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Analysis of Effect of Glass Fibre on Strength of Concrete

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***Abstract**: As we all know in modern-day construction, concrete is a conventional building material used for its properties to withstand high compression, ease to handle and display high durability in rough environmental conditions.*
Normal concrete has various desired properties but it has major flaws like low tensile strength, less ductility and it contains soluble salts. Soluble salts further become the cause for efflorescence. To overcome these insufficiencies we are using glass fibre mixed with normal concrete to increase its tensile strength, ductility and fire resistance.
Glass Fibre Reinforced Concrete (GFRC). Glass fibre is mixed with normal concrete mix in proportion to provide more tensile strength to the concrete. Glass fibre is used with concrete as it displays excellent compatibility with concrete and yields high strength in the final product. Glass fibre is mixed with normal concrete in different doses of glass fibre 1%, 1.5% and 2.5% by weight of concrete, no admixture is used to enhance workability. Standard sized cubes and beams of glass fibre reinforced concrete was casted as per Indian Standard Code and tested for compressive strength and flexural strength for 7 days, 14 days and 28 days and then results were compared with the strength of cubes and beams of normal concrete of M25 grade.
Keywords: Glass Fibre, Glass Fibre Reinforced Concrete, Efflorescence, Compatibility, Admixture, Workability.

I.Introduction

Concrete is the most widely used construction material in the world on construction sites. Concrete is one of the oldest and most common construction materials globally, mainly due to its low cost, availability, long durability, and ability to sustain extreme weather environments. Concrete is the most generally utilized building material and it has low tensile strength, low shear strength, and brittle characteristics. Concrete has a few attractive mechanical properties like durability, stiffness, and high compressive strength. Concrete can be defined as the composite material composed of the binding medium such as the mixture of water, cement, and different fine and coarse aggregates. It may also contain some supplementary cementing materials (SCMs), such as fly ash or slag cement, and chemical admixtures as per adverse conditions. Concrete is weak in tension so to enhance its tensile strength we can use FRC (Fibre Reinforced Concrete). Fibre-reinforced concrete uses e steel Fibres, glass Fibres, synthetic Fibres, and natural Fibres. Glass Fibre Reinforced Concrete is defined as a composite mixture of cement, coarse and fine aggregates, admixtures, and uniformly dispersed glass Fibres. Fibres are usually used in concrete to control drying shrinkage cracking and plastic shrinkage cracking. It also lowers the permeability of concrete and thus reduces the bleeding of water. Some Fibre produces a greater impact on abrasion and shatters resistance on concrete. Fibres with a non-circular cross-section use an equivalent diameter for the calculation of aspect ratio (l/d) where l is the length and d is the diameter. Amount of Fibres mixed with concrete as per volume or by weight of concrete.
The main ingredients of GFRC are given below:
1. Cement
2. Aggregates
3. Water
4. Alkali resists glass fibre
5. Admixture

Cement

Cement is an effective binder material, which is used for construction, which hardens and adheres to other materials to bind them together. The cement should be free from hard lumps, it should give a smooth feeling, be uniform in colour, and be cool inside the cement bag. As per IS 1489 (Part I): the 1991 Portland-Pozzolana Cement has been used. The specific gravity of cement is 2.82 with the help of LeChatelier's Flask method.

Coarse Aggregates:

Coarse aggregates are irregular in shape, size, broken stones, or naturally occurring materials that are used to make concrete. Coarse Aggregates in concrete provide a desired shape and strength to the concrete and act as a filler material which will give the homogeneous mass of the concrete. To be coarse aggregate particles size are larger than 4.75 mm. coarse aggregate should be free from cobbles and boulders. The various other properties of coarse aggregate to be efficient for concrete are durable, hard, strong, chemically inert, and should be free from dust and organic materials. The crushed stone aggregate of size12.5mm to 20mm and of maximum size aggregate of 20mm has been used in the project work having a specific gravity of 2.65.

Fine aggregate

Fine aggregates are generally natural sand particles that are extracted through the mining process, the fine aggregates consist of natural sand or any crushed stone particles that are 4.75cm or smaller. To be a good fine aggregate it should be strong and durable, it should not react with cement, and it should be free from lumps and organic matters. The fine aggregate used in project work has an average size passing through a 4.75mm sieve and retaining a 75-micron sieve. The specific gravity of sand used in project work is 2.6.

