Comparitive Analysis Between Plain Cement Concrete And Glass Fibre Used Concrete

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Abstract- *Prior studies in the literature show promising results regarding the improvements in strength and durability of concrete upon incorporation of glass fibers into concrete formulations. However, the knowledge regarding glass fiber usage in concrete is scattered. Moreover, this makes it challenging to understand the behavior of glass fiber-reinforced concrete. Therefore, a detailed review is required on glass fiber-reinforced concrete. This paper provides a compressive analysis of glass fiber-reinforced composites. All-important properties of concrete such as flowability, compressive, flexural, tensile strength and modulus of elasticity were presented in this review article. Furthermore, durability aspects such as chloride ion penetration, water absorption, ultrasonic pulse velocity (UPV) and acid resistance were also considered. Finally, the bond strength of the fiber and cement paste was examined via scanning electron microscopy. Results indicate that glass fibers improved concrete's strength and durability but decreased the concrete's flowability. Higher glass fiber doses slightly decreased the mechanical performance of concrete due to lack of workability. The typical optimum dose is recommended at 2.0%. However, a higher dose of plasticizer was recommended for a higher dose of glass fiber (beyond 2.0%). The review also identifies research gaps that should be addressed in future studies.*

Keywords- glass fiber, compressive strength, durability, scanning electron microscopy

I. INTRODUCTION

Development of composite materials represents a milestone in the history of our civilization. Along with conventional building materials such as steel, concrete, aluminium, and wood, composite materials offer an excellent alternative for a multitude of uses. Use of composite materials was pioneered by the aerospace industry beginning in the 1940s, primarily because of the material's high-performance and lightweight qualities. Today their potential is being harnessed for many uses. Advanced composite materials — so called because of their many desirable properties, such as high performance, high strength-to-weight and high stiffness-to-weight ratios, high energy absorption, and outstanding corrosion and fatigue damage resistance — are now increasingly used for civil engineering infrastructure such as buildings and bridges. Composite materials are manufactured from two or more distinctly dissimilar materials — physically or chemically — that are suitably arranged to create a new material whose characteristics are completely different from those of its constituents. Basically, composites consist of two main elements: the structural constituent, which functions as the load carrying element, and the body constituent called matrix, which encloses the composite. The structural constituent can be in the form of fibres, particles, laminae (or layers), flakes, and fillers.

The matrix performs important dual functions: It acts as a binder to hold the fibrous phase in place (i.e., holds the fibres in a structural unit) protecting fibres from environmental attack, and under an applied load, it deforms and distributes the load to the high modulus fibres. The mechanical properties of a composite that influence its behaviour and performance as structural material depend on the properties of its constituent — fibres and matrix — and the process used for its manufacture. Understanding these properties is very important for proper application of the composite.

In addition to using composites for stand-alone load-carrying components (such as prefabricated bridge modules, beams, and girders), they can be also used in conjunction with concrete and steel as load-sharing elements. For example, glass fibre reinforced polymer (GFRP) bars can be used as reinforcement for concrete members in lieu of conventional steel reinforcing bars. Prestressing bars and strands made from carbon fibres can be used as tendons for prestressed concrete construction. This type of application is commonly referred to as internal reinforcement. Similarly, carbon fibre reinforced polymer (CFRP) strips can be used as external reinforcement for increasing the load-carrying capacity concrete beams. In this type of application, the CFRP strips are bonded to the exterior tensile face of a beam to complement its flexural capacity.

The application of geosynthetics in infrastructure is an innovative development in concrete with the usage of geogrid. In the plastic hinge region of Reinforced Concrete (RC) beams the additional shear reinforcement was provided by using glass fibres. The study is carried out by ***Joel Shelton J et al (2021)*** for the RC beam specimens, in which the additional shear confinement was given by geo-grid of various sizes was studied. In RC beams, less labour work only needed for the confinement and with the usage of geo-grid and for the confinement the usage of geo-grid will be an effective solution. The effect of geo-grid with the glass fibre reinforced concrete has also been investigated by experimental observations and non-linear finite element simulations.

