Sirte University Scientific Journal SUSJ Vol 14, No.1 (2024) 1-10

Sirte University Scientific Journal (SUSJ)

Journal home page: http://journal.su.edu.ly/index.php/SUSJ/index

DOI:10.37375/susj.v14i1.2793

Influence of E-Glass Fiber on the Properties of Fresh &Hardened Concrete

Ahmed. M. Alsadaai [1], Ghusen M. AL Kafri [2], Aziza. Al jarari[3]

[1,2,3]*Civil Engineering Department, Faculty of Engineering Sirte University, Libya.*

DOI: 10.37375/susj.v14i1.2793

Keywords: Glass Fibers, Compressive Strength, Split tensile strength Flexural Strength *Grade of concrete.*

A B S T R A C T

Concrete is a composite material consist of aggregate (gravel and sand), cement and water. This material reigns supreme in the construction industry, captivating builders with its exceptional compressive strength, unwavering durability, and boundless versatility. Plain concrete has a very low tensile strength, limited ductility and little resistance to cracking. To enhance mechanical properties of concrete (compressive strength, tensile strength usually added fibers to it. Researchers are cheering the addition of fibers to various materials. This research discusses the effects of E- glass fibers on the mechanical properties and workability of concrete. Experimental programmer consists of conducting compressive strength test, flexural strength test and split tensile strength and workability of concrete containing varying proportions of E-glass fiber. In our research we used the E-Glass fibers at different percentages as 0%.0.2%,0.4%.0.6% by the volume of fracture on C30 grade of mix proportion (1: 3: 1.8) with water cement ratio 0.56. From the results of experiments turns out that the Adding 0.2% glass fibers to concrete significantly improves its flexural strength (11.7%) and slightly boosts compressive (4.4%) and splitting tensile (6.16%) strength at 28 days. GFRC specimens also exhibit more resilient behavior under testing compared to plain concrete. However, workability declines with increasing fiber content

1 Introduction

Concrete is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors and on other hand the concrete is weak in tension. Plain concrete has two deficiencies, low tensile strength and a low strain at fracture. These shortcomings are generally overcome by reinforcing concrete. Fiber Reinforced Concrete (FRC) is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibers. FRC is a relatively new material. This is a composite material consisting of a matrix containing a random distribution or dispersion of small fibers, either natural or artificial, having a high tensile strength. Due to the presence of these uniformly dispersed fibers, the cracking strength of concrete is increased and the fibers acting as crack arresters. Glass-fiber reinforced concrete (GRC) is a material made of a cement matrix composed of cement, sand, water and admixtures, in which short length glass fibers are dispersed. It has been widely used in the construction industry for non-structural elements, like façade panels piping and channels. GRC offers many advantages, such as being lightweight, fire resistance, good appearance and strength. In this study trial tests for concrete with glass fiber and without glass fiber are conducted to indicate the differences in compressive strength and flexural strength by using cubes and prism. Various applications of GFRC shown in the study, the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material.

Objectives

The main objective of the research can be summarized as follows:

- Analyze the base strength of plain concrete.
- Study how E-Glass fiber (aspect ratio 857.1) at 0%, 0.2%, 0.4%, and 0.6% fracture volume affects concrete's mechanical properties.
- Measure the flow ability and ease of working with each concrete mix.
- Comparing the compressive, tensile, and flexural strength of E-glass fiber concrete and ordinary concrete.
- How failure looks different in fiber-reinforced vs. plain concrete.

2.Literature Review

Kumar et al., 2019 The researchers investigated how incorporating glass fibers into M30 concrete impacted its mechanical properties. They added varying amounts of glass fibers (0%, 0.4%, 0.8%, 1.2%, and 1.6% of the cement weight) to the concrete mix, maintaining a water-cement ratio of 0.45. They then tested the compressive, tensile, and flexural strengths of the resulting concrete. Their findings showed that adding 1.2% glass fibers by weight was the optimal amount for enhancing the concrete's strength. Compared to plain concrete, this mix exhibited: 17.36% increase in compressive strength, 35% increase in flexural strength and 40% increase in split tensile strength. These results demonstrate that incorporating glass fibers effectively improves the mechanical properties of M30 concrete. Notably, the flexural strength improvement was more significant than the compressive strength increase in this study [1].

