Influence of Percentage Glass Fiber Reinforcement on Flexural Strength

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Abstract - Today's globe is seeing the creation of extremely complex and demanding civil engineering facilities. Being the most significant and commonly utilized material, concrete is frequently required to have extremely high strength and adequate workability qualities. In the field of concrete technology, attempts are being undertaken to create such concretes with unique qualities. Researchers worldwide are working to use fibers to create high-performance concretes. and other additives in concrete up to a specific percentage. This paper attempts to study the influence of the rate of glass fiber reinforcement in concrete on flexural strength. UTM tests are carried out to measure the strength of glass fiber-reinforced concrete beams. It was observed that there is considerable improvement in the flexural strength after adding glass fiber to concrete.

***Key Words*:** GFRC, Flexural Strength

1. INTRODUCTION

The most common building material utilized is concrete. material has several advantageous qualities, such as high compressive strength, rigidity, and longevity in typical environmental conditions. Concurrently, concrete is fragile and feeble while under stress. Two drawbacks of plain concrete are low strain at fracture and poor tensile strength. Generally, weaknesses are addressed by strengthening concrete. Reinforcement typically consists of ongoing twisted steel bars or tendons used for pre-stressing. The benefit of pre-stressing and reinforcing technologies using high-tensile steel wires as steel reinforcement has aided in overcoming concrete's limitations in stress, but the compressive strength's ductility power. FRC, or fiber-reinforced concrete, is a type of concrete composed mostly of aggregates, hydraulic cement, and distinct fibers that reinforce. FRC is a recent innovation. substance. Considering the worldwide sustainable advances, it is essential to show fibers with properties similar to aramid, glass, carbon, and polypropylene enhance fatigue and tensile strength features, resilience to erosion, durability, shrinkage, impact, cavitation, and serviceability of concrete. Fibers impart impact, toughness, and energy absorption.

