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Experimental Analysis of Glass Fibre in Concrete

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Abstract. Compared compared to concrete in a construction, the essential portion of the structure has higher weight, however steel utilised as reinforcement has no weight. To address this problem, the Glass Fibre Reinforced Concrete (GFRC) material was developed. Polymers and glass fibre are impregnated in the cementation framework of GFRC, which is a material. Glass fibre, Fly ash, silica sand, Portland cement and water are all components of concrete. The glass content, mix procedure, and casting process all have an impact on the qualities of GFRC concrete. We present the fibre glass as well as other characteristic synthetic chemicals in GFRC to develop a material that is extremely solid and adaptableto construction.By this research, using 0.5 percent and 0.1 percent glass fibres increases compressive and flexural strength of concrete for 7,14 and 28 days with no admixtures.

Introduction

Fibre reinforced concrete, as well as a variety of cement types, is currently used in a number of tough settings for future Structural Engineering applications. One of the most essential aspects of Fibre Reinforced Concrete (FRC) is its superior resistance to cracking and crack propagation, as well as the presence of fibrous material that promotes structural integrity [1].Fibreglass is a resilient, flexible, and durable material. When compared to metals, its bulk strength and weight qualities are also quite beneficial, and it can be easily manufactured utilizing moulding procedures [2].Fibre-reinforced cementation composites with excellent performance for a variety of Structural Engineering applications, including great durability and impact load resistance [3]. It is now feasible to develop the characteristics of both fresh and hardened concrete primarily to the development of a variety of chemical admixtures [4].Fibre-reinforced concrete has shown better fracture resistance than non-fibre concrete, as well as higher durability, shear strength, and fatigue resistance [5]. Concrete can be strengthened and made more ductile by adding fibre. Several methods for impact testing concrete have been developed in the past [6]. The most common testing devices are drop weight machines, swinging pendulum machines, and split Hopkinson pressure bar equipment.Several admixtures have been utilized to improve the performance of concrete, including fibre reinforcement, super plasticizer, air-entraining agent, accelerators, retarders, waterproofing compounds, and others [7,8]. Compressive, tensile, flexural, and impact strength all improve when admixtures are added to ready-mixed fibre-reinforced concrete. Plastic shrinkage and other types of volume changes in concrete will cause concrete without fibre to fracture [9].

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Table 1. Types of fibres and their characteristics

S. NO	FibreType	Characteristics	Remarks
1	PVA (Polyvinyl Alcohol)Fibre	ρ = 900 kg/m³ σ = 1100 – 1400 N/mm² ε = 10,000 – 64,000 N/mm²	PVA fibres with a high modulus may be made using special manufacturing procedures.
2	Glass Fibre (ECR glass)	ρ = 2720 kg/m³ σ = 3400 N/mm² ε = 80,000 N/mm²	It outperforms E-glass fibre in terms of mechanical characteristics, heat resistance, water resistance, electrical leakage rate, and surface resistance.
3	Carbon fibre	ρ = ~1,800 kg/m³ σ = 3,500 N/mm² ε = 1.83x10⁵N/mm²	It has a high durability.
4	Polyester fibre	ρ = ~1830 kg/m³ σ = 650 N/mm² ε = 920 N/mm²	Developed for the textile industry but can also be found in the construction materials industry.
5	Basalt fibre	ρ = ~2,700 kg/m³ σ = 3,700 – 4,840 N/mm² ε = 89- 90 GPa	Heat insulators, fire resistance, high tensile strength, high E-modulus, and environmental friendliness are all features of this material.

Fibres used

Fibre

Fibre is a very small strand of reinforcing material that has specific properties. They are flexible with circular cross section. The aspect ratio is a useful metric for defining the fibre. The aspect ratio of a fibre is the length-to-diameter ratio. Generally aspect ratiovaries from 30 to 150. Table 1 lists the fibres that were employed in this study, as well as their properties. Even though all type of fibres can be used in concrete, not all of them can be used as efficiently and economically. Each fibre has its own set of qualities and constraints. Glass fibres, polypropylene, Nylons, asbestos, basalt fibre and polyester fibreare some of the materials that might be employed.

