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An Experimental Investigation on Strength Properties of Fiber Reinforced Concrete Using Glass Fibers

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Abstract: *Concrete created with Portland cement has bound characteristics: it's comparatively robust in compression however weak in Another elementary weakness of concrete is that cracks begin to create as before long as concrete is placed and before it's properly hardened. These cracks square measure major rationalization for weakness in concrete notably in massive on web site applications leading to succeeding fracture and failure and general lack of sturdiness. Fiber concrete (FRC) may even be outlined as a composite materials created with Portland cement ,aggregate, and incorporating distinct discontinuous fibers. Fiber- concrete (FRC) is concrete containing fibrous material that will increase its structural integrity. additionally, the character of fibre-reinforced concrete changes with variable concretes, fiber materials, geometries, distribution, orientation, and densities. During this experimental investigation, a shot has created to hunt out strength connected tests like Compressive Strength, Split concrete, Flexural Strength exploitation Pure concrete, Glass Fibers with to volume fraction of zero.0%,0.25%,0.5% , 0.75% and I Chronicles and for quantitative relation and regarded for M40 Grade of concrete. The results of the tests showed that the strength properties square measure increased to addition of glass fibers.*

Keywords: Fiber Reinforced Concrete, Glass Fibers, Volume Fraction, Compressive strength, Aspect Ratio, Mechanical Properties

I. INTRODUCTION

Concrete is one in all the foremost common materials utilized within the development trade for many years .Due to property consumption and growth inside the civil below structure systems, there is a raise inside the need of construction materials that square measure designed and used with nearly inside the past few years, several researchers square measure created for the event of performance of concrete in numerous desired characteristics. there is invariably a research for concrete with higher strength and strength .Concrete has comparatively high compressive strength, however a lot of lower permanency .Also, Concrete options a awfully low constant of thermal growth and shrinks as a result of it natures. Concrete is used extensively as a construction material thanks to its skillfulness. it's smart in compression, however weak in tension. This disadvantage square measure usually overcome by providing steel in tension zone.this method referred to as "REINFORCED CEMENT CONCRETE", improves the load carrying capability of concrete members. At a similar time sturdiness of concrete is to boot vital. sturdiness is very affected due to cracks developed by creep and shrinkage. This can be avoided by exploitation bound chemical admixtures. however once a crack develops inside the member there aren't any barriers to stop the propagation of such cracks. In RCC it leads the corrosion of the reinforcement slowly and eventually it results in the failure of the structures. it's now well established that one among the important properties of Fiber ferroconcrete is its superior resistance to cracking and crack propagation. As a results of this ability to arrest crack, Fiber composites possess increased extensibility and lastingness , both initially crack and at ultimate, particular under flexural loading, and therefore the fibers are ready to hold the matrix together even after extensive cracking. However, adding fibers causes relatively little improvement in impact resistance. In an attempt to control the so formed cracks has led to the development of FIBRE REINCORCED CONCRETE (FRC), obtained by dispersing in concrete, very small sized reinforcement called fiber. The small closely

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spaced fibers so used act like crack arresters, substantially improve the static and dynamic strengths. Fiber reinforcement is widely used as the main and unique reinforcing for industrial concrete floor slabs, shot Crete and prefabricated concrete products. The performance required by the FRC so as to achieve in the finished structure the performance that was assumed in the design.

A) Initiative of the Present Analysis

The economic application of any material to field problems demands universal knowledge of its performance under different loads. Therefore, the thorough knowledge of the properties of FRC is quite essential. A lot of work has been carried out on FRC using low strength concrete like M20, M30 etc. A little work has been done on FRC high strength concrete. Here in this work an attempt has been made to bring out certain characteristics of high strength pure concrete and FRC (glass fiber) using different proportions (0.0%, 0.25%, 0.50%,0.75%,1.0%) in M40 grades of concrete. The characteristics studied are compressive strength (cube strength, size of specimen 150mm*150mm*150 mm), split tensile strength (cylinder strength, size of specimen 150 mm diameter and 300mm length) .