P. Bhuvaneshwari and R. Murali (2013) conducted an experimental investigation by replacing fine aggregate in the concrete mix with bottom ash and glass fibre, enhancing the concrete's strength characteristics. The concrete mix design is done for M30-grade concrete. The mix is prepared for different combinations of 0%, 30%, 40%, 50% and 100% of replacement of sand by bottom ash with 0.3% of glass fibre by weight of cement. The mechanical properties were compared with the control mix and it was found that the optimal combination was 50% bottom ash and 0.3% glass fibre (BGC). In this study, bottom ash, a hazardous material, is used as a replacement for fine aggregate to reduce pollution. [1]. Taherkhani, H (2016) worked on Glass fibres and nano clay by adding them to asphalt concrete at different proportions and some engineering properties have been evaluated. Results show that the Marshall stability of asphalt concrete increased with increasing glass fibre and nano clay content, with the highest Marshall stability achieved at 0.2% of fibre content and 6% of nanoclay. Also, the Flow of asphalt concrete increased with increasing glass fibre content and decreased with increasing nano clay content. The Marshall quotient of asphalt concrete decreased with increasing glass fibre content and increased with increasing nano clay content. [2]. J W Han et. al (2015) evaluated Glass/natural jute FRP bars for use as a tensile reinforcement material in concrete structures. The tensile properties of the glass/natural jute FRP bars are discussed. The tensile load-displacement behaviour of the composite bars showed almost perfect linear elasticity up to a fibre volume fraction of 50% natural jute fibre. For 70% natural jute fibre, the linear elastic behaviour of the glass fibre was evident to the point of rupture, followed by plastic deformation, which was minimal as glass fibre has high elasticity modulus, tensile strength, and deformation rate. For a fibre volume fraction of 100% natural jute fibre, linear elastic behaviour was observed. The tensile strength of glass/natural jute FRP bars decreased as the fibre volume fraction of natural jute fibre increased. [3]. N. Pannirselvam and S. Manivel (2020) evaluated the mechanical properties of concrete with and without glass fibre in varying percentages. The rating increment in compressive strength of various glass fibre concrete proportions is seen from 20 to 40 percent contrasted with 28 days of compressive quality. The rating increment in flexural and split tensile strength of glass fibre solid blends of various evaluations is seen from 15 to 25 per cent contrasted with 28 days. Reduced bleeding is observed by adding glass fibres, improving its homogeneity and reducing cracking. For higher concrete evaluations, the penetrability of glass fibre-strengthened chloride concrete shows less chloride porousness. Generally, glass fibres reduce cracks that cause minimal vacuum interconnection. The penetrability of cement with the addition of 0.03% of glass fibres in M20 and M30 grades diminishes at 28 days by 15.37 and 23.29% [4]. Chandramouli K et. al. (2010) conducted an experimental investigation for the alkali resistance glass fibres to study the effect on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. A reduction in bleeding is observed by adding glass fibres in the glass fibre concrete mixes. Reduced bleeding improves the surface integrity of concrete, improves its homogeneity and reduces the probability of cracks. The percentage increase of compressive strength of various grades of glass fibre concrete mixes compared with 28 days compressive strength is observed from 20 to 25% and the percentage increase of flexural and split tensile strength of various grades of glass fibre concrete mixes compared with 28 days is observed from 15 to 20% [5]. Muhammed İSKENDER and Bekir KARASU (2018) reviewed 184 research papers and listed Glass Fibre fibre-reinforced concrete data. GFRC can be used wherever a light, strong, fire-resistant, weather-resistant, attractive, impermeable material is needed. As technology advances, it is possibly expected to build the whole building and complex freeform at low cost. In recent years, the effect of glass fibres in hybrid mixtures has been investigated for high-performance concrete (HPC), an emerging technology that has become popular in the construction industry. Generally, GFRC's service life is generally longer than traditional concrete due to controlling micro-crack propagation, corrosion (especially AR–glass fibre), and less permeability [6]. Xiaofeng Yang et. al. (2024) studied the effects of thermal treatment temperature on the properties of RGF and the microstructural morphology of RGF and its reinforcement effect on concrete are evaluated. The permeability resistance of recycled glass fibre-reinforced concrete (RGFRC) is investigated, and the mechanism of elevated permeability resistance in RGFRC is revealed. Results indicate that with increasing thermal treatment temperature, the diameter of the thermal treated RGF is notably reduced and the fibre's surface is covered with a significant amount of impurity. When thermal treated under 600 ◦C, the RGF presents the optimal structure with appropriate surface roughness, higher crystallinity, stable molecular structure, and good compactness. Thus the concrete with RGF calcinated under 600 ◦C demonstrates the highest compressive strength, demonstrating that the optimal thermal treatment temperature is around 600 ◦C. Furthermore, the concrete exhibits a continuous reduction in internal water penetration height and sustained improvement in permeability resistance as the fibre content increases. The mechanism behind the improved impermeability of RGF to RGFRC lies in the interweaving of RGF within the concrete matrix, forming a three-dimensional network structure. [7]. Leiyang Liu and Xingquan Wang (2017) proposed innovative thinking to realise local material acquisition in island construction and life dependence on the sea, namely alkali-resistant glass fibre mixed in coral aggregate concrete as reinforcing material. The glass fibre is characterised by low price, low hardness, good dispersibility and convenient construction. A reliable guarantee is provided for the wide application of the material in future projects. The paper first applies an orthogonal test method to determine the mix proportion of grade C50 coral aggregate concrete. Then, the design plan for the mix proportion of alkali-resistant glass fibre-enhanced seawater coral aggregate concrete is determined [8]. J.A.O. Barros et al. (2015) studied the tensile behaviour of GFRC specimens at 28 days of age. They summarised conclusions as the Fracture energy of cement-based materials is significantly increased by adding glass fibre to the mix composition. - The fibre orientation largely determines tensile strength, which depends on the mixing method. A tensile strength of about 11 MPa is found when a spray-up technique is used for the PGFRC. A tensile strength between 4.5 and 5.5 MPa is found for (P)GFRC mixes made with the premix method [9]. Dr. Mrs. S. A. Bhalchandra and Mrs. A. Y. Bhosle (2010) conducted an experimental program to determine the mechanical properties of glass-reinforced Geopolymer Concrete which contains fly ash, alkaline liquids, fine & course aggregates & glass fibres. The effects of including glass fibres on density, compressive strength & flexural strength of hardened geopolymer concrete composite (GPCC) were studied. The alkaline liquids to fly ash ratio was fixed as 0.35 with 100% replacement of ordinary Portland cement by fly ash. For alkaline liquid combination ratio of Sodium hydroxide solution to Sodium silicate solution was fixed as 1.00. Glass fibres were added to the mix in 0.01%, 0.02%, 0.03% & 0.04% by volume of concrete. Based on the test results, the glass fibres reinforced geopolymer concrete have relatively higher strength in short curing time (3 days) than geopolymer concrete & Ordinary Portland cement concrete [10].