Steel fibre

One of the most often utilizedfibres is steel fibre. Round fibres are commonly utilized. The size ranges from 0.25 to 0.75mm in diameter. When it is employed, rusting of steel fibres is a big issue, and as a result, some strength is lost. The use of polypropylene and nylon fibres to boost impact strength has been discovered to be effective. They have a high tensile strength, but their low modulus of elasticity and increased elongation don't help with flexural strength.

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Asbestos
Acid may be used with Portland cement to make asbestos, which is a mineral fibre that has proven to be the most successful of all fibres. Asbestos tensile strength ranges from 560N/mm^2 to 980N/mm^2. Asbestos cement is a composite product with significantly better flexural strength than Portland cement paste.

Admixtures inGFRC
Admixture is becoming an unavoidable part of concrete construction. Admixtures are employed to a higher extent in the GFRC. The use of plasticizer and superplasticizer is necessary since the high dose of glass fibres in the GFRC makes the combination stiff and difficult to deal with.

Plasticizer
Plasticizer is vital substances to minimize the force required to make the flow able mix and also tomake GFRC to flow more smoothly for a particular water-cement ratio.The water-cement ratio is primarily used to determine the workability and hydration of cement. We can lower the water-cement ratio to a certain extent using plasticizer.

Viscosity modifyingadmixtures
Viscosity modifying admixtures keep cement paste from washing out of porous concrete mixes. VMA enhances the binding between cement paste and aggregate, increasing the concrete's strength. It also improves the ability of cement paste to keep its ingredients in suspension by increasing the viscosity of the mixing water. It also used for reducing the possibility of bleeding and segregation.

Polymers
White latex, usually acrylic emulsions with a solid concentration of roughly 50%, is the most common polymer used. It is recommended that a dose of 5-6 percent by weight of cement be used. As flexible polymer bridges help to bind brittle mineral components, the polymers must be resistant to them.

Anti-efflorescence and water-repellentadmixtures
Due to the increased cement content of GFRC, more lime is produced during the setting process. This renders it susceptible to efflorescence, which is caused by lime. Pozzolana injected at a rate of 15-20% in cement usually removes efflorescence and reduce lime production. However, depending on the circumstance, a small amount may be added.

Properties of GlassFibre
Tensile and flexural strength, modulus of elasticity, compressive strength, impact resistance, shear strength, shrinkage and moisture movement, fire endurance, acoustical properties, thermal conductivity, permeability, and moisture absorption are all factors that influence the performance of GFRC materials. Table 2 shows the properties of Glass Fibre.

Table 2. Propertiesof Glass Fibre

Properties	**Value**
Flexural strength	16-32N
Tensile strength	9-19N
Elongation test	1-2.5%
Compressive strength	15-25N
Impact strength	4-12KN
Specific gravity	0.8-1
Aspect ratio	0.67
Co efficient of thermal expansion	12-20

Experimentalwork

General

The total no of 18cubes 150mm×150mm×150mm and 18 beams 100mm×100mm×500mm with the addition of 0.5% and 1% of glass fibre for analyzing compressive strength, flexural strength.

Materials Used

Cement

In the local market, 53 grades of Ordinary Portland cement are available, which have been employed in this study. The cement used here was tested for various amounts according to IS: 4031-1988 [20] and found to meet various IS: 12269-1987 [21] requirements. Cement was discovered to have a specific gravity of 3.15.

Coarseaggregate

Crushed angular granite as source material was used as coarse aggregate.60% of 20mm aggregate (specific gravity-2.78) and 40% of 12mm aggregate (specific gravity-2.80) has been used here for this investigation.