Dr.K.Vidhya et.al. (2017) explain that Concrete is a relatively brittle material, when subjected to normal stresses and impact loads. As a result for these characteristics, plain concrete members could not support loads and tensile stresses that occurred, on concrete beams and slabs. Concrete members are reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. The addition of steel reinforcement significantly increases the strength of concrete, and results in concrete with homogenous tensile properties; however the development of micro cracks in concrete structures must be checked. The introduction of fibres is generally taken as a solution to develop concrete in view of enhancing its flexural and tensile strength. M40 grade of concrete are arrived with the following ingredients such as Cement, Fine aggregate, Coarse aggregate, Water, Steel fibre, Fly ash, Silica fumes and Super plasticizers. Then variables in this study include the steel fibre (Hooked end and crimpled) percentage in addition to the weight of cement. The Compressive strength, tensile strength and flexural behaviour of steel fibre reinforced concrete beam with the varying percentage of fibre of M40 grade of concrete.

Di Zheng et al (2020). The concrete specimens with different fibre dosages (0 wt%, 0.4 wt%, 0.8 wt%, or 1.2 wt%) and fibre types (polypropylene, glass and polyacrylonitrile fibres) were prepared and subjected to uniaxial compressive testing. Besides, the industrial computed tomography (CT) scanning was conducted on samples before and after compression to analyze the temporal and spatial evolution of internal micro-cracks. The experimental results show that the uniaxial compressive strength of fibre-reinforced concrete first increased and then decreased as fibre dosage increased. The peak stress of glass fibre-reinforced concrete was higher than those of polypropylene and polyacrylonitrile fibre-reinforced concretes. The peak stress of concrete with 0.8 wt% glass fibres was 39% higher than that of ordinary concrete. The strain of fibre-reinforced concrete linearly increased with fibre dosage increased. Furthermore, the fractal characteristics were investigated in the concrete cracks. The internal and external cracks revealed that the failure mode of fibre-reinforced concrete transitions from shear failure to tensile failure with fibre dosage increased. The extent of bridging effects of the three fibre types on cracks in the concrete could be ranked in descending order as follows: glass fibre > polypropylene fibre > polyacrylonitrile fibre according to the CT scanning results

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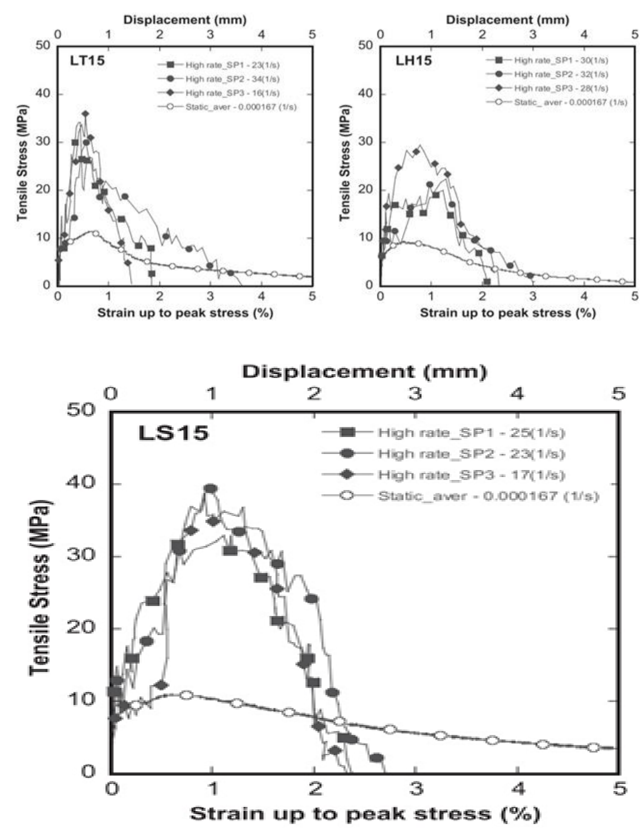
Ngoc Thanh Tran (et. al. 2017) investigated the synergistic tensile response of blending 1% long and 0.5% short steel fibers in ultra-high-performance concrete (UHPC) at high strain rates of 16e37 s. Three ultra-high-performance hybrid-fiber-reinforced concretes (UHP-HFRCs) containing twisted, hooked, or smooth long (30 mm) fibers blended with short (13 mm) smooth fibers, as well as one sample (LS10MS05) blending long and medium (19 mm) smooth fibers, were examined.



a) UHP-MFRCs

E. Arunakanthi et.al. (2016) explain the important of Concrete. which is one of the most widely recognized development material for the most part delivered by utilizing locally accessible ingredients. The present trend in concrete technology is towards increasing the strength and durability of concrete to meet the demands of the modern construction. The main aim of the study is to study the effect of glass fibre and steel fibres in the concrete. FRC has the high tensile strength and fire resistant properties thus reducing the loss of damage during fire accidents. In the present work the strength studies are carried out to compare the glass and steel fibre concrete. The FRC is added 0.5, 1, 2 and 3% are added for M20 grade concrete. Result shows the percentage increase in compressive strength, flexural strength and split tensile strength for 28days.