2.MATERIALS AND METHODS

Since the properties of materials incorporated for concrete production may largely influence the shear and flexural behaviour and bond strength of concrete, it is discussed in detail in this section.

. 1. Cement: Cement is a construction material made by combining argillaceous and calcareous materials in a definite proportion. It is a critical engineering material that serves as the foundation for engineering projects. Cement occupies a major proportion of concrete, which is a fixed-proportion mixture of cement, sand, and aggregates (both coarse and fine). It is one of the most important and indispensable components in the construction industry. Cement was invented by Joseph Aspdin of the UK in 1824. Portland cement is the commonly used name because of its resemblance in the hardened state to natural stones occurring in Portland in England. Cement is a product obtained by pulverising clinkers by calcinating raw materials consisting of Lime (CaO), Silica (SiO_2), Alumina (Al_2O_3) and Iron Oxide (Fe_2O_3). Cement is primarily used as a binding agent in concrete. Because of its cohesive and adhesive properties, which develop after mixing with water, cement acts as a bond between concrete and steel in reinforced cement concrete. Cement is used in mortars for plastering, masonry works, pointing's etc. It is used in water tightness of structures and making joints in drains and pipes. In situations where the exterior hard walls are exposed to harsh environments, cement is used to take care of the chemical attacks. Ultratech OPC 43 Grade having specific gravity of 3.15 cement is used for casting of cubes and cylinders. The cement has uniform greenish grey colour and is free from lumps.

2. Fine aggregates: Sand is a naturally occurring granular material comprising finicky divided minerals. Sand is defined by its grain size. Sand used in construction is divided into different types depending upon the grain size like fine sand, medium sand and coarse sand. Sand is used as a filler material to fill voids created by the coarse aggregate to have a dense body of concrete. Sand can be used as a road base, a protective layer underneath all roads. Apart from the construction industry. Natural river sand confirming to IS-383, Zone-II having specific gravity 2.67.

3. Coarse aggregates: They are responsible for providing the body with concrete. They are derived from igneous, sedimentary and metamorphic rocks. Almost 80% of

the total volume of concrete is attributed to aggregates. Aggregates are broadly classified into two categories namely coarse aggregates and fine aggregates. Coarse aggregates form the main matrix of concrete, and fine aggregates form the matrix between coarse aggregates. Aggregates act as fillers with different binding materials such as cement and sand. Aggregates are responsible for taking the impact load which concrete structures are susceptible to in their service life. Aggregates are used as base courses in road constructions to take care of loads (both static and dynamic) and in railway tracks as ballast. They are also used as supporting structures as well as to take care of drainage. Apart from these, aggregates are also employed in water filtration and sewage treatment processes. Local available coarse aggregate having size of 20 mm was used in this work.

4. The fibrillated polypropylene microfiber PSI FIBERSTRAND F is intended to assist in the prevention of development of plastic shrinkage cracks in concrete and complies with ASTM C 1116, Standard Specification for Fiber Reinforced Concrete and Shotcrete. Its applications include Slabs on grade, sidewalks, driveways, curb work, overlays and toppings Footings, foundations, walls and tank etc.

Table -1: Flexural Strength of GFRC under varying glass fiber percentage

Sr. No.	0 % Glass Fiber		5 % Glass Fiber		10 % Glass Fiber	
	Load (KN)	Flexural Strength (N/mm2)	Load (KN)	Flexural Strength (N/mm2)	Load (KN)	Flexural Strength (N/mm2)
1	7.9	3.95	8.8	4.4	10.7	5.35
2	8	4	9.5	4.75	11.9	5.95
3	8.4	4.2	9.1	4.55	10.8	5.4
4	8.1	4.05	8.9	4.45	10.5	5.25
5	7.8	3.9	9.3	4.65	11.3	5.65
6	8.5	4.25	9.8	4.9	12	6
7	8.6	4.3	9.7	4.85	12.6	6.3
8	8.3	4.15	9.9	4.95	11.7	5.85
9	7.9	3.95	10	5	13.2	6.6
Average	**8.16**	**4.083**	**9.44**	**4.722**	**11.63**	**5.816**

During experimentation flexural strength under the varying percentage of glass fiber was examined as in table 1. Glass fiber percentage was varied in the range of 0 ,5 and 10 % of concrete and for these samples force and flexural strength was studied.