Fineaggregate

River sand was used as fine aggregate. The specific gravity and size for fine aggregate was found to be 2.64 and 4.75mm respectively.

Water

For mixing and curing, only pure, impurity-free water was used. Because the ratio of water to cementitious ingredients determines the strength and durability of concrete, only pure water free of contaminants was used for mixing and curing. Throughout the experiment, the pH of the water was kept between 6.5 and 7.5.

Fibre

Chopped glass fibre is the fibre used here and aspect ratio for glass fibre is 0.67. The specific gravity of this fibre is of 0.8 to 1.

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MixProportion

Mix design as per IS: 10262-1982 [22]. All the samples were prepared using designed mix. Design for the M25 (25N\mm^2) grade concrete was done based as I.S code method. Table 3 presents the mix proportions that have been used in this experiment.

Table 3. Mix Proportions

Ingredients	Unit	Quantity
Water	Liter	185.580
Cement	kg/m^3	412.400
Fine aggregate	kg/m^3	446.600
Coarse aggregate	kg/m^3	1320.940

Mixing

All of the components were hand mixed at room temperature in the laboratory. Chopped AR glass fibre – 2–3% by weight for premixed, 4–6% for spray–up. 5 percent acrylic solids by weight of cement in acrylic polymer emulsion At 10 to 25% cement replacement, sand: cement equals roughly 1:1 pozzolana (VCAS).

Admixtures

For face coat and pourable (self–consolidating) back coat, use a superplasticizer (high–range water reducer, such as a polycarboxylate). The mixed concrete is poured into the mould in such a way that no segregation occurs. A tamping rod was used to ensure proper compaction.

CuringProcess

The cement mixture builds strength in glass fibre reinforced concrete by maintaining the correct moisture in temperature, similar to the process in conventional concrete. For the first 24 to 48 hours after moulding, all test specimens must be stored under conditions that are representative of the concrete in the structure or pavement.The specimen can be sent to the laboratory for further curing and testing after the initial cure time. A minimum of 95% humidity and a temperature of 73.4 3°F (230.94°C) are required for laboratory curing.

Discussion of Testresults

Based on the results of the experiment, it was determined that adding glass fibre to concrete reduces bleeding. Reduced bleeding increases the integrity of concrete, improves its homogeneity, and minimizes the probability of cracks forming in areas where settlement is restricted.

Compressivestrength

Compressive strength of cube with addition of 0.5% & 1% glass fibre with results are tabulated below in Table 4 and Table 5.

Table 4. Compressive Strength (Normal concrete)

No of days	Sample A (N/mm^2)	Sample A ((N/mm^2)	Sample A (N/mm^2)	Average (N/mm^2)
7	13.130	13.250	13.180	13.240
14	20.190	20.980	20.690	20.960
28	27.640	27.800	27.680	27.770

Table 5. Compressive Strength (Fibre inclusion)

% of fibre added	No of days	Compressive strength (Average)
0.5	3	15.910
	7	21.650
	28	31.010
1	3	18.870
	7	22.990
	28	32.560

Flexuralstrength

Flexural strength of beam with addition of 0.2% & 0.3% glass fibre with results are tabulated below in Table 6, and Table 7 shows the final results of compressive and flexural strength.

Table 6. Flexural strength

%of Fibre Added	No of Days	Sample A (N/Mm^2)	Sample B (N/Mm^2)	Sample C (N/Mm^2)	Average
0.5	7	0.310	0.129	0.125	0.128
	14	0.227	0.217	0.224	0.243
	28	0.586	0.589	0.622	0.604
1	7	0.153	0.158	0.156	0.156
	14	0.269	0.227	0.272	0.282
	28	0.618	0.624	0.630	0.624

Table 7: Final Results

% of Fibre Added	No of Days	Compressive Strength (N/mm²)		Flexural Strength (N/mm²)	
		Without Glass Fibre	With GlassFibre	Without Glass Fibre	With Glass Fibre
0.5	7	13.240	15.910	0.090	0.128
	14	20.960	21.650	0.194	0.243
	28	27.770	31.010	0.512	0.604
1	7	13.240	18.870	0.090	0.156
	14	20.960	22.990	0.194	0.282
	28	27.770	32.560	0.512	0.624

Graph

A graph is drawn for above compressive and flexural strength in such a way that the strength is taken in differently.Fig .1 and Fig .2 shows compressive and flexural strength.