II. LITERATURE REVIEW

It is now well established that one among the important properties of fiber ferroconcrete (FRC) is its superior resistance to cracking and crack propagation. As a results of this ability to arrest cracks, fiber composites possess increased extensibility and lastingness , both initially crack and at ultimate, particular under flexural loading; and therefore the fibers are ready to hold the matrix together even after extensive cracking. internet results of these is to impart to the fiber composite pronounced post-cracking ductility which is unprecedented in ordinary concrete. The transformation from a brittle to a ductile sort of material would increase substantially the energy absorption characteristics of the fiber composite and its ability to face up to repeatedly applied, shock or impact loading. Steel fibre ferroconcrete is emerging as a superior construction of fabric than plain cement concrete thanks to its better engineering properties.

The research and development in FRC has been happening since last three decades. Romuldi. J. P. and Batson G.B. are the pioneers who stressed the importance of FRC as a construction material, since then extensive research has been done on various aspects of FRC. a quick review of the important investigations concerned with FRC is presented within the following articles

1. Roger Leinen "An investigation on Steel Fiber ferroconcrete (SFRC) for industrial floors particularly sections without joints and chunks on heaps".
2. Groth, P., ―Fibre Reinforced Concrete—Fracture Mechanics Methods Applied on Self-Compacting Concrete and Energetically Modified Binders,‖ doctoral theory, Department of Civil and Mining Engineering, Division of Structural Engineering, Luleå University of Technology, Luleå, Sweden, 2000, 237 pp.".
3. Nguyen Van CHANH " Experimental and hypothetical examination on steel fiber strengthened cement"

A) Survey on Concrete

Concrete is that the most by and large utilized human-made item inside the World. As opposed to its inside intricacy, adaptability, solidness, and economy, it's been the chief broadly utilized development material with a creation more than six billion tons for each annum . Concrete is utilized to frame asphalts, building structures, establishments, streets, bridges, stopping structures, block/block dividers and bases for doors, fences and posts. Concrete is fundamentally a proportionate blend of total, concrete, and water.

B) Superior Concrete

HFC is an uncommon sort of solid gathering ordinary blend of show and consistency prerequisites that can't generally be accomplished typically utilizing traditional constituents and typical blending, setting, and relieving rehearses. It has high-usefulness, high-quality, and high solidness. The High Performance Concrete guarantees long-term sturdiness in structures when presented to forceful conditions.

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C) High Strength Concrete

From the general standards behind the arranging of high-quality solid blends, it's clear that prime qualities are made conceivable by lessening porosity, in homogeneity, and miniature breaks inside the hydrated concrete glue and the change zone. The usage of fine pozzolanic materials in high quality solid outcomes in a rebate of the components of the translucent mixes, especially, lime .Consequently, there's a markdown of the thickness of the interfacial progress zone in high-quality cement.

D) Fiber Reincorced Concrete

(FRC) acquired by scattering in concrete, minuscule measured support called strands. The little firmly divided strands so utilized act like break arresters, significantly improve the static and dynamic qualities. That is the properties like sturdiness, sway obstruction and solidness under various stacking conditions are improved. In nature the properties of filaments control the properties of FRC composites. Presently, for what reason would we wish to highlight such strands to concrete? Plain, unreinforced cement might be a weak material, with an espresso lastingness and an espresso strain capacity. The function of haphazardly conveys rotating strands is to connect over the splits that create gives some post-breaking pliability. In the event that the strands are adequately solid, adequately attached to material, and grant the FRC to convey noteworthy worries over a moderately huge strain limit in the post-breaking stage. The fiber fortification could likewise be used looking like three – dimensionally arbitrarily dispersed filaments all through the help when the additional focal points of the fiber. The presentation of filaments relies upon both the measurement (kg/m3) and the strands boundaries (rigidities, length, breadth and dock). A key factor for quality fiber is the connection between the length and measurement of the filaments. The higher l/d proportion, the better the presentation.