Yoddumrong, et al., 2019 Researchers explored the potential of inexpensive glass fiber reinforced polymer (GFRP) in enhancing the strength of both normal (15 MPa) and low-strength (5 MPa) concrete. They tested eight cylindrical specimens, some plain and some wrapped with one, two, or three layers of GFRP. The results demonstrated that low-cost GFRP effectively increased the compressive strength of both concrete types. Compared to the control specimens (without GFRP): 5 MPa concrete: Increased by 2.27 MPa with one GFRP layer, increased by 3.96 MPa with two GFRP layers and Increased by 4.13 MPa with three GFRP layers 15 MPa concrete: Increased by 1.75 MPa with one GFRP layer, increased by 2.29 MPa with two GFRP layers and Increased by 2.95 MPa with three GFRP layers. These findings suggest that using low-cost GFRP to strengthen concrete is a cost-effective and efficient technique. It significantly improves the compressive strength of both normal and low-strength concrete, offering a valuable approach for infrastructure repair and renovation [2].

Dawood A. Eethar, 2013 The researchers investigated how adding glass fibers to foamed concrete impacted its mechanical properties. Using foam as a light weighting agent and 1% superplasticizer by cement weight, the researcher added varying amounts of glass fibers (0.06%, 0.2%, 0.4%, and 0.6%) to the mix. introducing 0.6% glass fiber into high-performance lightweight concrete significantly boosted its strength: 33.7% increase in compressive strength and 16.1% (without superplasticizer) or 15.44% (with superplasticizer) increase in flexural strength. However, workability dropped by 38% compared to plain foamed concrete. This suggests optimal strength improvement through fiber addition may require further workability enhancements for practical implementation. [3].

Ravikumar and Thandavamoorthy 2013 have done an assessment on Glass Fiber in concrete to improve its mechanical properties like tensile and ductility. Glass Fiber has higher tensile strength and fire resistance properties, thus, reduction happened while firing an accident to the concrete structure. In this experiment Glass Fiber of 450mm length is added to concrete by volume fraction up to 1% of concrete. Comparison of the strength of fire resistance performance of conventional concrete and concrete with glass fiber is made, result shows, with adding 0.5% Glass fiber increase in compressive strength is 13%, increase in flexural strength 42%, and increase split tensile strength is 20% in control mixture. With adding of 1% Glass Fiber increase in compressive strength 35% shows improvement 1,78 more than normal concrete, and fire resistance shows that there is reduction in compressive strength, after giving heating to concrete at 300C for 2 hours, without the addition of the Glass Fiber the decrease is 35% from its original strength. In addition, 0.5% of Glass Fiber decreases in compressive strength by 25% from its original strength, and by adding 1% Glass Fiber the reduction in compressive strength after the fire in just 10% from its original strength. The evaluation shows that Glass Fiber has better fire resistance characteristics [4].

Kene et al., 2012, Researchers. conducted experiments to compare the performance of steel and fiberglass as reinforcement in concrete. They prepared fiber-reinforced concrete specimens with two variables: Steel fiber volume: 0% and 0.5%, Alkali-resistant glass fiber weight: 0% and 25% of the 12mm cut fibers. Both sets were made without admixtures and tested under different loading conditions. The findings were: Steel fibers, even at a low volume of 0.5%, significantly reduced crack formation in the concrete compared to plain concrete and fiberglass-reinforced concrete. This indicates that steel fibers are more effective in mitigating cracking under various stresses. Steel fibers were also more efficient in improving the brittleness of concrete than fiber glass. Concrete, by nature, has weak tension resistance, leading to brittle failure. Steel fibers, with their high tensile strength, help the concrete resist stretching forces, effectively increasing its tensile strength and reducing brittleness [5].

Chandramouli, et al., (2010). The researchers investigated the impact of adding A.R. glass fibers to different grades of concrete (M20, M30, M40, and M50) on its strength properties. Aiming for a strong concrete throughout its thickness, they created a new GFRC by incorporating both fibers and chemical admixtures. They tested cube, beam, and cylinder specimens for various properties (bleeding, workability, compressive strength, split-tensile strength, and flexural strength) at curing ages of 28, 56, 90, and 180 days. Notably, they added 0.03% A.R. glass fibers by weight of concrete volume in all four mix designs. The results can be drawn as the following: Adding A.R. glass fibers improved workability (compaction factor 0.93-0.97) and reduced bleeding, enhancing surface integrity and homogeneity, and potentially reducing crack formation. Compared to the reference mix without fibers, A.R. glass fibers increased compressive strength by 20-25% across all concrete grades at 28 days. Similar improvements were observed for flexural and split-tensile strength, with increases of 15-20% at 28 days compared to the reference mix [6].

3. Methodology

3.1 Work Methodology

Several batches of concrete mixes are prepared in the civil engineering laboratory according to approved mix design and using same material and with the same proportional constituents. Different amount of fiber is added to each batch. Control batches (Concrete without fibers) are used to compare the properties of concrete with and without fibers. Workability of fresh concrete batches and mechanical properties of hardened concrete are estimated. Concrete are cast in three different specimen forms: Cubes (for compression tests), Cylinders (for split indirect tensile tests) and Prisms (for flexural strength tests). Hardened concrete tests are performed at different times (7, 28 days). All results are then presented, compared and finally conclusion & recommendations are produced.

