AN EXPERIMENTAL STUDY OF HYBRID FIBER REINFORCED CONCRETE

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Abstract - Concrete has been proved to be a leading construction material for more than a century. Natural aggregates are becoming increasingly scarce and their production andshipment is becoming more difficult. The primary aim of this research was to evaluate the strength of concrete made with HFRC. For the present study M40 grade concrete shall be designed, by adding 0.5%, 1%, 1.5% and 2%.The performance of reinforced Concrete Cube mixing with Hybrid fiber reinforced has been evaluated. The compression behavior of concrete cube and Hybrid fiber reinforced concrete cube arecompared.

The performance of reinforced Concrete Cube mixing with Hybrid fiber reinforced concrete has been evaluated. The compression behavior of cube and cylinder are compared with trial concrete cubes. In this project, the cubes and cylinders are casted and with Steel, Glass fibers. The HFRC and Ordinary specimens (Trial mix concrete cube) are tested after 28days curing period. The ultimate load of Hybrid Fiber cube can be increased up to 35 to 40%. Compression strength of cube is 40N/mm^2 Then the test results obtained from this research have compared with ordinary concrete specimen, Weather HFRC will enhance the strength and other parameters. Keywords: HYRC (Hybrid Fiber Reinforced Concrete), Steel fiber, Glass fiber, Compression strength, Split tensilestrength.

1.0 Introduction

Hybrid fiber-reinforced concrete is a type of fiber reinforced concrete characterized by its composition. Specifically, it contains at least two or more types of fibers of different sizes, shapes or origins. It is well known that cracking in fresh concrete can be effectively inhibited by glass fibers and that different sizes contribute to different mechanicalproperties.

Considering that fibers of different types have different effects on the properties on fresh and hardened concrete, the use of hybrid fibers allows optimization of the properties of fiber reinforced concrete at all levels. Specific fibers retain their individual effects on the properties of fiber reinforced concrete.

Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distribute fibres. (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. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. Steel fibre is one of the most commonly used fibre. Generally round fibres are used. The diameter may varyfrom 0.25 to 1 mm. Glass fibres have very high tensile strength.

In this project, investigating the behavior and flexural strength of hybrid fiber reinforced concrete with partial replacement of cement with Fly ash and Rice husk ash. Two types of fibers such as steel and glass are used. Steel Fibers are added in the order 0.25%, 0.5%, and0.75% by volume of concrete. Glass fibers are added 0.25% by weight of cement. The fibers substitutes are to be used by adding Ordinary Portland Cement by each 20% by weight of cementproportions.

The total replacement level is 40%. Superior properties of concrete can be developed with the help of hybridization concept mainly to increase in flexural strength of concrete. The hybrid fiber reinforced concrete composites specimens are to be tested for mechanical properties and durability related properties. The results are to be compared to the control specimen that contains no fibers and with Cement replacement materials. With the appropriate interpretation of the obtained results, it can be possible to determine the optimum fiberpercentage

2.0 LITERATURE REVIEW

R.Gowri and M.AngelineMary, this study, the present trend in concrete technology is towards increasing the strength and durability of concrete to meet the demands of the modern construction world at lower cost. These factors can be achieved in concrete by adding natural or synthetic fiber. The strength parameters of concrete such as compressive strength and tensile strength were studied by varying the percentage of fiber from 0.025% to 0.075% of the weight ofconcrete.

Machine Hsie et al (2007) Machine Hsie et al investigated the mechanical properties of glass hybrid fiber reinforced concrete. There are two forms of glass fibers including coarse monofilament and staple fibers. The content of the former is at 3 kg/m3, 6 kg/ m3 and 9 kg/ m3 and the content of the latter is at 0.6 kg/ m3.The experimental results show that the compressive strength, splitting tensile strength and flexural properties of the glass hybrid fiber reinforced concrete are better than the properties of single fiber reinforced concrete. Comparing with the strengths of pure concrete, the compressive strength of glass hybrid fiber reinforced concrete increased by 14.60-17.31%, the splitting tensile strength increased by 8.88-13.35%, the modulus of rupture is increased by 8.99-24.60%. Fiber dosage at 9 kg/m3 of coarsemonofilament fiber and 0.6 kg/m3 of staple fiber gives the highest values.

Dr.MazinBurhanAdeen et al (2009)

Dr.Mazin Burhan Adeen et al (2) investigated the mechanical properties of hybrid steel fiber reinforced concrete. In order to achieve and verify that 0.5%,1% and 1.5% fiber percentage by volume of concrete are used in this study with five different mixes of 100-0%,70-30%, 50-50%,30-70% and 0-100% for each fibers percentage. Silica fume is used weight percentage (by cement weight) for all mixes is 10%.