Pradeep L. et.al. (2006) gives a study on Surface texture of a harder mating surface has a great influence on frictional behaviour during sliding against softer materials. In the present investigation, experiments were conducted using a Pin-on-Plate inclined sliding tester to study the effect of the surface texture of hard surfaces on the coefficient of friction and transfer layer formation. 080 M40 (EN8) steel plates were ground to attain surfaces of different texture with different roughness. Pure magnesium pins were then slid at a sliding speed of 2 mm/s against the prepared steel plates. Scanning electron micrographs of the contact surfaces of pins and plates were used to reveal the morphology of transfer layer.

A number of research study had been showed to see the consequence of mixing steel fibre as reinforced material with concrete as base material. A large number of minor and major investigating tests were conducted similar as Compressive, flexure and tensile strength test with steel fibre mixed with concrete at various percentages of steel fibre. Most of the research studies confirmed that various mechanical, chemical and engineering properties similar split tensile strength, compressive strength, impact strength and flexure strength of concrete mixed with different percentages of steel fibre have been improved. From the above considerations it can be said that steel fibre proved to be a good reinforcing material and economically viable for improving the strength and durability characteristics of concrete.

II. EXPERIMENTAL INVESTIGATION

2.1 Test Materials

CEMENT

Ordinary Portland cement Type I (OPC) commercially available namely ACC cement was used as the cementitious material in this experimental work for all concrete mixes. It conforms to the IS code 3346 standard. It has a specific gravity of 3.15 and a Blaine specific surface area of 380 m2/g. The initial and final setting times were 74 min and 385 min, respectively. (As per manufactured specification). W/C ratio considered as 40% from IS 456:2000.

Fine aggregate

Dry and clean Narmada River sand was used as fine aggregate and passed through a 4.75-mm sieve. The fine aggregate has a specific gravity of 2.59, a fineness modulus of 2.98 and water absorption of 0.93%. The loose and compacted bulk density values of the fine aggregate are 1600 and 1688 kg/m^3, respectively

Coarse aggregate

Crushed granite aggregate available from local sources was used as coarse aggregate. The maximum size of the coarse aggregate is no more than 10 mm and has a specific gravity of 2.65 (measured by fine aggregate specific gravity test), and a fineness modulus of 5.95 (0.395- inch sieves). The loose and compacted bulk density values of the coarse aggregates are 1437 and 1526 kg/m3, respectively.

Fibres

Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Glass fibres used for the study are short, having discrete lengths of steel with an aspect ratio from about 30 to 150, and with any of several cross sections. The glass fibres used for the study have hooked ends as shown in figure 3.1

Glass fibre used for study

The concrete used in construction today consists of cement, aggregate (sand and gravel) and water and often additives. Immediately during production, concrete has a plastic to liquid property after the mixing process as fresh concrete, which slowly changes into a solid substance, the concrete, after the curing time. After the curing time, the concrete is referred to as hardened concrete.

2.2 TEST CONDUCTED AND QUALITY DETERMINE

According to the mix design, the targeted compressive strength is 26.25 MPa and the maximum water cement ratio is 0.55 while the adopted water–cement ratio is

0.5, with a water content of 260 kg/m3 and a cement content of approximately 520 kg/m3. The recommended slump should be maintained between 30 and 60 mm with this water–cement ratio.

Mix Specification	Glass Fibre Content % (by Mass of Sand)	W/C	Water (kg/m^3)	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)
MS-1	0	0.5	220	518	840	1554
MS-2	0.5	0.5	207	518	840	1554
MS-3	1	0.5	207	518	840	1554

2.2.1 TEST OF SPECIMEN

For concrete cube test the specimen's cubes of 15cm×15cm×15cm size are used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. For having top surface of these specimens even and smooth the cement paste has been used by spreading smoothly on whole area of specimen.