3.2. Materials Used:

In our work, local materials from Libya are used to determine the influence of adding fibers (E-Glass Fiber) on the concrete properties. All tests are done in the laboratory of Civil Engineering Department of Sirte University according with relevant BS and ASTM standards which considered suitable for the scope of this study

3.2.1 Coarse aggregate:

We used locally sourced coarse aggregate, half 20mm from Ajdabiya and half 10mm from Sirte, retained on a 4.75mm sieve. See Table 3.1 for their properties.

Table (3-1): Properties of Coarse aggregate size 20mm and 10mm:

Material Test	**Coarse aggregate 20mm**	**Coarse aggregate 10mm**	**Fine aggregate**
Bulk specific gravity	2.31	2.45	2.59
Bulk specific gravity SSD	2.39	2.5	2.62
Apparent specific gravity	2.51	2.56	2.67
Absorption %	3.41	1.86%	1.17%

3.2.2 Fine aggregate:

For our experiments, we sourced the fine aggregate from Sirte beaches, ensuring all particles were smaller than 4.75mm. See Table 3.1 for their properties.

3.2.3 Water:

tap water was used for the mixing and curing of concrete in this study.

3.2.4 Cement:

Ordinary Portland cement was used in this study of 42.5N grade available in local market. The cement used has been tested and found to conforming to the ASTM specifications, and the specific gravity was 3.15.

3.2.5 Fiber glass:

This study features E-glass fiber, a lightweight and incredibly strong material made from tiny glass filaments (13 microns thick) cut into various lengths (6, 12, 18, 24mm). While different types exist, we focused on E-glass with properties detailed in Table 3.2.

Figure (3.1): Glass fiber

Table (3-2): Properties of glass fiber:

Density	0.91gm nominal
Absorption	Nil
Specific surface area	sq. meters per kg 250
Melt point	°C160
Ignition Point	360 C
Thermal conductivity	Low
Electrical conductivity	Low
Acid resistance	High
Alkali resistance	100 %

3.3 Preparation and Mixing Procedure:

At the first, mix the cement, sand, and aggregates in a dry state for 1-2 minutes using a mixer and ensures all the dry contents are evenly distributed before adding water and after then add the specified amount of water to the dry mix. The precise quantity will depend on your specific mix design. Mix everything together for 2-3 minutes until you achieve a consistent, wet concrete mixture. Finally, incorporate the wet glass fibers into the concrete mix. Gently blend them in for 1 minute, ensuring they are evenly distributed throughout the mixture. This step adds additional strength and crack resistance to the concrete. Once set, the concrete is extracted and molded into cubes, cylinders, and prisms for testing. The mixing procedures was applied in accordance with BS 882:1992. However, for addition of the glass fibers; careful attention must be given when mixing the glass fibers. The glass fibers are always added last and mixed for the minimum time required to achieve uniform dispersion. It is important to ensure that minimum time is spent mixing the fibers because they can be damaged by excessive mixing. Concrete mixes were prepared containing 0%, 0.2%, 0.4%, and 0.6% of E-Glass fibers). Detail of mixes proportion for this research can be seen in the table 3.3

Table (3-3): proportion of mix

Cement (kg)	**Water ((liter)**	**Coarse aggregate (kg)**	**Fine aggregate (kg)**
390	220	1170	720
1	0.564	3	1.846

3.4 Experimental procedures and lab analysis.

To assess how E-glass fiber affects ordinary concrete's strength, four mixes were made: 0%, 0.2%, 0.4%, and 0.6% fiber content by fracture volume. Cubes, cylinders, and prisms were tested for compressive, splitting tensile, and flexural strength at 7 and 28 days using standard methods as explaining in tab.3.4

Table 3.4: Details of Test Program

Test	Mixture Designation	0%		0.2%		0.4%		0.6%	
Compression Test	Age	7	28	7	28	7	28	7	28
	NO. of Specimens	3	3	3	3	3	3	3	3
	Sample shape and size (mm)	Cube 150 x150 x150		Cube 150 x150 x150		Cube 150 x150 x150		Cube 150 x150 x150	
Splitting Tensile Strength Test	Age	7	28	7	28	7	28	7	28
	NO. of Specimens	3	3	3	3	3	3	3	3
	Sample shape and size (mm)	Cylinder 150 x 300		Cylinder 150 x 300		Cylinder 150 x 300		Cylinder 150 x 300	
Flexural strength test	Age	7	28	7	28	7	28	7	28
	NO. of Specimens	2	2	2	2	2	2	2	2
	Sample shape and size (mm	Prism 150 x 150 x 750		Prism 150 x 150 x 750		Prism 150 x 150 x 750		Prism 150 x 150 x 750	

