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Experimental Investigation on Fiber Reinforced Concrete by Addition of Steel Fibers and Glass Fiber

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Abstract – The purpose of this investigation is to find the usefulness of fiber reinforced concrete (FRC) in various civil engineering applications by addition of glass and steel fiber. Fiber reinforced concrete has so far been successfully used in slabs on grade, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. Fiber Reinforced Concrete (FRC) is gaining attention as an effective way to improve the performance of concrete. Fibers are currently being specified in tunneling, bridge decks, pavements, loading docks, thin unbounded overlays, concrete pads, and concretes slabs. These applications of fiber reinforced concrete are becoming increasingly popular and are exhibiting excellent performance. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers this study presents understanding strength of fiber reinforced concrete. Mechanical properties and durability of fiber reinforced concrete.

Key Words: Fibre Reinforced Concrete, synthetic fibre, glass fibre, steel fibre….

1. INTRODUCTION

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone-like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and they finally make the concrete to fail. The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete many attempts have been made. One of the successful and most commonly used method is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until they encounter steel bars. Thus, need for multidirectional and closely spaced steel reinforcement arises. That cannot be practice call possible. Fiber reinforcement gives the solution to this problem so to increase the tensile strength of concrete, a technique of introduction of fibers in concrete is being used. These fibers act as crack arrestors and prevent the propagation of the cracks (glass, carbon, steel, natural, sisal. etc.)

1.1 Glass Reinforced Fibers

Glass fibers were first used to reinforce cement and concrete in Russia. However they were corroded by the highly alkaline Portland cement matrix. Therefore, alkali resistant glass fibers have been subsequently developed in UK and other countries.

Glass fibers are available in the form of continuous roving, chopped strand mats, Wool, ropes and woven fabric. Glass fibers coated with epoxy resin compounds have also been Tried out to protect them from alkali attack by Portland cement.

1.2 Steel Reinforced Fibers

During recent years, steel fiber reinforced concrete has gradually advanced from a new, rather unproven material to one which has now attained acknowledgment in numerous engineering applications. Lately it has become more frequent to substitute steel reinforcement with steel fiber reinforced concrete. The applications of steel fiber reinforced concrete have been varied and widespread, due to which it is difficult to categorize. The most common applications are tunnel linings, slabs, and airport pavements.

2. Objectives

The main objective of this experimental investigation is to study the performance of Steel & Glass Fiber in concrete under variable amplitude loading by varying the percentages of Steel & Glass fiber by the weight of coarse aggregates and cement respectively.

Experimental investigation include the basic tests carried out to check the physical properties of material used and properties of concrete in fresh state like Compaction factor

test, Slump test, Vee-Bee test. Testing on hardened concrete like compressive strength for cubes and split tensile for cylinders is carried out.

3. Physical Properties of Steel Fiber

Length of: Generally the length of the fiber is 30mm, the length of fibers were measured using steel ruler and 10 pieces were randomly chosen to find out the length of steel fiber.
Diameter: Filament diameter 14 microns. Steel fibers are pieces of steel wire from 0.3 to 1.1 mm in diameter
Cross-section: Round, flat, crescent, etc.
Deformations: Straight, wavy, end hook
Length 19-60 mm
Aspect Ratio (length/diameter): 30-100
Tensile strength: 345-1700 N/mm2
Young´s modulus: 205kN/mm2

4. Physical Properties of Glass Fiber

Length: Glass fibers of 10mm to 50mm in length and a few microns in diameter can be added up to 5% by weight and premixed with cement and water in a pan or a paddle mixer.
Material thickness: Typically range from 1/16"to 1/2".
Corner radius 1/8" or larger
Shrinkage: .002in/in
Young's Modulus: 51.7-86.9 GPa
Density: 2.11-2.72 g/cm^3

5. Results and Discussions

This chapter consists of two types of hardened concrete testing. They are compression test and tensile test. All the procedure used was according to the Indian Standard Code. Experiments were conducted on normal concrete and modified concrete by addition of steel & glass fiber with varying percentages of 0.5%, 1.5%, 1% & 2% by weight of cement

5.1 Compressive Strength

Compressive strength of concrete can be defined as the measured maximum resistance of a concrete to axial loading. Compression test is the most common test used to test the hardened concrete specimens because the testing is easy to make. The strength of the concrete specimens with different percentage of fibers can be indicating through the compression test.

Table -1: Compressive strength for 7 days

Specimen	W/C Ratio	% steel fiber	% glass fiber	Total % of fiber	Compressive Strength (7 days)
1.	0.5	0	0	0	8.76
2.	0.5	0.25	0.25	0.5	9.40
3.	0.5	0.5	0.5	1	10.51
4.	0.5	0.75	0.75	1.5	12.38
5.	0.5	1	1	2	11.2

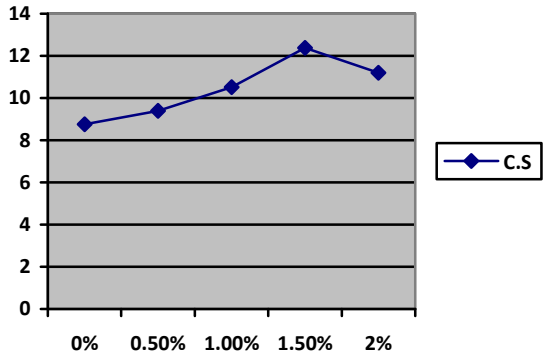

Chart -1: Compressive Strength

The value obtained for 1.5% and water cement ratio 0.5 yielded highest results for compressive strength. However, the compressive strength decreased on the increase in fiber addition. Therefore there is an optimum value of fiber to cement ratio, beyond which the compressive strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fiber.

