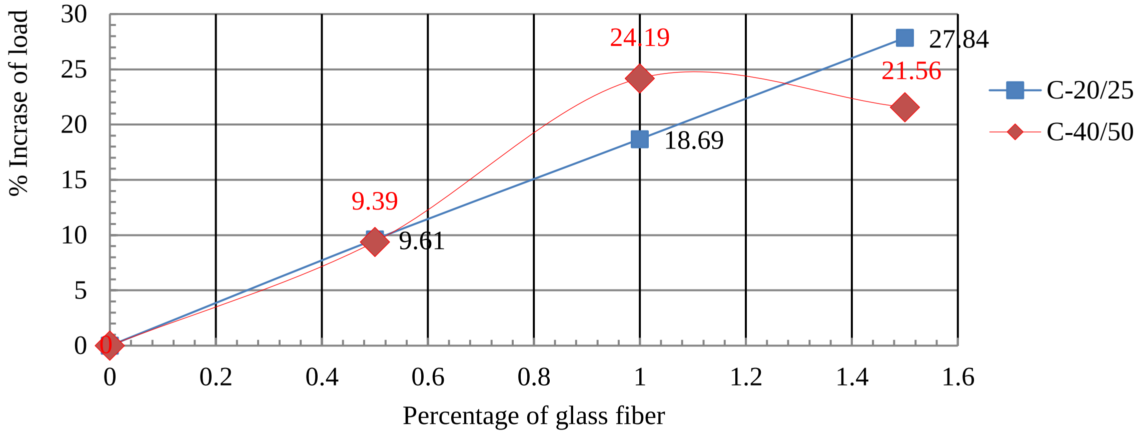

Figure 3. Average peak load vs GF increase in %

3.2. Comparision of the structural failure resistance of C-20/25 and C-40/50 concrete samples

Other factors that can affect structural failure resistance include the type and aspect ratio of fibers used, as well as curative conditions. The type of fibers affects the bond between the fibers and the concrete matrix, which in turn affects structural failure resistance. The aspect ratio of fibers (the ratio of length to diameter) can also affect shear resistance, with longer fibers generally providing better structural failure resistance. Curing conditions can also affect structural failure, with proper curing conditions helping to prevent cracking and improve structural failure resistance. This can also protect the antenna from physical and structural damage by avoiding corrosion to antennas embedded in buildings. Table 2 indicates the change between the average maximum structural failure resistance of C-40/50 and C-20/25 concrete beams, which are 4.45, 4.79, 7.7, and 2.94 for plain, 0.5% GF, 1% GF, and 1.5% GF, respectively. Furthermore, Figure 4 indicates the percentage change of A.P.L. and GF for C-20/25 and C-40/50 samples.

Table 2. Average maximum structural failure resistance of GFRC beams (C-20/25 and C-40/50)

Percentage (%) of GF	A.P.L for C-20/25 sample (KN)	A.P.L for C-40/50 sample (KN)	A.P.L difference (KN)	A.P.L difference (%)
0	39.34	43.79	4.45	11.31
0.5	43.12	47.91	4.79	11.11
1	46.69	54.39	7.7	16.49
1.5	50.29	53.23	2.94	5.85

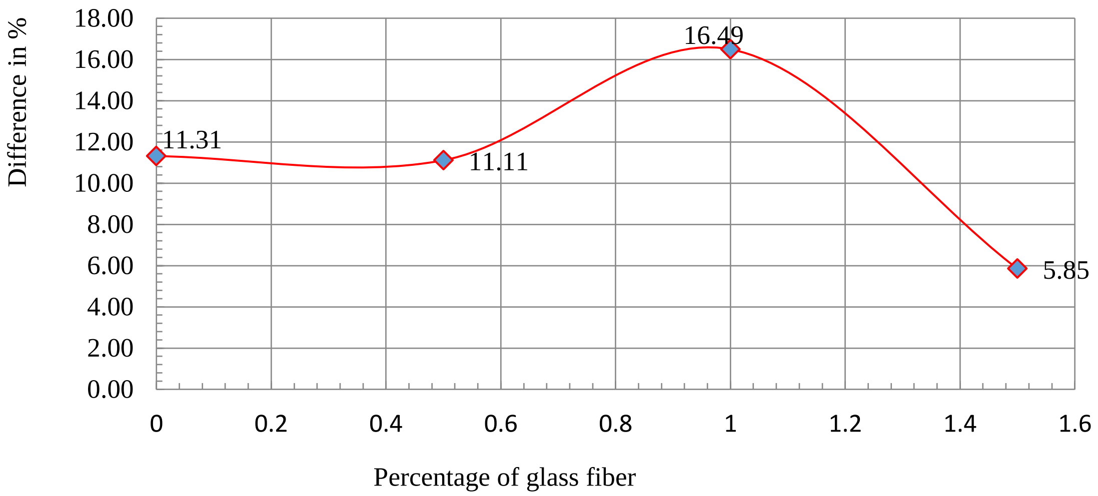

Figure 4. The shear load resistance with difference of GF in %

4. CONCLUSION

In conclusion, GFRC is a promising material for construction due to its high strength and durability. Adding glass fibers to the concrete mix significantly improves the structural failure resistance of GFRC beams. However, additional research is necessary to fully comprehend the shear behavior of GFRC and optimize its design for maximum shear resistance. Adding glass fibers to the concrete mix significantly improves the shear strength of GFRC beams, with an increase in fiber content up to a certain limit. The orientation of the fibers also has a significant effect on shear resistance, with beams with fibers oriented at 45 degrees having higher shear resistance than those with fibers oriented at 90 degrees. Other factors that can affect shear resistance include the type and aspect ratio of the fibers used, as well as curing conditions. To fully understand the shear behavior of GFRC and optimize its design for maximum shear resistance, researchers need to conduct further research.

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