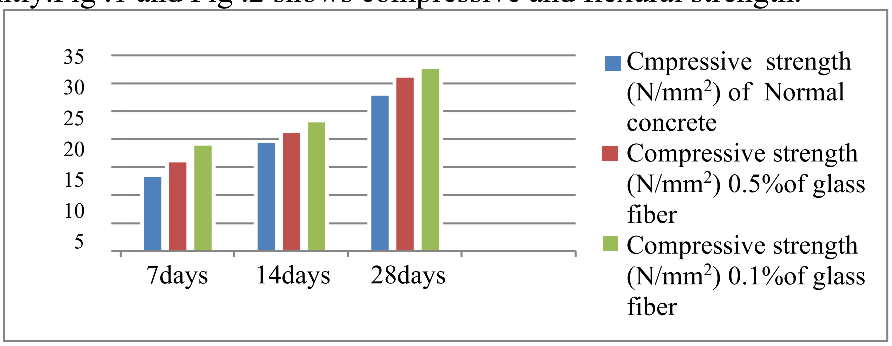

Fig 1. Compressive strength

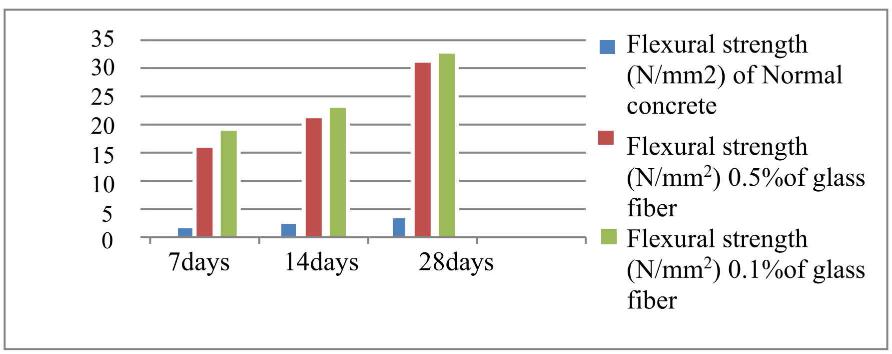

Fig 2. Flexural strength

Conclusion

In this analysis, compressive and tensile strength of concrete with glass fibre are studied and it is concluded as follows

- Adding glass fibre to concrete has made them more workable than conventional concrete.
- The compressivestrength of concrete with 0.5% of glass fibre for 7 days is 15.910N/mm^2, 14 days is21.650N/mm^2 and 28 days is 31.010N/mm^2.
- The compressivestrength of concrete with 0.1% of glass fibre for 7 days is 18.870N/mm^2,

14 days is22.990 N/mm^2 and 28 days is32.560N/mm^2.

- The flexural strength of concrete with 0.5% of glass fibre for 7 days is 0.128N/mm^2, 14 days is0.243N/mm^2 and 28 days is 0.604 N/mm^2.
- The flexural strength of concrete with 0.1% of glass fibre for 7 days is 0.156N/mm^2, 14 days is0.282N/mm^2 and 28 days is 0.624N/mm^2.
- In addition of 0.5% and 1.0% of glass fibre in concrete efficiently increases the compressive and flexural strength of concrete.
- Compressive and flexural strength increases with increasing the curing days.
- Hence concrete with 0.5% and 1.0% of glass fibre is efficient to resist the loads when compared with conventional concrete without any addition of admixtures.

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