Table 2- Compressive strength for 28 days.

Specimen	W/C Ratio	% of steel fiber	% of glass fiber	Total % of fiber	Compressive Strength (28 Days)
1.	0.5	0	0	0	9.5
2.	0.5	0.25	0.25	0.5	10.12
3.	0.5	0.5	0.5	1	16.85
4.	0.5	0.75	0.75	1.5	18.65
5.	0.5	1	1	2	16.9

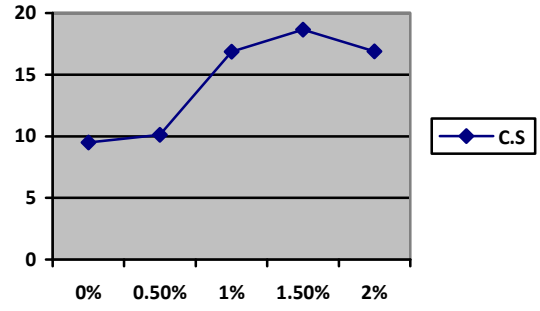

Chart 2: Compressive Strength

From the graph it is seen that when fibre content is increased there is an increase in tensile strength with a maximum at 1.5% fiber. However when the fiber content is increased beyond this value a downward slope of the graph is observed

5.2 Split Tensile Strength

Split tensile strength tests were conducted on standard cylinders of dimension 15cm diameter and 30cm depth, specimens each for plain concrete, Steel & glass fiber reinforced concrete were cast at varying percentages of RCA (0%, 0.5%, 1%, 1.5%, and 2%).For each case7 &28days strength values were obtained by loading under a compression testing machine.

Table 1: Split Tensile Strength for 7 days

Specimen	W/C Ratio	% of Steel fiber	% of Glass Fiber	Total % of Fiber	Tensile Strength (7 Days)
1.	0.5	0	0	0	2.131
2.	05	0.25	0.25	0.5	2.344
3.	0.5	0.5	0.5	1	2.557
4.	0.5	0.75	0.75	1.5	2.770
5.	0.5	1	1	2	2.599

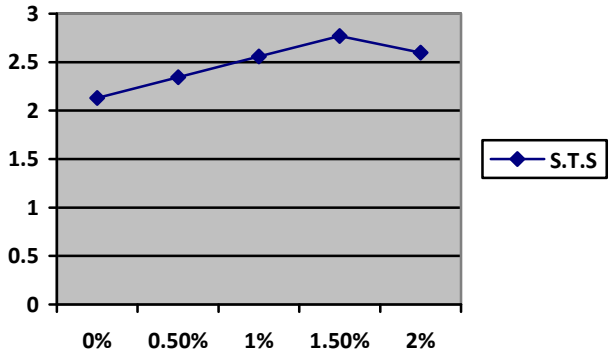

Chart 1: Split Tensile Strength

Table 2: Split Tensile Strength for 28 Days

Specimen	W/C Ratio	% of Steel Fiber	% of Glass Fiber	Total % of Fiber	Tensile Strength (28 days)
1.	0.5	0	0	0	2.15
2.	0.5	0.25	0.25	0.5	2.46
3.	0.5	0.5	0.5	1	2.62
4.	0.5	0.75	0.75	1.5	2.88
5.	0.5	1	1	2	2.93

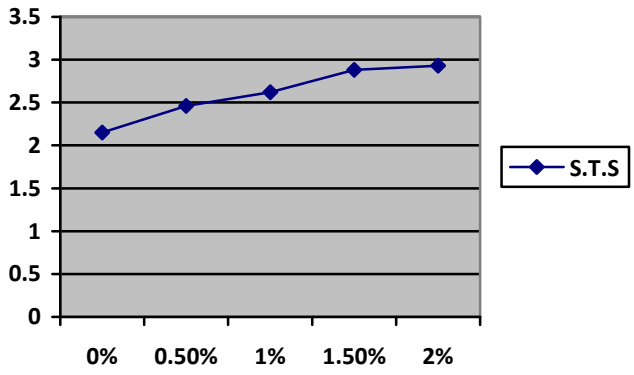

Chart 2: Split Tensile Strength

The value obtained for 2% addition of fiber and water cement ratio 0.5 yielded highest results for tensile strength. However, the tensile strength decreased on the increase in Fiber addition. Therefore there is an optimum value of Fiber to cement ratio, beyond which the tensile strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fiber content was taken as 2%.

3. CONCLUSIONS

Experimental works on the use of glass fibers and steel fibers have proven that good quality concrete could be produced with glass fibers and steel fibers. Based on the experimental investigation reported in the work, the Following conclusions are drawn:

- The workability of glass fibers and steel fiber concrete mix is satisfactory compare to natural aggregate, concrete mix with 2% steel fibers and 1% glass fibers has satisfied workable concrete.
- The glass fibers concrete has a convenient compressive strength and appreciable improvement in tensile strength, which means it, can be convenient for structural elements in concrete structures.
- Although glass fibers can be applied in the high strength concrete structure, but one issue must not be neglected as glass fibers with reduce water content would have low workability. Whenever glass fibers is used, water content in the concrete mix has to be monitored carefully.

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