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1. The Effect of E-Glass Fiber on the Fresh Properties of NGFRC

4.1.1 Workability

To assess the workability of the fresh normal concrete, we measured its slump flow using an Abram's cone, following the procedures outlined in ASTM C496 (2004). The results of these tests are presented in Table 4.1 and Figure 4.1

Table (4-1): The Slump Test Value

% Glass fiber	Slump (mm)
0	85
0.2	40
0.4	25
0.6	0

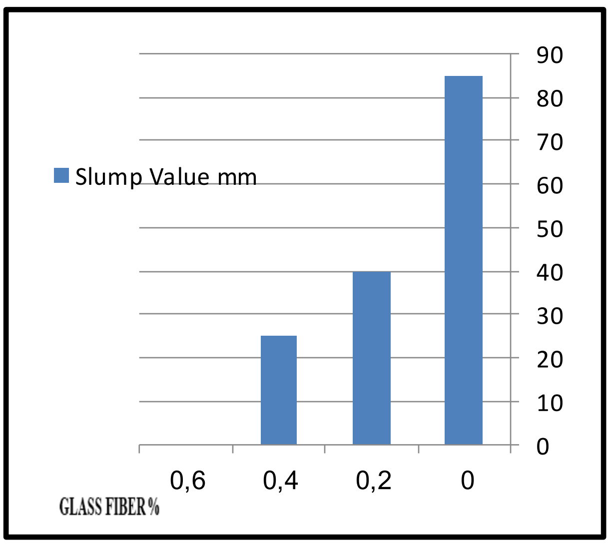

Figure 4.1: Slump value (mm)

E-glass fiber reinforced concrete (E-GFRC) becomes harder to work with (less workable) as you add more fibers. Table 4.1 shows workability dropping by 52.94% at 0.2% fiber content, 70.59% at 0.4%, and 100% at 0.6% (completely unworkable!). Figure 4.1 plots these results and suggests the decreasing workability is due to friction between fibers and concrete components.

4.2 Compressive strength:

The compressive strength tests were performed after 7 and 28 days of curing of specimens by using universal testing machine (UTM). The results of the compressive strength for all 4 mix designs at 7 days are shown in Table 4.2 and also represented in Fig.4.2 and for 28 days are shown in tab.4.3and fig 4.3

Table (4-2): Compressive strength test result

Sample No	%Of Glass Fiber	Applied Load kN	Average compressive strength MPa	Compressive strength MPa at 7days
No.1	0%	540	24	24
No.2		473	21	
No.3		608	27	
No.1	0.2%	520	23.11	23.88
No.2		524	23.3	
No.3		568	25.24	
No.1	0.4%	500	22.2	22.67
No.2		531	23.6	
No.3		500	22.2	
No.1	0.6%	520	23.1	23.27
No.2		531	23.6	
No.3		520	23.1	

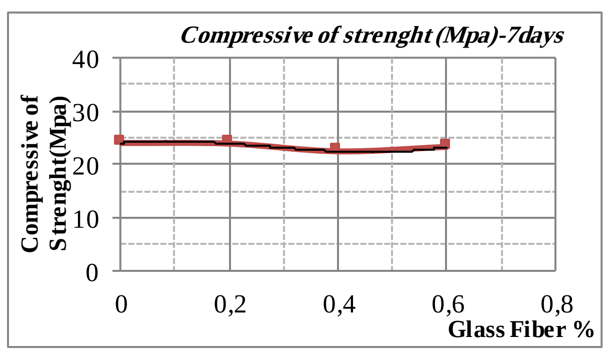

Figure 4.2: Compressive Strength Result for 7 Days

Sample No	Of Glass Fiber %	Applied Load KN	Compressive strength MPa at 28days	Average compressive strength MPa
No.4	0%	740	32.89	33.04
No.5		745	.3342	
No.6		738	32.80	
No.4	0.2%	776	34.5	34.49
No.5		772	34.3	
No.6		780	34.67	
No.4	0.4%	684	30.4	29.51
No.5		680	30.222	
No.6		628	27.9	
No.4	0.6%	592	26.3	28.26
No.5		656	29.15	
No.6		660	29.33	

