AN EXPERIMENTAL STUDY OF HYBRID FIBER REINFORCED CONCRETE

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Abstract - Concrete has been proved to be a leading construction material formore than a century. Natural aggregates are becoming increasingly scarceand their production and shipment is becoming more difficult. The primaryaim of this research was to evaluate the strength of concrete made withHFRC. For the present study M40 grade concrete shall be designed, byadding 0.5%, 1%, 1.5% and 2%.The performance of reinforced ConcreteCube mixing with Hybrid fiber reinforced has been evaluated. Thecompression behavior of concrete cube and Hybrid fiber reinforced concretecube are compared.

The performance of reinforced Concrete Cube mixingwith Hybrid fiber reinforced concrete has been evaluated. The compressionbehavior of cube and cylinder are compared with trial concrete cubes. In thisproject, the cubes and cylinders are casted and with Steel, Glass fibers. TheHFRC and Ordinary specimens (Trial mix concrete cube) are tested after 28days curing period. The ultimate load of Hybrid Fiber cube can be increasedup to 35 to 40%. Compression strength of cube is 40N/mm2 and Hybrid fibercube can increase up to 35 to 40%. The test results are compared withordinary cube specimen and at last the compression Strength of HFRC Cubecan high and it makes big change in construction field.**Keywords: HYRC (Hybrid Fiber Reinforced Concrete), Steel fiber, Glassfiber, Compression strength, Split tensile strength**.

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 vary from 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 Fly ash and Rice husk ash substitutes are to be used to replace Ordinary Portland Cement by each

20% by weight of cement proportions.

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 fiber percentage

2.0 LITERATURE REVIEW

SaeidHesami , SaeedAhmadi , Mahdi Nematzadeh Many studies have shown that the mechanical properties of concrete can increase dramatically (by more than an order of magnitude) with the addition of fibers individually and in hybrid condition. This chapter deals with the details regarding the review of literature on studies pertaining to mechanical properties of hybrid fiber reinforced concrete.

"Effects of rice husk ash and fiber on mechanical properties of pervious concrete pavement" SaeidHesami ,SaeedAhmadi , Mahdi Nematzadeh. "Construction *and Building Materials* 53 (2014): 680-691.

The use of pervious concrete pavement is significantly increasing due to reduction of road runoff and absorption of noise. However, this type of pavement cannot be used for heavy traffic due to a high amount of voids and consequently low strength of pervious concrete. Rice husk ash (RHA) was used in order to strengthen pozzolaniccement paste and the effect of 0%, 2%, 4%, 6%, 8 %, 10% and 12% weight percentages as a cement replacement in concrete mixtures on the mechanical properties was studied. Moreover, 0.2% V_f of glass (where V_f is the proportion of fiber volume to total volume of concrete), 0.5% V_f of steel and 0.3% V_f of polyphenylene sulfide (PPS) fibers were used to improve the mechanical properties of the pervious concrete.

Machine Hsie et al (2007)

Machine Hsie et al (1) investigated the mechanical properties of glass hybridfiber reinforced concrete. There are two forms of glass fibers including coarse monofilament and staple fibers. The content of the former is at 3 kg/m^3, 6 kg/ m^3 and 9 kg/ m^3 and the content of the latter is at 0.6 kg/ m^3.The experimental results show that the compressive strength, splitting tensile strength and flexural properties of the glasshybrid fiber reinforced concrete are better than the properties of single fiberreinforced 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/m^3 of coarse monofilament fiber and 0.6 kg/m^3 of staple fiber gives the highestvalues.

Dr.MazinBurhanAdeen et al (2009)

Dr.MazinBurhanAdeen et al (2) investigated the mechanical properties of hybrid steel-Nylon 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 (nylon to steel).Silica fume is used weight percentage (by cement weight) for all mixes is10%.

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 (50% Nylon-50% Steel fiber) and was equal to 242%,227% and 210% 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 for fiber 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 (0% Nylon with 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 increase in the flexural strength by about 154% ,157% and 181% and the peak increase is for 1.5% fiber fraction is 181%.

RanaA.Mtasher et al (2008)

RanaA.Mtasher et al investigated the effect of fibrillated glass fiber on the compressive and flexural strength of normal weight concrete. Four mixes used glass fiber weight with 0.4, 0.8, 1.0 and 1.5% of cement content. The increase inthe compressive strength for fibrous concrete compared to non-fibrous concrete is 11%, 24.35%, 46% and 56.4% for 0.4%, 0.8%, 1% and 1.5% fiber content respectively.

The increase in the flexural strength for fiberous concrete compared to the non-fibrous concrete is 24.6%, 49.36%, 57% and 85% for 0.4%, 0.8%, 1% and 1.5% fiber weight content respectively. The average ratio of flexural strength to compressive strength is about 11.18%.

RICE HUSK ASH

AlirezaNajiGivi et al (2004)

AlirezaNajiGivi et al investigated the effects of partial replacement of cement with different percentages and particle sizes of Rice Hush Ash on compressive strength, water permeability and workability of concrete to develop a structure with most favourableproperties. Two types of Rice Hush Ash with average particle size of 5 micron (ultra fine particles) and 95 micron and with four different contents of 5%, 10%, 15% and 20% by weight were used.

It is found that the cement could be advantageously replaced by Rice Hush Ash up to maximum limit of 15% and 20% with average particle sizes of 95 and 5µm respectively. It is concluded that partial replacement of cement with Rice Hush Ash improves the compressive strength and workability of concrete and decreases its waterpermeability.