When compared to the control sample that contains no fibers, for all fiber fraction mixes, the maximum compressive strength of concrete is increased for the hybridization ratio and was equal for 0.5%,1% and 1.5% fiber percentage respectively.

It can be seen that when compared to the control specimen increase in split tensile strength is forfiber percentage equal to 1% for the all mixes of different hybridization ratio. And the highest value for the all fiber fraction is for hybridization ratio (100% steel fiber). The maximum increase is for fiber fraction equal to 1% that is182%.

When compared to the control specimen, the maximum increasing of fiber volume fraction providing an enhancement in the flexure strength for the all hybridization ratio of 0.5%,1% and 1.5% by volume provides an increaseintheflexuralstrengthbyabout154% ,157% and 181% and the peak increase is for 1.5% fiber fraction is181%.

C. Selin Ravikumar and T.S. Thandavamoorthy, The study there has been a significant increase in the use of fibers in concrete for improving its properties such as tensile strength and ductility. The fiber concrete is also used in retrofitting existing concrete structures. Among many different types of fibers available today, glass fiber is a recent introduction in the field of concrete technology.

Deshmukh S.H., Bhusari J. P, ZendeA. M

Concrete is a tension weak building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage, and the like. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking.

Rui D. Neves and Joao C. O. Fernandes de Almeida varied the percentage of volume of fibre in the concrete up to 1.5%. There results indicates that the addition fibres to concrete enhances **its** toughness and strength and peak stress, but can slightly reduced young's modulus. Many other researchers had work on it, the recommended reinforcement of steel fibre in concrete is up to 3% by weight of cement only. Thus this thesis is on reinforcement of steel fibreupto 3% in 0.5%interval.

There are several types of steel fibres that have been used in the past. Apart from other mix constituents, there are four important features of steel fibre that are found to have an effect on the properties of the composite, namely: type (i.e.shape), volume fraction, aspect ratio (the ratio of length to the diameter of the steel fibre) and orientation of fibres in the matrix.

Recently, optimisation of these parameters have been studied to improve the fibre matrix bond characteristics and to enhance fibre dispensability **(Soroushianand Bayasi,1991) .** It was found that SFRC containing hooked end stainless steel wires has superior physical properties compared to straight fibres.

This was attributed to the improved anchorage provided and higher effective aspect ratio than that of the equivalent length of the straight fibre**(Ramakrishnan, 1985).**

Laboratory scale tests conducted by many agencies and researchers indicate that the addition of steel fibres to concrete significantly increase the total energy absorbed prior to complete separation of the specimen **(Johnston, 1985).**

The presence of steel fibres was also found to improve fatigue properties, flexural strength, shear strength and impact strength **(Johnston andZemp, 1991, Morgan and Mowat, 1984).** The improvement of mechanical properties of SFRC is attributed to the crack controlling mechanism.

3.0. PROPERTIES OF MATERIALS AND MIX-PROPORTIONS

STEELFIBRE

Steel fibers are short, discrete lengths of steel with an aspect ratio (ratio of length to diameter) from about 20 to100, and with any of several cross sections. Some steel fibers have hooked ends to improve resistance to pullout from a cement- based matrix.

The hooked end steel fiber was used. The steel fiber developed are used in this investigation was supplied by Go Green products. The properties of steel fiber used for this investigation are givenbelow.

- Length =30mm
- Diameter =0.3mm
- Aspect ratio=100

Modulus of Elasticity = $2.0x10^5$ to $2.1x10N/mm^2$

GLASS FIBER

Glass fibers, the most popular of the synthetics, are chemically inert, hydrophobic, and lightweight. They are produced as continuous cylindrical monofilaments that can be chopped to specified lengths or cut as films and tapes and formed into fine fibrils of rectangular cross section Used at a rate of at least 0.1 percent by volume of concrete, glass fibers reduce plastic shrinkage cracking and subsidence cracking over steelreinforcement.

The presence of glass fibers in concrete may reduce settlement of aggregate particles, thus reducing capillary bleed channels. Glass fibers can help reduce spalling of high strength, low-permeability concrete exposed to fire in a moist condition.

The Glass fiber (Fibrillated) developed are used in this investigation was supplied by Go Green Products. The properties and specifications are given by the supplier.

