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Experimental Study on Mechanical Properities of High Strength Concrete Using Hybrid Fibres

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ABSTRACT
The aim of this study is first to develop hybrid fibre reinforced concrete (HFRC) and then to characterize and quantify the benefits obtained by the concept of hybridization. Hybrid composites were cast using two fibres namely Glass and Steel of different fibre proportions i.e., 0.5%, 1%, 1.5% and 2% in M50 grade of mix. Compressive test and split tensile strength were performed and results were extensively analyzed to associate with above fiber combinations.

Keywords
Silica fume, Glass fibre and Steel Fibres.

1. INTRODUCTION
Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cemetitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. Concrete has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Plain concrete has two deficiencies, low tensile strength and a low strain at fracture.

Normally reinforcement consists of continuous deformed steel bars or pre-stressing tendons. Plain concrete possess very low tensile strength, limited ductility and little resistance to cracking .Internal micro cracks are inherently present in concrete and its poor tensile strength is due to propagation of such micro cracks.

Fibers when added in certain percentage in the concrete improve the strain properties well as crack resistance, ductility, as flexure strength and toughness. Mainly the studies and research in fiber reinforced concrete has been devoted to steel fibers. In recent times, glass fibers have also become available, which are free from corrosion problem associated with steel fibers.

2. HYBRID FIBRE REINFORCED CONCRETE
The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mixture. Different types of fibers, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibres help to transfer loads at the Internal micro cracks. Such a concrete is called fibre-reinforced concrete (FRC), the FRC in which Steel fibers are used is called Steel fibre-reinforced concrete (SFRC).

The one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading.

In recent times, glass fibre reinforced concrete (GFRC) has also become available, which are free from corrosion problem associated with steel fibres. Largest application for steel fiber reinforced concrete is floor slab construction, although it's use as a replacement for or complement to structural reinforcement in other applications is growing fast. Steel fiber floor/slab applications can save money when compared to other reinforcing systems. In addition, joint spacing can be increased and they can be used as a replacement for structural reinforcement in some cases.

2.1. Silica Fume Concrete
The supplementary cemetitious materials such as silica fume, fly ash and ground granulated blast furnace slag are more commonly used mineral admixtures in the development of high performance concrete (HPC) mixes. They generally used to resist compressive forces and also due to its pozzolanic action the properties of High Performance Concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved. Silica Fume is most commonly used supplementary cemetitious materials used in the development of High Performance Concrete. Silica fume (SF) is a by-product of the smelting process in the silicon and ferrosilicon industry. It is also known as micro silica, condensed silica fume, volatilized silica or silica dust. Silica fume colour is either premium white or grey.

Silica Fume consists of very fine vitreous particles with a surface area between 13,000 and 30,000 m^2/kg. Its particles are approximately 100 times smaller than the average cement particle. Because of its extreme fineness and high silica content, silica fume is a highly effective pozzolanic material. Silica fume is used in concrete to improve its properties. It has been found that silica fume improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion. When Silica fume are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete.

2.2. Objectives

Primary objective of the study is to investigate the mechanical properties by combination of glass and steel fibers. Increase the strength parameters by increasing flexural and shear toughness with increased fiber content while workability decreases with an increase in fiber content. To compare the conventional concrete with composite fiber concrete and to study the behavior of Steel Fiber Reinforced Concrete with addition of silica fume.

3. LITERATURES

S.T. Tassew, et al (2014), The Mechanical properties of glass fibre reinforced ceramic concretes. Concretes included either sand or light weight aggregate and up to 2% fibers by volume. The addition of glass fiber into ceramic concrete had the little influence of compressive strength and modulus of elasticity. But there is a significant increase in flexural strength and direct shear strength. Hence compression, flexural and shear toughness is increased in the increase of fiber content.

Gum Sung, et al (2014), The Effect of shrinkage reducing agent on pullout resistance of high strength steel fibers embedded in ultra-high performance concrete ,cement and concrete properties 49 (2014)Blending of long and short fibers in a cement based matrix can provide the tensile strength and ductility. Ultra-high performance concretes provide very high compressive strength and are potentially highly durable. It may have the brittle failure and tendency for high shrinkage. Some shrinkage reducing agent or expansive agent has been added to compensate the amount of matrix shrinkage.

Su Tae kang, et al (2011), The Effect of fiber distribution characteristics on the on the flexural strength of steel fiber reinforced ultra-high strength concrete. Flexural tests were carried out to quantify the effect of fiber distribution characteristics on flexural strength. Steel fiber reinforced ultra-high strength concrete has effect of flexural strength. Fiber distribution characteristics were dependent on the direction of placing.

H.S. Shi, et al (2009), The Correlations among mechanical properties of steel fiber reinforced concrete Correlations among compressive strength, split tensile strength and flexural strength of normal concrete, polypropylene fiber reinforced concrete and glass fiber reinforced concrete to steel fiber reinforced concrete is evaluated. The steel fibers of aspect ratio (55-80), water binder ratio (0.25 - 0.5) and volume fractions (0.5-2.0%) are used.