Water

The quality of water for construction work is the same as drinking water. As per IS 456:2000, the role of water in the concrete is it reacts chemically with cement; the reaction is called hydration of cement and brings about the setting and hardening of the cement. Water also works as lubricates when the mix with raw materials used for construction purposes and gives it the workability required to place and compact it properly. Water used for mixing in concrete should be free from oil, acids, alkalis, salts, sugars, organic materials, or any other substances that may be not liable to concrete. Generally, it should be of potable quality. The pH value of water for concrete work should be greater than six. The permissible limit of solid particles for construction purposes is given below-

Table 1. Permissible Limits of Solids in Water

S.no.	Type of Solid in water	Permissible Limits for Construction
1	Organic matter	200 mg/l
2	Inorganic matter	3000 mg/l
3	Suspended matter	2000 mg/l
4	Chlorides (Cl)	a) 1000 mg/l for RCC work and b) 2000 mg/l for PCC work
5	Sulphates (SO4)	500 mg/l

Alkali resists glass fibre

GFRC was firstly introduced in the 1940s in Russia, but it was not until the 1970's that the current form came into widespread use. Glass Fibres are formed by melts and manufactured in various compositions by changing the compositions of raw materials like sand for silica, clay for alumina, calcite for calcium oxide, and colemanite for boron oxide. Alkali resists glass Fibres have been prepared by mixing optimum amount of zirconium (ZrO_2) which has alkali resist properties. It is particularly suitable for Premix GFRC and other mortar and concrete reinforcement works. They have high tensile strength and modulus of elasticity, do not rust like steel Fibre, and are easily blended into concrete mixes. Glass fibre work as reinforcement which takes matrix like shape inside the concrete.

They are very high in temperature resistance as they absorb very high energy, thereby providing ductility property. Their lightweight property makes them very popular for concrete mix. 24mm alkali resist glass Fibre has been used in the project work.

Areas use for GFRC are thin sheets, roof tiles, pipes, prefabricated shapes, panels, curtain walls, slabs on grade, and precast elements.

II. LITERATURE REVIEW

Avinash Gornale, et al, in this paper entitled "Strength Aspects of Glass Fibre Reinforced Concrete" (2012): Studied that, the strongest aspect of glass Fibre reinforced concrete. They studied that the increase in compressive strength, flexural strength, and tensile strength for M20, M30, and M40 grades of concrete at 3, 7, and 28 days were observed to be 20% to 30%, 25% to 30%, and 25% to 30% independently after the addition of glass fiber as compared to the plain concrete.

Ravikumar and Thandavamoorthy, in this paper entitled "Glass Fibre Concrete: Investigation on Strength and Fire-Resistant Properties" (2013): Delved into strength and fire-resistant parcels of glass fiber concrete and concluded that when compared to the flexural, compressive, and tensile strength of conventional concrete, with the 0.5% addition of glass fiber, the value increased to 13%, 42%, and 20%. Thus, reinforcing concrete with glass fiber increases its strength by 1.78 times the normal concrete. Hitting the concrete for 2 hours at 300C decreases its compressive strength. The compressive strength of concrete without and with the addition of0.5% and 1% of glass fiber after hitting diminishments to 32%,25%, and 10% to its original strength.

Shrikant M. Harle, in this paper entitled "Review on the Performance of Glass Fibre Reinforced Concrete" (2014): Studied that there is almost 20% to 25 % increase in compressive strength, and flexural and split tensile strength as compared with 28 days of compressive strength of plain concrete. It improves the durability and resistance to acid attacks. Therefore, the GFRC can be used for blast-resisting structures, dams, and hydraulic structures.

Ankur Kumar Mishra et.al, in this paper entitled "Experimental Studies on Compressive and Flexural Strength Characteristics of Glass Fibre Reinforced Concrete" (2015): Studied that the compressive strength of GFRC marginally improved, but there is a significant improvement in the flexural strength. In the case of the addition of glass fiber by volume fraction, there is an increase in both compressive strength and flexural strength of GFRC at 0.33% and 0.66%. But further addition of glass fiber beyond 0.66% the compressive strength and flexural strength of GFRC continuously decreases.

Prof. Anu Retnakar, in this paper entitled "Performance Evaluation of Glass Fibre Reinforced Concrete" (2017): Delved that the addition of glass fibre in plain concrete increases the strength characteristics. Maximum compressive and flexural is attained in 0.4% addition of Glass fiber. Further addition of fiber showed a gradational drop in strength aspects. The plasticity decreases with the addition of glass fiber. But these problems can be solved by using plasticizers or superplasticizers.

Prasad Bishetti et.al, in this paper entitled "Glass Fiber Reinforced Concrete" (2019): Studied that there is a 20.22% increase in the compressive strength when 0.1% GFRC is mixed with the control blend and there is 31.32% increase in the flexural strength when 0.1% GFRC is mixed with the control blend.

