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A Comparative and Experimental Study on the Mechanical Properties of Various Steel and Glass Fiber Reinforced High Strength Concrete

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ABSTRACT:

Cement concrete is the most extensively used construction material in the world. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of hooked steel, crimped steel& glass Fiber Reinforced Concrete is its superior resistance to cracking and crack propagation. Concrete is most widely used construction material in the world. Fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like steel, G.I., carbon, glass, aramid, asbestos, polypropylene, jute etc. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. FRC has found many applications in civil engineering field.

Based on the laboratory experiment on fiber reinforced concrete (FRC), cube and cylinders specimens have been designed with steel fiber reinforced concrete (SFRC) and Glass fiber reinforced concrete (GFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85, 50 aspect ratio and alkali resistant glass fibers containing 0% and 0.25% by weight of cement of 12mm cut length were used without admixture In this paper effect of fibers on the different mechanical properties of grade M 80 have been studied. It optimizes 1.5% for steel Fiber content and 1% for glass fiber content by the volume of cement is used in concrete. The percentage increase in compressive strength at 28 days for hooked end steel fiber when compared to conventional concrete is 7.3% , crimped steel fiber with 6.08%, glass fiber with 4.3. The percentage increase in split tensile strength at 28 days hooked end steel fiber when compared to conventional concrete is 4.54%, crimped steel fiber with 3.40%, glass fiber with 2.27% and also The percentage increase of flexural strength at 28 days for hooked end steel fiber when compared to conventional concrete is 3.57%, crimped steel fiber with 2.380%, glass fiber with 2.140%.

Keywords:

Steel fiber reinforced concrete (SFRC) and Glass fiber reinforced concrete (GFRC), High strength concrete, M-80 Grade, IS:1386, IS:383.

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 the finally makes 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 methods is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encounter ring are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible. Fibre reinforcement gives the solution for this problem. So to increase the tensile strength of concrete a technique of introduction of fibres in concrete is being used.

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These fibres act as crack arrestors and prevent the propagation of the cracks. These fibres are uniformly distributed and randomly arranged. This concrete is named as fibre reinforced concrete. The main reasons for adding fibres to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption Fibre Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibres.

Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres FRC increases the tensile strength of the concrete, it reduce the air voids and water voids the inherent porosity of gel. It increases the durability of the concrete. Fibres such as graphite and glass have excellent resistance to creep. The addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. Fibre reinforced concrete is in use since many years in India, but the structural applications are very much limited. However, its application is picking up in the recent days.

2. FIBRE REINFORCED CONCRETE:

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. So we can define fibre reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed fibre. Fibre is discrete material having some characteristic properties. The fibre material can be anything. But not all will be effective and economical. Some fibres that are most commonly used are:

• Steel • Glass • Carbon
• Natura l• NBD

Steel fibre is one of the most commonly used fibre. Generally round fibres are used. The diameter may vary from 0.25 to 0.75mm.The steel fibre sometimes gets rusted and lose its strength. But investigations have proved that fibres get rusted only at surfaces. It has high modulus of elasticity. Use of steel fibres makes significant improvements in flexure, impact and fatigue strength of concrete. It has been used in various types of structures. Glass fibre is a recently introduced fibre in making fibre concrete. It has very high tensile strength of 1020 to 4080Mpa. Glass fibre concretes are mainly used

3.PROPERTIES OF FIBRE REINFORCED CONCRETE:

Properties of concrete are affected by many factors like properties of cement, fine aggregate, coarse aggregate. Other than this, the fibre reinforced concrete is affected by following factors:

• Type of fibre
• Aspect ratio
• Quantity of fibre
• Orientation of fibre

3.1 Type of Fibre:

A good fibre is the one which possess the following qualities:

• Good adhesion within the matrix.
• Adaptable elasticity modulus (sometimes higher than that of the matrix)
• Compatibility with the binder, which should not be attacked or destroyed in the long term
• An accessible price, taking into account the proportion within the mix
• being sufficiently short, fine and flexible to permit mixing, transporting and placing
• Being sufficiently strong, yet adequately robust to withstand the mixing process.

3.2 Aspect ratio:

Aspect ratio is defined as the ratio of length to width of the fibre. The value ofaspect ratio varies from 30 to 150. Generally the increase in aspect ratio increases the strength and toughness till the aspect ratio of 100. Above that the strength of concrete decreases, in view of decreased workability and reduced compaction. From investigations it can be found out that good results are obtained at an aspect ratio around 80 for steel fibres. Keeping that in view we have considered steel hooked end fibres with aspect ratio of 80 (Length 60 mm and Diameter 0.75 mm).

3.3 Fibre quantity:

Generally quantity of fibres is measured as percentage of cement content. As the volume of fibres increase, there should be increase in strength and toughness of concrete. Regarding our fibre, we hope that there will be an increase in strength, with increase in fibre content.We are going to test for percentages of1.0, 2.0 and 3.0.