Type – Alkali resistant glass fiber
Length – 12mm
Color – Brilliant White

Glass fibre has used over 30 years in several construction elements, mainly non constructional ones, like façade panels, piping for sanitation, decorative non recoverable from work and other products. Concrete is one of the most durable building materials. It provides superior fire resistance compared with wooden construction and gains strength over time. Structures made of concrete can have a long service life. Concrete is used more than any other manmade material in theworld Concrete, has relatively high compressive strength, but much lower tensile strength. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage andtension.

Glass fiber concrete (GFC) consists basically of a matrix composed of cement, sand, water and admixtures in which short length glass fibers are dispersed. The effect of the fibers in this composite leads to an increase in the tension and impact strength of the material. Glass wool which is commonly is known as " fiber glass" today however was invented in 1938 by Russell Game Slayter of Owens-Coming as a material to be used insulation. It is marketed under the trade name Fiber glass, which has become a generalized trademark. It is material made fromextremely fine fibers ofglass.

Glass fiber is a lightweight, extremely strong and robust material. Although its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using moulding processes. Glass is the oldest, and most familiar, performance fibre.

4.0. TESTS

4.1 Compressive Strength of Concrete

This standard test method provides procedures for obtaining and testing specimens to determine compressive, splitting tensile, and flexural strength of in-place concrete. Common core diameters submitted for testing are 4 inches (actual diameter of 3.75 inches
matching the inner diameter of a diamond- tipped core barrel). Core diameters should be a minimum of two times the maximum aggregate size. The preferred core diameter for a compressive strength specimen is three times the maximum aggregate size of the concrete (see section 7 of ASTM C 42). Length-to-diameter ratios are ideally 2:1, but thistest.
method provides correction factors for ratios low as 1:1. Note that for compressive strength to be considered structurally adequate, an average of 3 cores should be 85% of specified strength with no core falling below 75% of specified strength. Cores also allow a visible examination for general concrete characteristics, such as thickness of a slab if core is full depth, general degree of consolidation, aggregate distribution or signs ofsegregation.

4.2.Split Tensile Strength of Concrete

The split tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. The concrete is not usually expected to resist the direct tension due to its low tensile strength and brittle nature.
However the determination of split tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The test split tensile strength of concrete is very simple to perform and the most important fact is that it gives uniform results than the other tension tests like ring tension test and double punchtest.
IS Code for Split Tensile Strength Test of Concrete Mix:-
IS: 456: 2000, Code for method of practice for plain and reinforced concrete
IS: 5816: 1999, Method of test for split tensile strength of concrete

RESULTS ANDDISCUSSION

The tests on the hybrid fiber reinforced cement concrete with the help of the material which is added with a concrete such as steel and glass fibers showed considerable improvements in properties over by adding of cement with concrete without fibers. Change of properties and behavior of blended concrete with fibers are discussed in this chapter using the results obtained from the experimentalprogram

BEHAVIOUR OF CONCRETE SPECIMENS

CUBE COMPRESSION TEST The compressive strength of the cubes at the 7 days and the 28 days are provided in the Table5.1.

The compressive strength cubes for conventional concrete at 7 days is 24.72N/mm^2 and 28 days 46.48 N/mm^2

Table 5.1.1 Compressive strength of the cubes.

Specimen	Compressive Strength (N/mm^2)			
	Mean load in kN	7 days	Mean load in kN	28days
S1	657	29.24	1105	49.73
S2	665	29.56	1131	50.27
S3	670	29.82	1140	50.70
S4	674	29.96	1145	50.93
S5	666	29.64	1111	49.40
S6	679	30.18	1154	51.30
S7	**695**	**30.93**	**1249**	**55.55**
S8	639	24.72	1079	46.48