Mayur S. Pawar et.al, in this paper entitled "Impact Resistance of Glass Fiber Reinforced Concrete" (2021): Impact resistance of concrete increases with increase in strength of concrete. Normal concrete shows brittle behaviour while glass fiber reinforced concrete shows ductile behaviour under impact loading. Addition of glass fibers into concrete shows significant improvement for first crack impact (N1) at 0.5, 1, 1.5, 2% Vf of glass fiber for both the grades of concrete. Ductility index for both the grades of concrete and for all the volume fractions of glass fibers is nearly similar to that of normal concrete.

III. EXPERIMENTAL PROGRAMME

Materials Used:

Portland Pozzolana Cement:

In this experimental work, Portland Pozzolana Cement (PPC) was used.

Table 2. Properties of Cement

S.No.	Properties	Value
1	Fineness Modulus	6.26
2	Normal Consistency	31
3	Specific Gravity	2.82

Fine Aggregate:

River sand was used as fine aggregate. According to IS: 383-1970 specification sand used.

Table 3.Sieve Analysis of Fine Aggregate

Sieve size	Weight retained(g)	Cumulative percentage weight retained (%)	Cumulative weight retained(g)
4.75mm	0	0	0
2.36mm	56	5.6	56
1.18mm	236	29.2	292
0.6mm	294	58.6	586
0.3mm	240	82.6	826
0.15mm	152	98.6	978
0.075mm	14	99.2	992
Pan	8	100	1000
Total			1000

Coarse Aggregate:

The coarse aggregates used in the experimentation were 20 mm and downsized aggregate and tested.

Table 4. Properties of Coarse Aggregate

S.No.	Properties	Value
1	Impact Value	20.9
2	Specific Gravity	2.65

MIX PROPORTIONS:

Table 5. Mix Proportion

Trial no.	Water (l)	Cement (kg/m3)	W/C ratio **3**	FA(kg/m3)	CA(kg/m3)	Compressive Strength(N/mm2)
1.	186	413	0.45	662.38	1115.22	31.1
2.	191.57	406	0.47	669.09	1098	31.6
3.	197	394	0.5	667.88	1097.53	31.8

Trial 3 is recommended

RESULTS AND DISCUSSIONS:

Workability Test

Slump Test

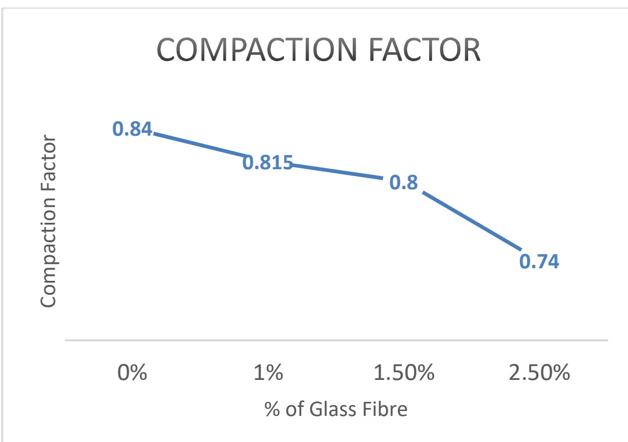
Slump Value is decreasing as we increase fibre content.

Compaction Factor Test

Table 6. Compaction Factor Test

S.no	% Of Glass Fibre	Compaction Factor
1	0%	0.84
2	1%	0.815
3	1.5%	0.80
4	2.5%	0.74

Chart 2. Compaction Factor



Weight Comparison of Cubes

Table 7. Weight Comparison of cubes

S.no	% of glass fibres	Weight of Cubes (kg)	
1	0%	8.1	7.98
		7.9	
		7.96	
2	1%	7.5	7.48
		7.54	
		7.4	
3	1.5%	7.1	7.06
		6.92	
		7.16	
4	2.5%	6.74	6.74
		6.7	
		6.8	