Table (4-3): Compressive strength test result

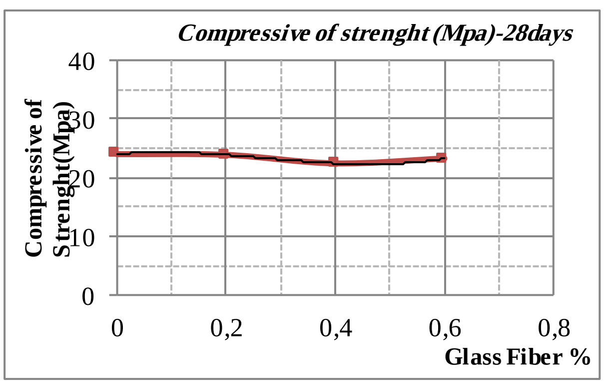

Figure 4.3: Compressive Strength Result for 28

Adding 0.2% of fibers increased the concrete's 28-day compressive strength by 4.4% compared to the control mix. However, using more fibers, 0.4% and 0.6%, actually reduced the strength by 10.68% and 14.5%, respectively. This might be because the fibers didn't distribute well in the small molds.. However, maximum increase of compressive strength observed at the addition of 0.2% glass fiber by the volume of fracture for that we can consider this percentage as optimum value of fiber addition for compressive strength enhancement. The figure 4.4 represents the graph between the Compressive strength against percentage of glass fiber. The glass fiber is added at the rate of 0%.0.2%, 0.4%, 0.6%. Out of these, the compressive strength is very high at 0% having for 7 days is 24N/mm^2 and for 28 days is 34.49N/mm^2 at 0.2%.

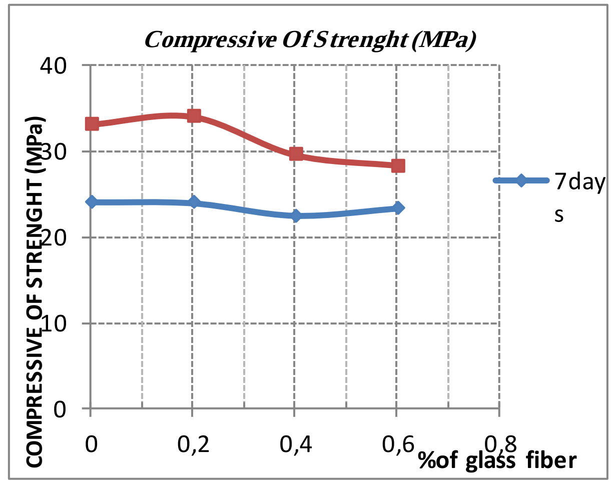

Figure 4.4: Compressive Strength Result for 7 and 28 Days

4.2.1 Fracture characteristics and failure mechanisms

As the fiber content increases, we see a shift from catastrophic failures to a slower, crack-by-crack breakdown. This reveals the critical role of fibers in boosting crack resistance. Even though higher fiber percentages don't directly increase compressive strength, they act like tiny shields at the macro level, controlling crack growth, absorbing energy, and delaying the appearance of the first major fracture. This fundamentally changes the failure mode from a brittle snap to a more gradual, energy-absorbing process.

Figure 4.5: Failure Mode

4.3 The Split Tensile Strength:

The split tensile strength tests were performed after 7 and 28 days of curing of specimens by using universal testing machine (UTM). The results of the split tensile strength for all 4 mix designs at 7 days are shown in Table 4.4 and also represented in Fig.4.6 and 28 days are shown in table. 4.5 and figure 4.7.

Table 4.4: Tensile splitting strength test result

Sample No	%Of Glass Fiber	Applied Load KN	Split tensile strength MPa at 7days	Average split tensile strength MPa
S1	0%	170	2.4	2.542
S2		180	2.546	
S3		190	2.68	
S1	0.2%	195	2.758	2.78
S2		200	2.89	
S3		190	2.687	
S1	0.4%	160	2.263	2.314
S2		164	2.3	
S3		168	2.38	
S1	0.6%	156	2.2	2.13
S2		148	.209	
S3		150	2.12	