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3.4 Orientation of fibre:

The orientations of fibres play a key role in determining the capacity of concrete. In RCC the reinforcements are placed in desired direction. But in FRC, the fibres will be oriented in random direction. The FRC will have maximum resistance when fibres are oriented parallel to the load applied.

3.5 Bridging Action:

Pullout resistance of fibres (dowel action) is important for efficiency. Pullout strength of fibres significantly improves the post-cracking tensile strength of concrete. As an FRC beam or other structural element is loaded, fibres bridge the cracks. Such bridging action provides the FRC specimen with greater ultimate tensile strength and, more importantly, larger toughness and better energy absorption. An important benefit of this fibre behavior is material damage tolerance. Bayasi and Kaiser (2001) performed a study where damage tolerance factor is defined as the ratio of flexural resistance at 2-mm maximum crack width to ultimate flexural capacity. At 2% steel fibre volume, damage tolerance factor according to Bayasi and Kaiser was determined as 93%.

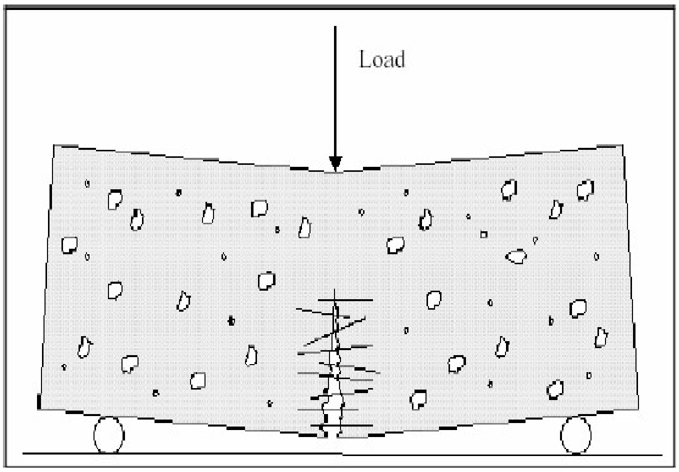

Fig:1 Pullout Mechanism

3.6 Workability;

A shortcoming of using fibres in concrete is reduction in workability. Workability of FRC is affected by fibre aspect ratio and volume fraction as well the workability of plain concrete. As fibre content increases, workability decreases. Most researchers' limit volume of fibres to 4.0% and aspect ratio to 100 to avoid unworkable mixes.

In addition, some researchers have limited the fibre reinforcement index [volumeof fibres as % ×aspect ratio] to 1.5 for the same reason. To overcome the workability problems associated with FRC, modification of concrete mix design is recommended. Such modifications can include the use of additives.

4. EXPERIMENTAL INVESTIGATION:

The materials used in the experimental investigation are locally available cement, sand, coarse aggregate, mineral and chemical admixtures. The chemicals used in the present investigation are of commercial grade.

4.1 STEEL FIBRES:

Steel fibre-reinforced concrete (SFRC) is concrete (spray concrete) with steel fibres added. It has higher tensile strength than unreinforced concrete and is quicker to apply than weldmesh reinforcement. It has often been used for tunnels.

•Addition of steel fibers into the concrete improves the crack resistance (or ductility) capacity of the concrete. Traditional rebars are generally used to improve the tensile strength of the concrete in a particular direction, whereas steel fibers are useful for multidirectional reinforcement. This is one of the reasons why steel fiber reinforced (shotcrete form) concrete successfully replaced weldmesh in lining tunnels.
•Less labour is required.
•Less construction time is required

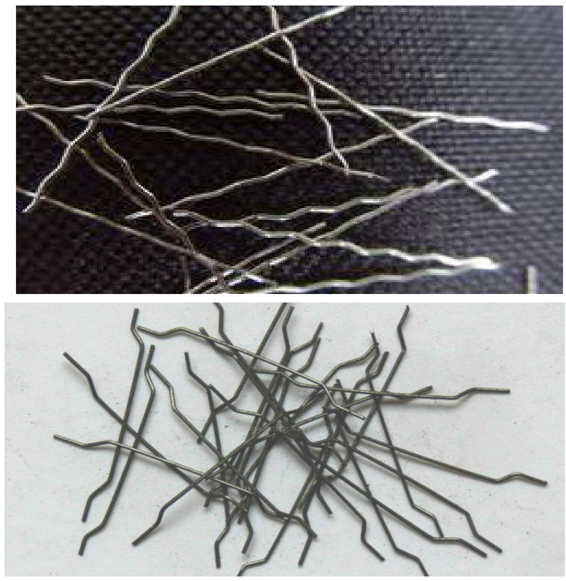

Fig:2 crimped and hooked steel fibres

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4.2 GLASS FIBRES:

Glass fiber reinforced concrete, also known as GFRC or GRC, is a type of fiber reinforced concrete. Glass fiber concretes are mainly used in exterior building façade panels and as architectural precast concrete. Somewhat similar materials are fiber cement siding and cement boards. The photograph of glass fibres is shown in Fig. 3.