2.2.2 Workability Testing

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Workability of concrete mixture is measured by:

1. Vee-bee consistometer test
2. Compaction factor test
3. Slump test

Compaction Factor Test (IS 1199)

Compaction factor test for workability is used when the nominal maximum size of the aggregate does not exceed 38 mm. Compaction factor test is primarily design as laboratory. Compaction factor test for workability is used when the nominal maximum size of the aggregate does not exceed 38 mm. Compaction factor test is primarily design as laboratory.

Slump Test

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The inexpensive test, which measures consistency, is used on job sites to determine rapidly whether a concrete batch should be accepted or rejected. Additional qualitative information on the mobility of fresh concrete can be obtained after reading the slump measurement

III. RESULT AND DISCUSIONS

3.1 Compressive Strength

From tables 4.1 to 4.3 and figures 4.1 to 4.6, it can be noted that the compressive strength values are increasing significantly with the increase of percentage addition of glass fibres to the M20 grade concrete. It can be seen that there is an increase in compressive strength for the three different glass fibre-reinforced concrete specimens, with sand replacement fraction of 5%, 10% & 15% at 7, 14 and 28 days respectively, when compared with the concrete that does not contain fibre.

Table 3.1 Compressive Strength of Concrete

Mix. No	Glass Fibre Percentage	Compressive Strength of Concrete (N/mm^2)		
		7 Days Curing	14 Days Curing	28 Days Curing
1	0	11.65	16.35	21.23
2	5	12.80	21.87	25.74
3	10	14.30	24.18	28.45
4	15	14.55	24.10	28.43

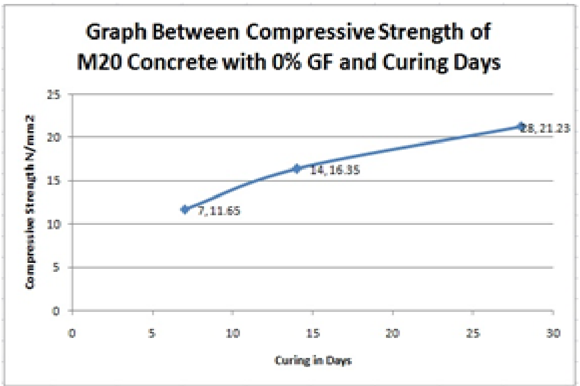


Fig. 3.1 Compressive Strength of concrete block with 0% glass fibre at different aspect ratio

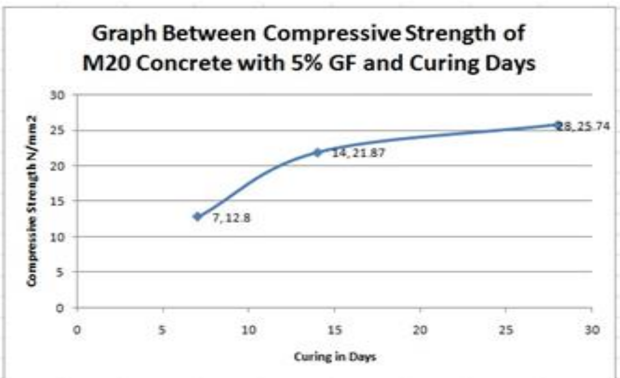
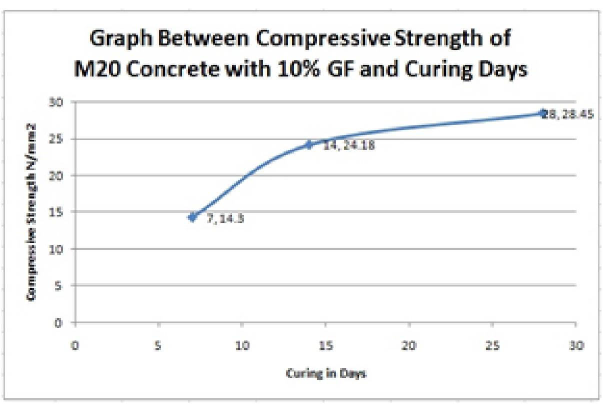


Fig. 3.2 Compressive Strength of concrete block with 5% glass fibre at different aspect ratio



3.3 Compressive Strength of concrete block with 10% glass fibre at different aspect ratio

3.2 Workability

Mix. No.	Glass Fibre Percentage Content	Slump (mm)	Compaction Factor
1	0	124	0.95
2	5	129	0.96
3	10	141	0.96
4	15	142	0.97

Slump is a measurement of concrete's workability, or fluidity. It's an indirect measurement of concrete consistency or stiffness.