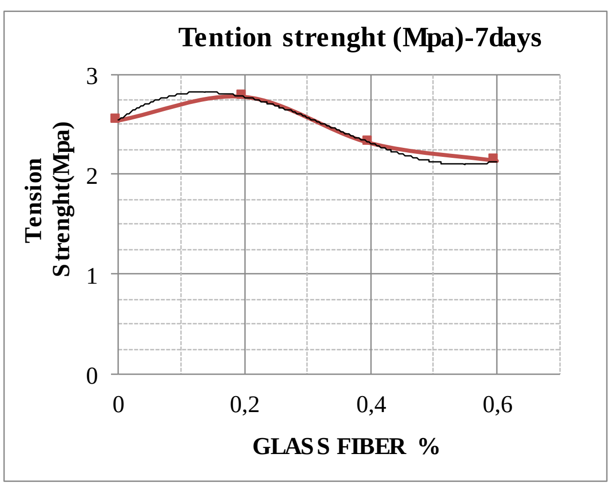

Figure 4. 6: Tension Strength Result for 7 Days

Table 4.5: Tensile splitting strength test result

Sample No	%of Glass Fiber	Applied Load kN	Split tensile strength MPa at 28days	average split tensile strength MPa
S4	0%	212	2.999	3.05
S5		220	3.11	
S6		216	3.055	
S4	0.2%	232	3.28	3.25
S5		228	3.22	
S6		230	3.25	
S4	0.4%	192	2.71	2.77
S5		212	3	
S6		180	2.55	
S4	0.6%	180	2.54	2.57
S5		168	2.38	
S6		198	2.8	

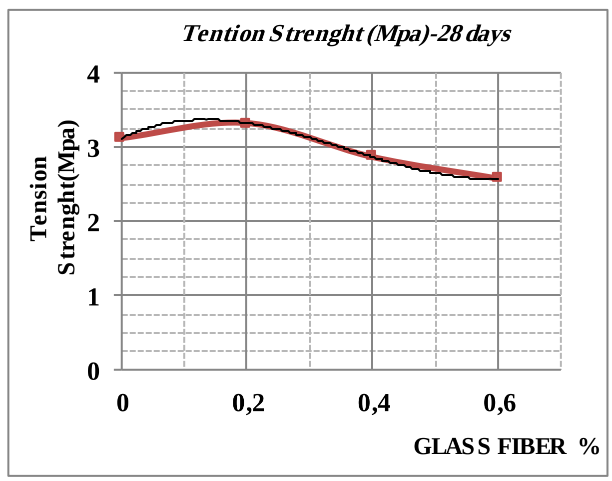

Figure 4.7: Tension Strength Result for 28 Days

The results of crushing cylinders at the age of 7 days show a slight improvement in tensile strength at 0.2% about 8.56%, while noting a decrease in the resistance value at 0.4% and 0.6% about 9.76%,19.3%, respectively, which may be due to how the fibers are distributed within the narrow cylinder mold Relatively speaking, when comparing the amount of resistance development with the crushing results at 28 days, it was found that the percentage of reaching the required resistance at the age of 7 days is 75% with a correlation coefficient equal to one**.** This graph highlights the relationship between the tensile splitting strength of the concrete and the percentage of glass fiber added (0%, 0.2%, 0.4%, 0.6%). the tensile splitting strength reaches its highest point at 0.2% fiber content. For 7 days at 0.2% fiber, the strength reaches an impressive 2.78 N/mm².This value further increases to 3.25 N/mm² after 28 days of curing.

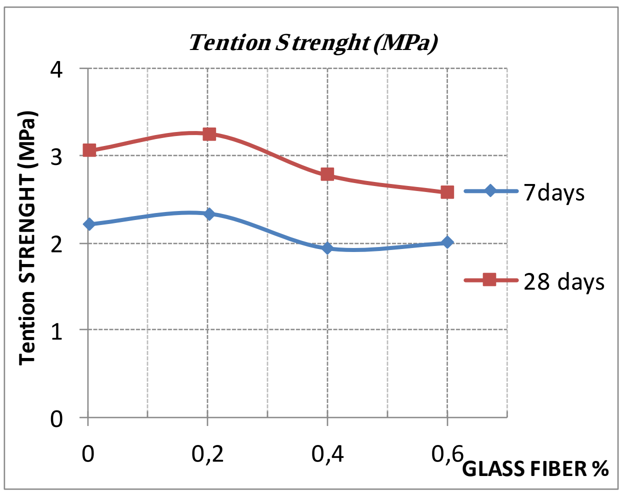

Figure 4.8: Tension Strength Result for 28 Days

The results of crushing cylinders at the age of 28 days show an improvement in the tensile strength value of 0.2% of the fiber over the reference mixture by about 6.16%, while we notice a marked and gradual decrease with the increase of the percentage of fiber in concrete to reach 10.1% in the ratio of 0.4% and 18.67% in the proportion of 0.6% of the reference mixture may be due to technical problems in the compaction and how the fibers are distributed in the relatively narrow cylindrical mold or the mixing conditions or the noticeable increase in the percentage of fiber that prevents the occurrence of homogeneity in the mixing and the poor operationally of the mixture despite maintaining the rate of wetness in it with a correlation coefficient equal to one.

4.3.2.1 Fracture characteristics and failure mechanisms:

When testing plain NC specimens (without fibers) for splitting tensile strength, their failure was sudden, brittle, and with a loud crack, as illustrated in Figure 4.9. Surprisingly, adding fibers at 0.2%, 0.4%, and 0.6% did not change the nature of the failure. Despite the presence of fibers, the specimens still experienced sudden and complete splitting, similar to the plain NC without fibers, as shown in Figure 4.9.