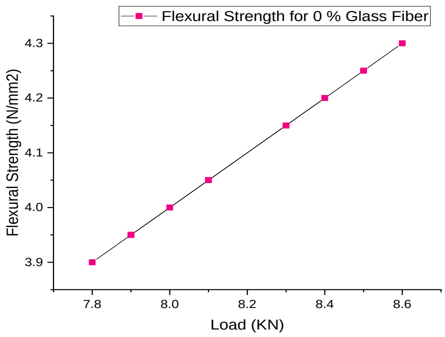
3.RESULT AND DISCUSSION

For experimentation Flexural Strength (N/mm2) obtained on UTM for GFRC beams of Size: 100x100x500 mm and the age of beam was kept 28 days. Figure 1 shows the casting of glass fiber reinforced concrete beam casting process. These beams are prepared as per standards and then tested on UTM machine for flexural strength against the varying percentage of glass fiber reinforced concrete.

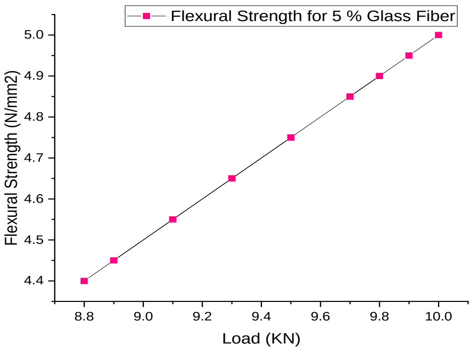
a)

b)

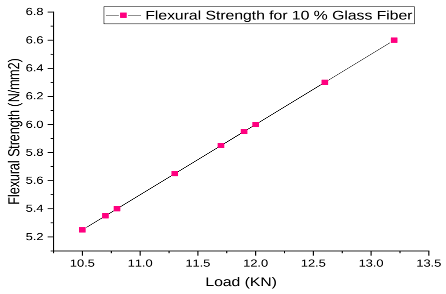
Fig -1: Test sample during casting and after casting



a)



b)



c)

Fig -2 a) Load Vs Flexural Strength for 0 % Glass fiber reinforced Concrete, b) Load Vs Flexural Strength for 5 % Glass fiber reinforced Concrete, c) Load Vs Flexural Strength for 10 % Glass fiber reinforced Concrete.

Individual graph related load vs flexural strength and average force and average flexural strength was plotted. Figure 2 a), Figure 2 b), Figure 2 c) shows the graph of load vs flexural strength for 0 %, 5 % and 10 % glass reinforced concrete; it shows increasing trend of flexural strength with respect to increase in load**.**

Figure 3 shows the graph for average load vs average flexural strength for 0 %, 5 % and 10 % glass reinforced concrete; it shows increasing in flexural strength with increase in % glass fiber reinforcement. For average load of 8.16 KN 0 % GFRC beam provided flexural strength of 4.083 N/mm2 and for average load of 9.44 KN 5 % GFRC beam provided flexural strength of 4.722 N/mm2 and for average load of 11.63 KN 10 % GFRC beam provided flexural strength of 5.816 N/mm2.

Fig -3 Average Load Vs Average Flexural Strength for 0 %, 5 % and 10 % Glass fiber reinforced Concrete

4.CONCLUSIONS

Experiments were carried out to evaluate Flexural Strength (N/mm2) obtained on UTM for GFRC beams of Size: 100x100x500 mm and the age of beam was kept 28 days. The beams are prepared as per standards and then tested on UTM for flexural strength against the varying percentage of glass fiber reinforced concrete. Graph for average load vs average flexural strength for 0 %, 5 % and 10 % glass reinforced concrete shows increase in flexural strength with increase in % glass fiber reinforcement. For average load of 8.16 KN 0 % GFRC beam provided flexural strength of 4.083 N/mm2 and for average load of 9.44 KN 5 % GFRC beam provided flexural strength of 4.722 N/mm2 and for average load of 11.63 KN 10 % GFRC beam provided maximum flexural strength of 5.816 N/mm2.

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