Weight Comparison of Beams

Table 8. Weight Comparison of beams

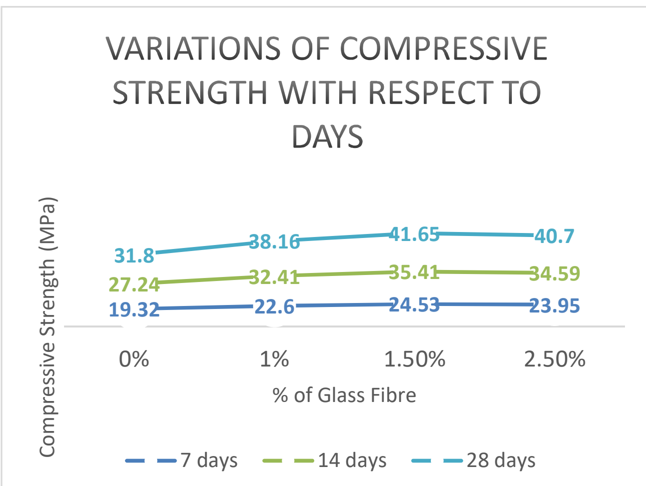
S.no	% of glass fibres	Weight of Beams (kg)	
1	0%	13.6	13.23
		13.2	
		12.9	
2	1%	12.2	12.26
		12.5	
		12.1	
3	1.5%	11.4	11.2
		11	
		11.2	
4	2.5%	10.4	10.36
		10.6	
		10.1	

Compressive Strength Test

Table 10. Compressive Strength

S.no	% of Glass Fibre	Compressive Strength (MPa)		
		7 days	14 days	28 days
1	0%	19.32	27.24	31.80
2	1%	22.60	32.41	38.16
3	1.5%	24.53	35.41	41.65
4	2.5%	23.95	34.59	40.70

Chart 3. Compressive Strength

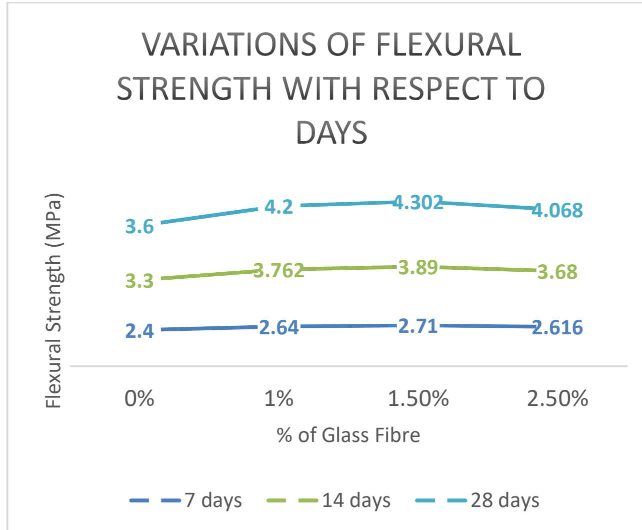


Flexural Strength Test

Table 10. Flexural Strength

S.no	% of Glass Fibre	Flexural strength (MPa)		
		7 days	14 days	28 days
1	0%	2.4	3.3	3.6
2	1%	2.64	3.762	4.2
3	1.5%	2.71	3.89	4.302
4	2.5%	2.616	3.68	4.068

Chart 4. Flexural Strength



IV. CONCLUSION

This project allows us to learn about Glass Fibre Reinforced Concrete at different levels. We have observed an increase in compressive strength and flexural strength for fibre content 1% and 1.5% of glass fibre % by weight of concrete, we have also observed that as we increase % of glass fibre mixed concrete the workability of concrete decreases, from the results we reach to the conclusion that 1.5% by weight of concrete glass fibre content is Optimum Fibre Content for GFRC, and further increase of glass fibre content after OFC the strength of concrete decreases. We also observed as we increase % of glass fibre in the concrete mix the weight of the cubes and beams reduces.

The variation in compressive strength for M25 grade of concrete on comparing 7, 14, and 28 day strength of glass fibre reinforced concrete and normal concrete is as follows

Table.11. Variation in Compressive Strength

S.no	% of glass fibre	Compressive Strength		
		7 day	14 day	28 day
1	1%	+17%	+19%	+23%
2	1.5%	+27%	+30%	+31%
3	2.5%	+24%	+27%	+28%

Compressive Strength is increasing for 1% and 1.5% and gradually starts decreasing from 2.5% of glass fibre content.

The variation in flexural strength for M25 grade of concrete on comparing 7, 14, and 28 day strength of glass fibre reinforced concrete and normal concrete is as follows

Table.12. Variation in Flexural Strength

S.no	% of glass fibre	Flexural Strength		
		7 day	14 day	28 day
1	1%	+10%	+14%	+16%
2	1.5%	+13%	+18%	+19.5%
3	2.5%	+9%	+11.5%	+13%

Flexural Strength is increasing for 1% and 1.5% and gradually starts decreasing from 2.5% of glass fibre content.

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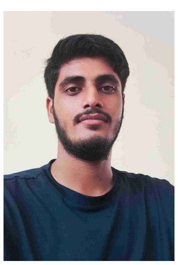

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