J -Y. Lee, et al (2008), The Interfacial bond strength of glass fiber reinforced polymer bars in high strength concrete .The main parameter is the compressive strength of concrete and the type of rebar used. Interfacial bond strength of glass fiber reinforced polymer increased the compressive strength of concrete used. The Bond failure of steel bar was caused by concrete crushing against the face of ribs. Hence the increasing rate of bond strength of glass fiber reinforced polymer bar with respect to concrete strength was much smaller than that of steel bars.

3.1.Review of Literature

Fibre distributions were dependent on direction of placing. So it reduces the flexural strength and cracking effect. The bond strength of glass fiber reinforced polymer bars tent to increase at constant rate as the compressive strength of concrete increased. Long smooth and twisted steel fibers were highly sensitive to reduce shrinkage and higher interfacial bond resistance. Hence flexural, compression and shear toughness all increased with an increase in the fiber content while workability decreased with an increase in fiber content.

3.2.Need for the Research

To increase strength and impact we are introducing composite fiber in the concrete. By the addition of glass and steel fiber there is an increase in the strength of mechanical properties of concrete. Hence the compressive strength, flexural strength, split tensile strength, impact strength are done. The conventional concrete is compared with the glass and steel fiber concrete with varying percentages of (0.5%, 1.0%, 1.5% and 2.0%).

4.MATERIALS USED

4.1 Cement

The cement used for this study is Portland Pozzolanic Cement is conforming to Indian Standard IS 12269 – 1987 of grade 53

4.2 Fine Aggregate

The sand is used as fine aggregate and it is collected from nearby area (zone-II).

The sand has been sieved using 4.75 mm sieve

4.3 Coarse Aggregate

The coarse aggregate is choosen by shape as per IS 2386 (Part I) 1963, surface texture characteritics of aggregate is classified as in IS 383 - 1970.

4.4 Fibres

Table 1 : Fibre properties

Properties	Glass	Steel
Aspect ratio	50	50
Young's modulus(GPa)	80	33-40
Tensile strength (MPa)	2000	350-500

4.5 Specimen Details

- Cube of size 150 × 150 × 150 mm are used for making both conventional concrete and hybrid fibre reinforced concrete Specimens.
- Cylinders of 150 mm diameter and 300 mm height are used for making both conventional concrete and hybrid fibre reinforced concrete Specimens.

5. EXPERIMENTAL STUDY

5.1 Compression Test of Cubes

Compression strength for conventional concrete (28 days) = 53 N/mm^2

Compression strength of M50 grade concrete for 0.5%, 1%, 1.5% and 2% of HFRC is shown in table 2

Table 2: Compression Strength of M50 grade concrete for 28 days

Percentage of fibres	28 days compressive strength(N/mm^2)	
	Types of Fibers	
	Glass	Steel
0.5%	57	59
1%	59	61
1.5%	57	65
2%	54	62

5.2 Split Tensile Test of Cylinder

Split tensile strength for conventional concrete (28 days) = 5.41 N/mm^2

Split tensile test of M50 grade concrete for Hybrid Fibres of HFRC is shown in table 3

Table 3: Split Tensile Strength of concrete for 28 days

Strength	28 days Tensile Strength N/mm^2	
	Dosage of fibre	
	conventional	Hybrid
Tensile Strength	5.41	6.28

5.3 Comparison of Compressive Strength

This graph shows the comparison Compression strength of Conventional concrete and Hybrid fibres is shown in figure 1.

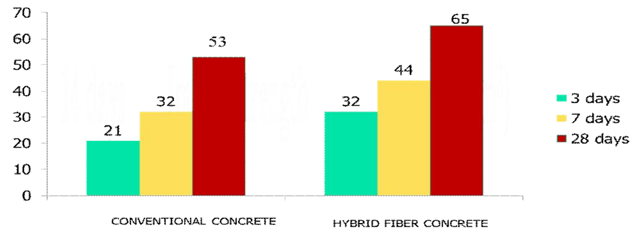

Fig 1 Comparison of 28 days compression strength of Conventional Concrete and hybrid Fibre

5.4 Comparison of Split Tensile Strength

This Graph shows the comparison of 28 days split tensile strength of conventional concrete and 1% of hybrid fibre is shown figure 2.

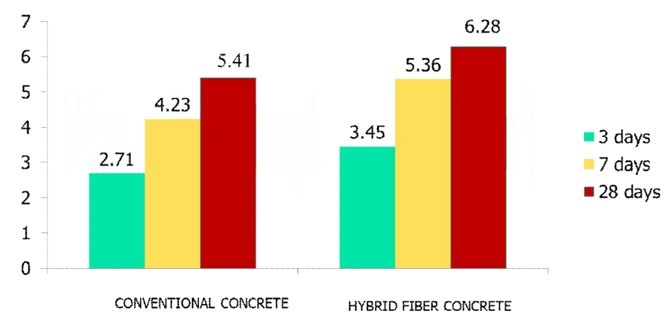

Fig 2 Comparison of 28 days Split Tensile strength of Conventional Concrete and hybrid Fibre

6. CONCLUSION

The experimental investigation on the mechanical behavior of HFRC (glass and steel fibres) for various dosage of fibre was conducted. Properties such as the compression strength and Tensile strength were evaluated from experiments. The experiments lead to the conclusions that with 1% addition of glass fibre increases the compression strength by 1.5% of steel Fibres and tensile strength of Hybrid Fibre Reinforced Concrete increases than conventional concrete.

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