E) The Properties of FRC

The properties of FRC are largely depended on the effective transfer of stress between the matrix and the fibres. Following factors influence the characteristics and the performance of FRC

- Types of Fibres
- Aspect Ratio
- Fibre Volume and Spacing
- Orientation of Fibres

F) Classifications of Fibers

a) Natural Fibres

The natural fibres like jute, coir, horse hair etc. have got low tensile strength and low elastic modulus. By addition of such fibres static strengths are not improved, while the dynamic properties are improved.

b) Artificial Fibres

The Artificial fibres can be of both low or high tensile strength. For ex. Nylon, Polypropylene, polyethylene have got low tensile strength. Steel, Glass, Carbon have got high strength. The earlier three fibres are suitable for the mains structures as they are lease affected by the corrosion.

i) Steel Fiber
ii) Glass Fiber

c) Glass Fibers

Glass fiber-reinforced concrete uses fiber glass, much like you would find in fiber glass insulation, to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making it stronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fiber does not interfere with

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radio signals like the steel fiber reinforcement does. Glass fiber is made up from 200-400 individual filaments which are lightly bonded to make up a stand. These stands can be chopped into various lengths, or combined to make cloth mat or tape.Using the conventional mixing techniques for normal concrete.

d) Ingredients of Fibre Reinforced Concrete (FRC)

Concrete is used extensively as a construction material because of its versatility. It is good in compression, but weak in tension. This drawback can be overcome by providing steel in tension zone. This technique called "REINFORCED CEMENT CONCRETE".

1. **Cement:** Cements may be defined as adhesive substances capable of uniting fragments or masses of solid mater to a compact whole. Portland cement was invented in 1824 by an English mason, Joseph Aspin, who named his product Portland cement because it produced a concrete that was of the same colour as natural stone on the Isle of Portland in the English Channel.
2. **Fine Aggregate:** River sand passing through 4.75 mm sieve and conforming to grading zone II of IS: 383-1970 was used as the fine aggregate. Normal river sands are suitable for high strength concrete.
3. **Coarse Aggregate:** Crushed granite stone with a maximum size of 20 mm was used as the coarse aggregate. The properties of aggregates used.
4. **Water:** The requirements of water used for mixing and curing shall conform to the requirements given in IS: 456-2000.However use of sea water is prohibited.
5. **Glass Fiber:** Glass fiber is made up from 200-400 individual filaments and each fibers of a length of 25mm. was used at a volume fraction of 0.00%, 0.25%,0.50%,0.75% and 1.00%.

III. METHODOLOGY

This chapter describes the materials used, the preparation of the test specimens and the test procedures. They are listed down in this section.

1. **Materials:** The materials used in this study were cement, sand, aggregates (both fine and coarse) and water. The description of each of the material is described in the following sections
2. **Cement:** Cement used in this study was KCP brand Ordinary Portland Cement of grade 53. The cement was kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to moisture. and various tests were conducted as per code provisions

Characteristics	Test results	IS:12269-1897 specifications
Initial setting time (minutes)	45 minutes	>30 minutes
Final setting time (minutes)	580 minutes	<600 minutes
Consistency	29%	-
Specific gravity	3.15	3.15
Fineness	4.9%	<10%

Table 1

3. **Coarse and Fine Aggregates:** Locally available graded aggregate of maximum size of 20mm is used for our present investigation. Testing of coarse aggregates was done as per IS: 383-1970. The 20mm aggregates used were first sieved through 20 sieve and then retained on 4.75 mm sieve. They were then washed to remove impurities such as dust, clay particles and organic matters thereby dried to surface at dry condition. The coarse aggregate is also tested for its various properties by using IS: 2386-1963

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Property	Test Results	IS 2386-1963 Specifications
Fitness modulus	3.4	--
Specific gravity	2.65	2.6-2.8
Bulk density	1475 kg/m^3 (unrated)	
	1624 kg/m^3 (ridded)	

Table 2

Property	Test Results	IS 2386-1963 Specifications
Fitness modulus	7	--
Specific gravity	2.7	2.6-2.8
Crashing value	22%	<30%
Bulk density	1483 kg/m^3 (unrated)	-
	1563 kg/m^3 (ridded)	-
Abrasive test	34%	40%

Table 3

Synod	Aspect Ratio (DD)	Length if Fiber (mm)
1	100	25

Table 4

4. **Water:** Water is needed for the hydration of cement and to provide workability during mixing and for placing. There is not much limitation for water except that the water must not severely contaminated. In this study, normal tap water was used.
5. **Mix Design: For ordinary concrete**: Mix design for M40
6. **Target Strength**

   Fck = fck + ts (s)

   Fck = target average compressive strength at 28 days, Fck = characteristic compressive strength at 28 days =40 Ma, S=Standard deviation=5 (from Table 1 of IS: 10262:2009) t=1.65 (from Table 2 of IS: 10262:2009).