Fig:3 Glass fibre

4.3 INITIAL TESTS:

Material test	Result
Specific gravity of cement	3.12
Specific gravity of fly ash	2.24
Specific gravity of silica fume	2.21
Specific gravity of coarse aggregate	2.74
Specific gravity of fine aggregate	2.7
Slump cone test	2 inches
Dry rod unit weight of fine aggregate	107.7 lb/ft^3
Dry rod unit weight of coarse aggregate	101 lb/ft^3
Initial and final setting time	96 min &207 min

Table: 1 Initial Tests

4.4 MIX PROPORTION:

Cement	Fly Ash	Silica Fume	Fine Aggregate	Coarse Aggregate	Water	Super Plasticizer
1	0.28	0.28	1.38	2.38	0.23	0.01

Table: 2 Mix Proportions

5. TESTING OF SPECIMENS:

Different tests were conducted on the specimens to determine and compare the mechanical properties between crimped steel fibres, hooked steel fibres and glass fibres.

5.1 COMPRESSIVE STRENGTH:

Fig: 4 Cube specimens under test

Sl no	cubes casted day	Conventional concrete (N/mm^2)	Hooked end steel fiber (N/mm^2)	Crimped steel fiber(N/mm^2)	Glass fiber(N/mm^2)
1	3rd day	27	31.75	29.3	29
2	7th day	44	48	46.4	49
3	28th day	69	74	73.2	72

Table: 3 Compressive strength results

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5.2 FLEXURAL TEST:

Fig: 5 Flexural beam specimens under test.

Sl no	Beams casted day	Conventional concrete	Hooked end steel fiber	Crimped steel fiber	Glass fiber
1	3rd day	3.7	4.6	4.2	4.1
2	7th day	6.7	7.2	6.8	7
3	28th day	8.4	8.7	8.6	8.5

Table: 4 Flexure test results

5.3 SPLIT TENSILE TEST:

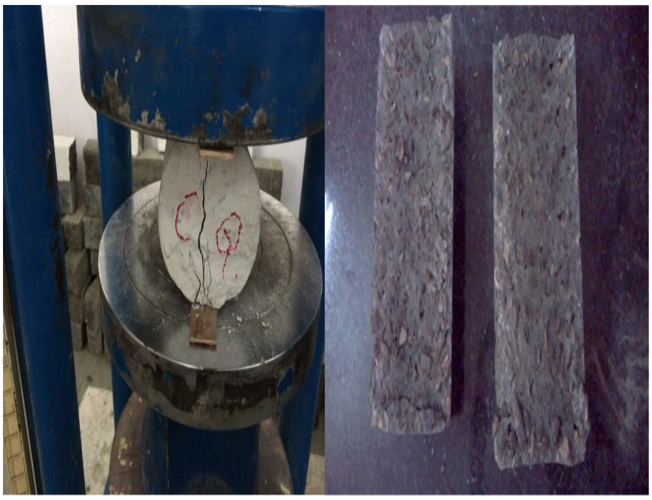

Fig: 6 Cylinder specimens under test

Sl no	Cylinders casted day	Conventional concrete (N/mm^2)	Hooked end steel fiber (N/mm^2)	Crimped steel fiber (N/mm^2)	Glass fiber (N/mm^2)
1	3rd day	1.9	2.6	2.4	2.3
2	7th day	5.2	5.7	5.3	5.5
3	28th day	8.8	9.2	9.1	9

Table: 5 Split Tensile Strength results

CONCLUSIONS:

The present study is about using different fibres i.e., crimped steel fibres hooked steel fibres and glass fibres after optimising them; comparison is made between the three fibres for different mechanical properties

•The increasing percentage of compressive strength of hooked end steel fiber reinforced concrete cubes when compared to the conventional concrete cubes at 28 days is 7.3%.And the increasing percentage of compressive strength of crimped steel fiber reinforced concrete cubes when compared to the conventional concrete cubes at 28 days is 6.08%.And The increasing percentage of compressive strength of hooked end steel fiber reinforced concrete cubes when compared to the conventional concrete cubes at 28 days is 4.34%.

•The increasing percentage of split tensile strength of hooked end steel fiber reinforced concrete cylinders when compared to the conventional concrete cylinders at 28 days is 4.54%.And the increasing percentage of split tensile strength of crimped steel fiber reinforced concrete cylinders when compared to the conventional concrete cylinders at 28 days is 3.40%.And The increasing percentage of compressive strength of hooked end steel fiber reinforced concrete cylinders when compared to the conventional concrete cylinders at 28 days is 2.27%.

•The increasing percentage of flexural strength of hooked end steel fiber reinforced concrete beams when compared to the conventional concrete beams at 28 days is 3.57%. And the increasing percentage of flexural strength of crimped steel fiber reinforced concrete beams when compared to the conventional beams at 28 days is 2.380%.

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And The increasing percentage of flexural strength of glass fiber reinforced concrete beams when compared to the conventional concrete beams at 28 days is 2.140%.

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