Figure 4.9: Failure Mode

4.4 Flexural Strength:

To evaluate the flexural strength (ability to resist bending) of the concrete mixes, researchers employed a universal testing machine (UTM) to apply pressure to test specimens which cured for 7 and 28 days. The results of the Flexural strength for all 4 mix designs at 7 days are shown in Table 4.6 and also represented in Fig.4.10 and 28 days are shown in table.4.7 and fig 4.11

Table4.6: Flexural strength test result

Sample No	**%Of Glass Fiber**	**Applied Load** kN	**Flexural strength MPa at 7days**	**Average Flexural strength MPa**
B1	0%	34.7	4.627	4.92
B2		39.1	5.214	
B1	0.2%	45.3	6.041	6.1
B2		46.2	6.161	
B1	0.4%	48.3	6.441	6.46
B2		48.5	6.468	
B1	0.6%	38.1	5.080	5.61
B2		46.5	6.201	

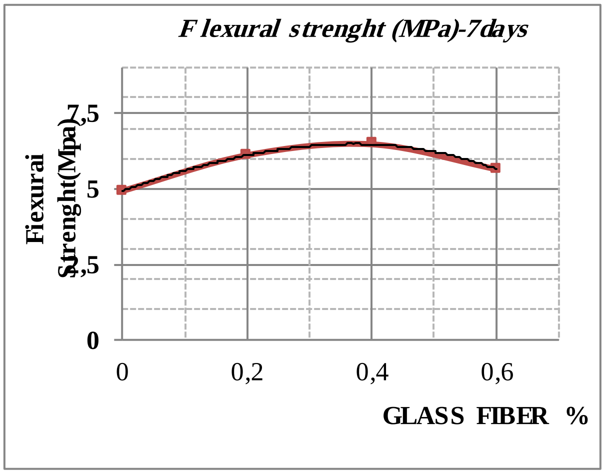

Table4.7: Flexural strength test result

Sample No	%Of Glass Fiber	Applied Load kN	Flexural strength MPa at 28days	Average Flexural strength
B1	0%	58.1	7.747	7.394
B2		52.8	7.041	
B1	0.2%	60.6	8.081	8.3745
B2		65	8.668	
B1	0.4%	56.3	7.508	7.748
B2		59.9	7.988	
B1	0.6%	54.4	7.254	7.374
B2		56.2	7.494	

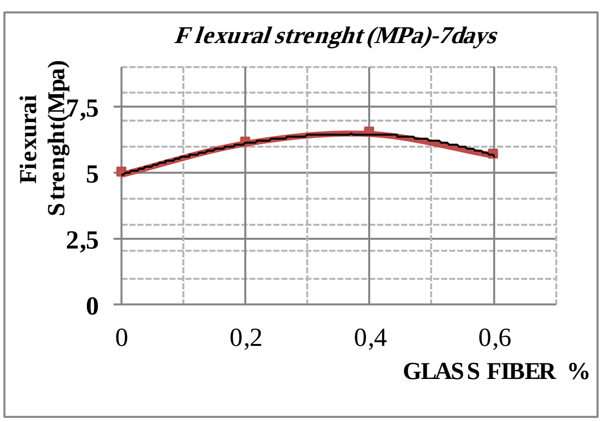

Figure 4.11: Flexural Strength Result for 28 Days

The results of crushing the beams at the age of 7 days show an improvement in the bending resistance at all percentages, about 19.34%, 23.84%, 12.3%, respectively, noting a decrease in the resistance value at 0.6%, about 12.3%, compared to 0.4%, which gave the highest percentage of improvement compared to the mixture. This may be due to how the fibers are distributed during mixing.