   Fck = 40+1.65(5) =48.25N/mm^2

MIX PROPORTION

	Mix	Cement	FA	CA	W/C
Ratio	M40	1	1.17	2.30	0.4

Table 5

7. **Mixes Adopted**
   a. Pure Concrete
   b. 0.25%,0.50%,075% and 1.0% of Glass fibers are added to Concrete

IV. Experimental Study

In this section, The test program is intended to comprehend whether the expansion of filaments in high quality concrete and typical quality solid strain solidifying and increment of measure of strands produces indistinguishable upgrade of mechanical properties. Various qualities are dictated by making examples of ordinary blend 0.25%,0.5%0.75% and 1.0% of Glass strands blends and exposing it to loadings until disappointment.

Sr. No.	Concrete Type	% of Fiber Mixed	Slump Value in mm
1	Pure Concrete	0	40
2	Glass Fiber	0.25	38
3		0.50	40
4		0.75	43
5		1.00	48

Table 4: Slump Cone Result

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Figure 1

a) Compressive Strength Test

As per Indian Standard determinations (IS : 516-1959) ,the pressure test on solid shapes of size 150mm X 150 mm X 150 mm were led. Compressive test is the most well-known test directed on solidified cement , halfway in light of the fact that it is a simple test to perform and somewhat in light of the fact that the vast majority of the alluring attributes properties of the solid are subjectively identified with its compressive quality . Metal shape ideally 0.6m long and projectile pointed at the lower end fills in as a packing bar. The test block examples are made when practicable cement with neither isolation nor excessive laitance. The dried examples are then tried on compressive testing machine.

Compression Strength= Load in N / Area in mm ^{2}

Figure 2

Sr. No.	Concrete Type	% of Fiber	3days	7 Days	28 Days
01	Pure Concrete	0.00	42.25	45.33	48.29
02	Glass Fiber	0.25	41.30	43.20	45.21
03		0.50	43.10	45.40	47.25
04		0.75	44.60	46.80	49.50
05		1.00	46.09	47.60	51.08

Table 7: Compressive Strength Test Result

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b) Split Tensile Strength Test

The elasticity is one of the essential and significant properties of the solid. The solid isn't typically expected to oppose the immediate pressure in light of its low elasticity and weak nature. Nonetheless, the assurance of rigidity of cement is important to decide the heap at which the solid individuals may split. The splitting is a type of strain disappointment.

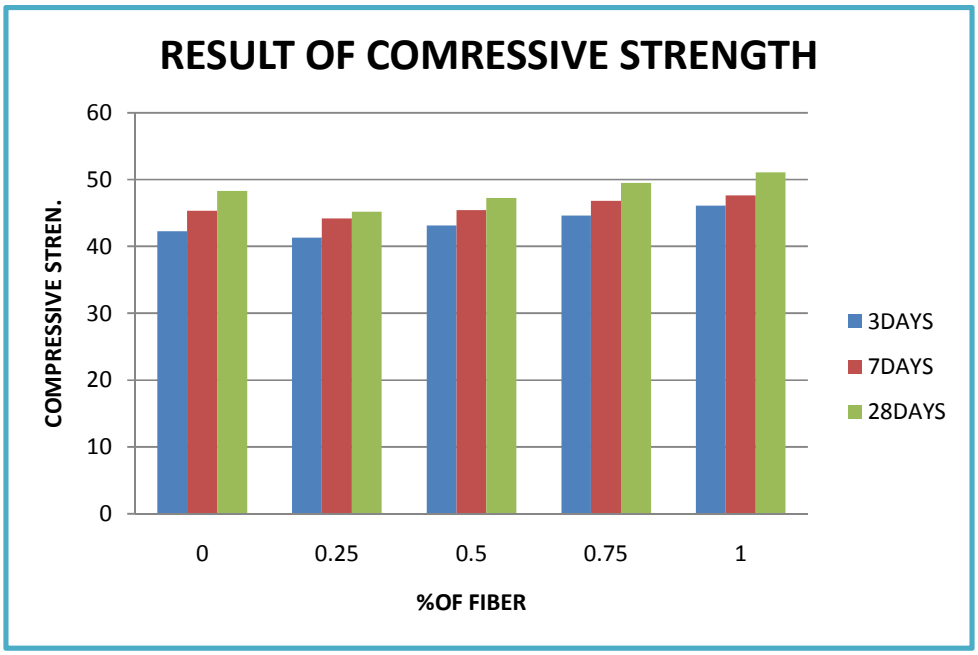
$$Split\ Tensile\ Test,\ Tsp = \frac{2P}{p\ DL}$$