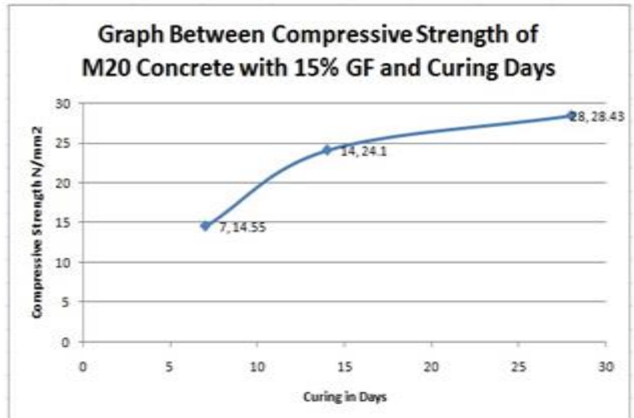


Fig. 3.4 Compressive Strength of concrete block with 15% glass fibre at different aspect ratio

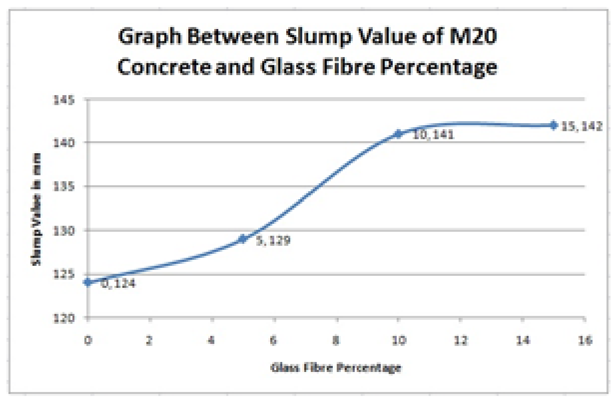


Figure 3.5 Variation in slump test results with respect to different percentage of glass fibre

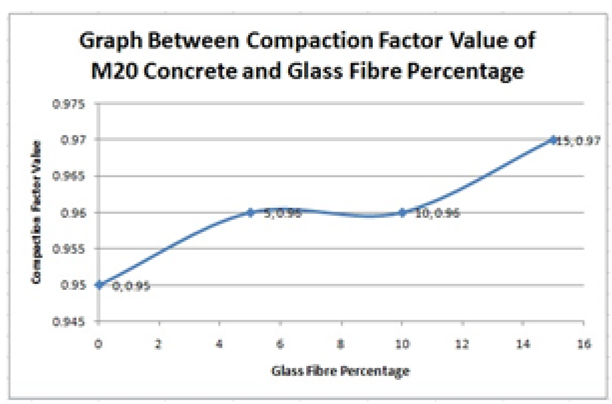


Fig. 3.6 Variation in Compaction Factor results with respect to Different % of Glass Fibre

3.3 Split Tensile Strength

This test for determining split tensile strength is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a Universal Testing Machine and the load is applied until failure of the cylinder along the vertical diameter.

The split tensile strength tests were carried out at 7, 14 and 28 days. For each mix proportion, 6 cylinders were cast and tested. The split tensile strength was calculated by evaluating the ratio of the ultimate load to the circumferential area.

Table 3.3 Tensile Strength of Concrete

Mix No.	Tensile Strength of M20 Concrete in 28 Days (N/mm^2)			
	0 %	5%	10%	15%
1	1.675	1.95	2.34	2.90

IV. CONCLUSION

After the experimental analysis the following conclusions have been made:

- It can be seen that there is an increase in compressive strength for the three different glass fibre-reinforced concrete specimens when replaced wtih sand in different volume fractions i.e. 5%, 10%, 15% in 7, 14 and 28 days respectively, when compared with the concrete that does not contain fibre.
- The concrete mixer contained 10% and 15% glass fibre having higher percentage of compressive strength increment compare then 5 percent glass fibre contained concrete.
- The results show that by increasing the Glass Fibre Content in the cement concrete there is increment in workability. These results show the workability of concrete with glass fibre is higher than the concrete without fibre.
- The Split Tensile strength of the various fibre-reinforced concrete specimens at different days of curing. The tensile strength of the glass reinforced concrete is increases, with increments of glass fibre content at 7, 14 and 28 days of curing respectively.

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