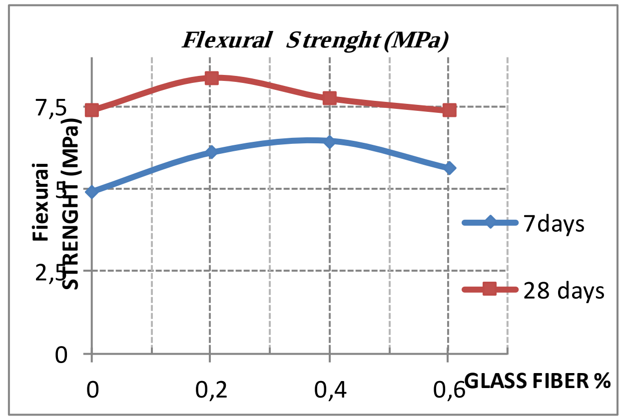

Figure 4.12: Flexural Strength Result for seven @ 28 Days

The results crushing the beams at the age of 28 days show an improvement in the tensile strength value of 0.2% and 0.4% of the fiber compared to the reference mixture by about 11.7%, 4.56%, respectively, while we note in the rate of 0.6% of the reference mixture the stability of the value without any significant effect. This may be due to this the improvement in the resistance to bending due to the nature of the work of the fibers, as it contributes significantly to the resistance to bending moments and directly. As for its lack of effect in the rate of 0.6%, it may be due to how it is distributed in the mixture due to its large quantity with a correlation coefficient equal to one. This figure represents the graph between the flexural strength against percentage of glass fiber. The glass fiber is added at the rate of 0%.0.2%, 0.4%, 0.6%, by volume of fracture. Out of these, the flexural strength is very high at 0.4% having for 7 days is 6.46 N/mm2 and at 0.2% for 28 days is 8.3745 N/mm^2

5. Conclusions and recommendation

This study investigated the influence of varying E-glass fiber additions on the mechanical properties of normal-strength concrete. Based on our experiments, we draw the following conclusions:

1. While adding 0.2% of glass fibers led to the highest compressive strength of NC at 28 days, with a 4.4% increase compared to the reference mix, we recommend considering 0.2% as the optimal fiber content.

2. Adding glass fibers to concrete significantly boosted its splitting tensile strength, with the peak improvement observed at 0.2% fiber content. Compared to the reference mix (concrete without fibers), the splitting tensile strength increased by a remarkable 6.16 % at 28 days with the addition of just 0.2% fibers.

3. Like tensile strength, the concrete's ability to resist bending (flexural strength) kept rising until 0.2% fiber content, showcasing a remarkable 11.7% improvement over plain concrete at 28 days.

4. Adding E-glass fibers significantly boosts tensile and flexural strength of concrete compared to compressive strength, suggesting its greater effectiveness in improving tensile properties.

5. Adding fibers transformed the failure mode from brittle and destructive to controlled and gradual, as cracks formed progressively instead of a sudden catastrophic break. This enhanced resistance to sudden crack formation is a major benefit of fiber reinforcement.

6. The Experimental work shows that workability of GFRC gets reduced as we increased the fiber amount

5.1 Recommendations:

To gain a deeper understanding of how E-GFRP affects the mechanical properties of normal concrete (NC), future research should explore a wider range of variables, including different strength grades, fiber percentages, and fiber sizes

1. Investigate the compressive and tensile behaviour of NGFRC and create a unified stress-strain curve.

2. Create a practical flexural model for NGFRC using a generalized stress-strain curve

3. Evaluate the mechanical behavior of NGFRC under a broader range of loading conditions, encompassing impact resistance, for comprehensive material characterization.

4.Investigate the influence of E-glass fiber reinforced polymer (E-GFRP) addition on the workability characteristics of normal strength concrete (NC).

5. Extensive testing and research are still required to fully understand the behavior of NGFRC as a repair and strengthening material for various types of damaged structural elements.

REFERENCES

[1] Manoj Kumar | Er. Shashi Sharma | Er. Vikram, "Improving Properties of M30 Grade of Concrete by Adding Glass Fibers," Int. J. Trend Sci. Res. Dev., vol. 3, no. 4, pp. 1509–1513, 2019

[2] P. Yoddumrong, K. Rodsin, and S. Katawaethwarag, "Experimental study on compressive behavior of low and normal strength concrete confined by low-cost glass fiber reinforced polymers (GFRP)," ESIT 2018 - 3rd Int. Conf. Eng. Sci. Innov. Technol. Proc., pp. 4–7, 2019.

[3] A. J. H. Eethar Thanon Dawood, "High-performance lightweight concrete reinforced with glass fibers," AL-Mansour J., no.20, pp. 73–87, 2013.

[4] C. S. Ravikumar, "Glass Fiber Concrete: Investigation on Strength and Fire-Resistant Properties," IOSR J. Mech. Civ. Eng. Vol. 9, no. 3, pp. 21–25, 2013.

[5] K. S. Kene, "Experimental Study on Behavior of Steel and Glass Fiber Reinforced Concrete Composites," Bonfring Int. J.Ind. Eng. Manag. Sci., vol. 2, no. 4, pp. 125–130, 2012.

[6] Chandramouli, K, Srinivasa Rao, P, Pannirselvam, N, Seshadri Sekhar, T, and Sravana, Priyadrashini, T. P, (2010), "Strength and durability characteristic of glass fibre concrete", International Journal of Mechanics of Solids, Vol. 5, No.1, pp. 15-26.