Sr. No.	Concrete Type	% of Fiber	3 Days	7 Days	28 Days
01	Pure Concrete	0.00	2.2	2.5	3.4
02	Glass Fiber	0.25	2.50	2.80	3.00
03		0.50	2.60	3.10	3.50
04		0.75	2.80	3.30	3.60
05		1.00	3.10	3.50	4.10

Table 8: Split Strength Test Result

V. RESULT ANALYSIS

In this chapter, all the strength performance of various mixes containing different percentage of steel fibers and glass fibers will be discussed. All the tests conducted were in accordance with the methods described in this chapter. Different strengths are determined by creating specimens of normal mix(M40),0.25%,0.50%,0.75%and 1.0% of steel fibers and glass fibers mixes and subjecting it to loadings until failure.



Graph No 1

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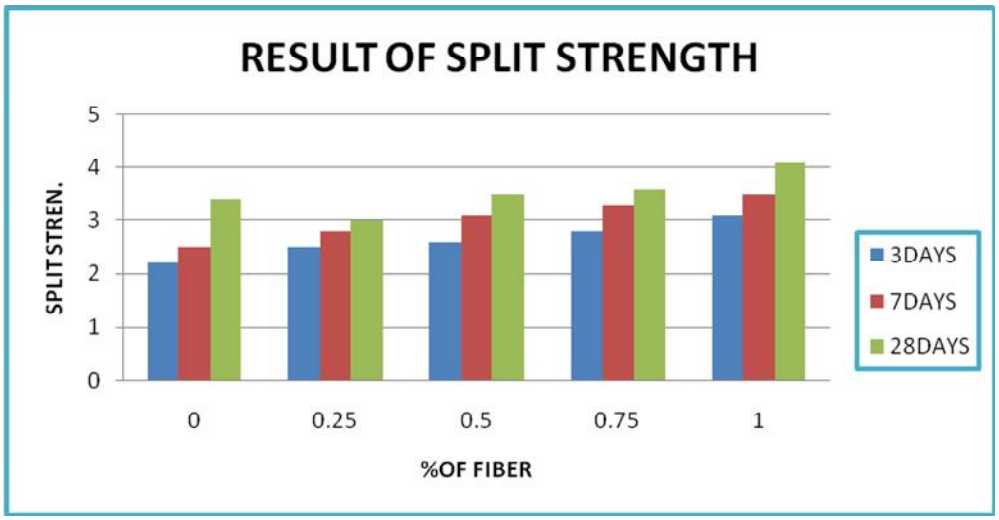

Graph No 2

VI. CONCLUSION

In this investigation we have compared Pure reinforced Concrete(PRC) and Glass Fiber Reinforced concrete(GFRC) with different percentage of fiber are added (0.25%,0.50%,0.75% and 1.0%) age .The final result is Pure reinforced Concrete(PRC) is having more strength than Glass Fiber Reinforced concrete(GFRC).

- In Compressive strength test results the Concrete mix containing 1.0% fibers as maximum improvement of Strength is observed
- In Split Tensile strength test results the Concrete mix containing 1.0 fibers as maximum improvement of 39.9% is observed

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