Figure 5.1.1 Compressive strength test 7 days

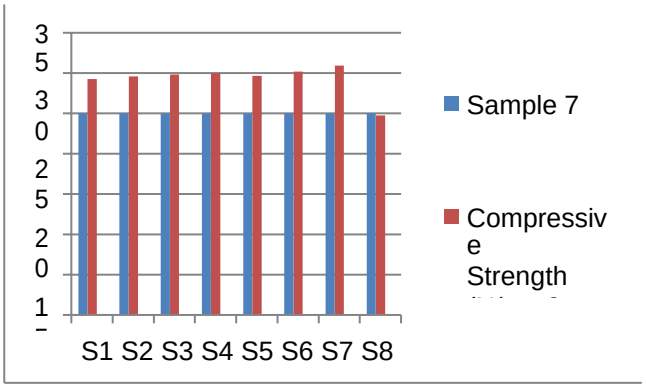
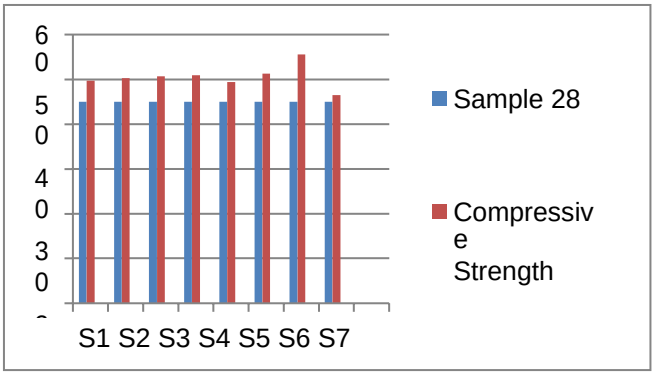


Figure 5.1.2 Compressive strength test 28 days



SPLIT TENSILESTRENGTH

The split tensile strength of the cylinder at the 7 days and the 28 days are provided in the Table5.2.

The split tensile strength cylinder for conventional concrete at 7 days is 3.69 N/mm^2 and 28 days 5.49 N/mm^2

Table 5.1.2 Split tensile strength of the Cylinders

Specimen	Compressive Strength (N/mm^2)			
	Mean load in kN	7 days	Mean load in kN	28days
S1	312	4.42	526	7.45
S2	324	4.59	552	7.82
S3	339	4.80	570	8.07
S4	356	5.05	573	8.11
S5	337	4.78	562	7.96
S6	364	5.16	577	8.17
S7	**393**	**5.57**	**662**	**9.37**
S8	289	3.69	473	5.49

Figure 5.1.3 Split tensile strength test 7 days

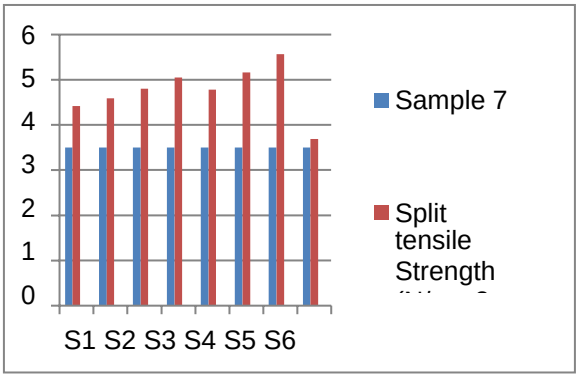
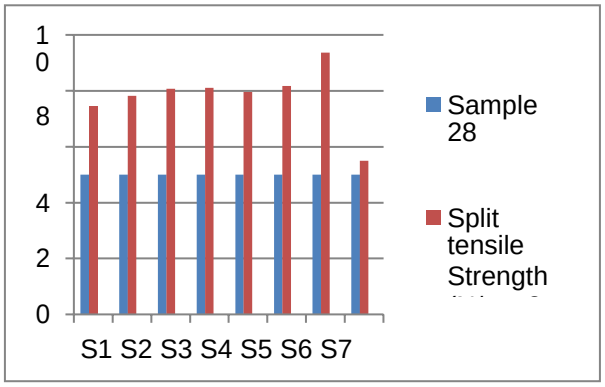


Figure 5.1.4 Split tensile strength test 28 days



CONCLUSION

Hybrid Fiber-reinforced concrete is a composite material consisting of mixtures of cement, fine aggregate, coarse aggregate, steel fiber and glass fiber. The hybrid fiber reinforced concrete exhibits better fatigue strength and increased static and dynamic tensilestrength.

In this project, the strength of fiber reinforced concrete was investigated with by adding cement with concrete and fibers. Steel fiber and Glass fiber was added in the order of 0.25%,0.5% and 0.75% by Weight of concrete and0.25% ,0.5% by weight of cement. Totally 48 cube specimens of size 150mm x 150mm x 150mm were casted to conducted compression strength and totally 32 cylindrical specimens of size 300mmx 150mm were casted to test splittensile strength. Totally 8 mixer were prepare to test the behavior of fiber. The specimens were casted and cured at 7 and 28 days to obtained better results. The results were compared with M40 grade of concrete without fiber. 0.25% of Glass Fiber and 0.5% of steel fiber showed higher compressive strength of 55.55 N/mm2 at 28 days and spilt tensile strength of 9.37 N/mm2 at 28days.

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