FLY ASH

P.Chindaprasirt et al (2006)

P.Chindaprasirt et al investigated the sulfate resistance mortars made from Ordinary Portland Cement containing available pozzolans such as fly ash and ground rice hush ash. Class F lignite fly ash and Rice Hush Ash were used at replacement dosages of 20 and 40% by weight of cement. Up to 40% of Portland Cement could be replaced with fly ash and Rice Hush Ash in making blended cement mortar with reasonable strength development and good sulfate resistance. This would reduce the amount of Portland Cement use and the green house gas, service life of the mortar would also be increased owing to the higher sulfate resistance

3.0 PROPERTIES OF MATERIALS AND MIX-PROPORTIONS

3.1 STEEL FIBRE

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 given below.

- Length = 30mm
- Diameter = 0.3mm
- Aspect ratio =100
- Modulus of Elasticity = 2.0 x 10^5 to 2.1 x 10^5 N/mm^2

3.2 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 glassfiber
- Length – 12mm
- Color – BrilliantWhite

3.3 FLY ASH

Pozzolans are siliceous and aluminous materials which, though

Themselves possessing little or no cementitiousvalue, will, in finely divided form and in the presence of moisture, react chemically with calcium hydroxide at ambient temperature to form compounds with cementitious properties.

Fly ash is a solid, fine-grained material resulting from the combustion of pulverized coal in power station furnaces. The material is collected in mechanical or electrostatic separators. The term fly ash is not applied to the residue extracted from the bottom ofboilers.

Fly ashes capable of reacting with Ca(OH)2 at room temperature can act as pozzolanic materials. Their pozzolanic activity is attributable to the presence of SiO2 and Al2O3 in amorphous form. According to ASTM C618-93 specification (1993) for "F1y Ash and Raw or Calcined Natural Pozzolan "for use as Mineral Admixture in Portland Cement Concrete," pozzolans are defined as "siliceous and aluminous materials which in themselves possess little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitiousproperties."

3.4 Class C fly ash

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). It is also called high calcium ashes. Alkali and sulfate (SO4) contents are generally higher in Class C fly ashes. Class C fly ashes are not only pozzolanic in nature but are invariably self cementitious

3.5 Class F fly ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanicin nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the additions of a chemical activator like sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

Presently, no appreciable amount of anthracite coal is used for power generation. Therefore, essentially all Class F fly ashes presently available are derived from bituminous coal. Class F fly ashes with calcium oxide (CaO) content less than 6%, designated as low calcium ashes, and are not self-hardening but generally exhibit pozzolanic properties.

These ashes contain more than 2%unburned carbon determined by loss on ignition (LOI) test. Quartz, mullite and hematite are the major crystalline phases identified fly ashes, derived from bituminous coal. Essentially, all the fly ashes and, therefore, most research concerning use of fly ash in cement and concrete are dealt with Class F fly ashes.

In the presence of water, the fly ash particles produced from a bituminous coal react with lime or calcium hydroxide to form cementing compounds similar to those generated on the hydration of Portland cement. Previous research findings and majority of current industry practices indicate that satisfactory and acceptable concrete can be produced with the Class F fly ash replacing 15 to 30% of cement by weight.

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	683	30.36	1184	52.63

4.0 PROPERTIES RICE HUSKASH

The Rice Husk Ash was used in this investigation was supplied by Sakthi Constructions, Coimbatore.

- Silica content - >90%
- Particle size - < 25microns
- Color –Grey

5.0 RESULTS AND DISCUSSION

The tests on the Partial replacement of cement with fly ash and rice husk ash concrete with steel and glass fibers showed considerable improvements in properties over the partial replacement of cement with fly ash and rice husk ash concrete without fibers. Change of properties and behavior of blended concrete with fibers are discussed in this chapter using the results obtained from the experimental program.

5.0 BEHAVIOUR OF CONCRETE SPECIMENS

5.1 CUBE COMPRESSION TEST

The compressive strength of the cubes at the 7 days and the 28 days are provided in the Table 5.1.

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

Table 5.1 Compressive strength of the cubes

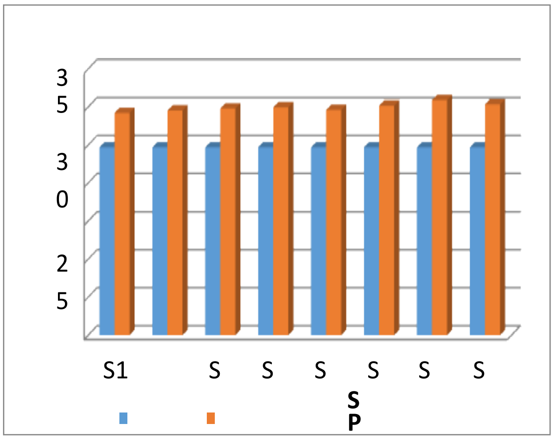

Figure 5.1Compressive strength test 7 days

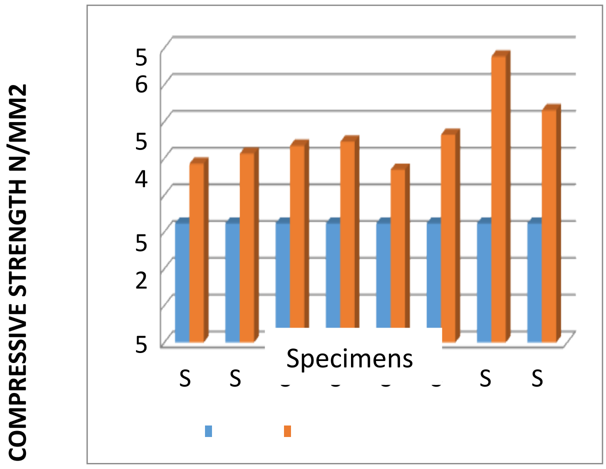

Figure 5.2 Compressive strength test for 28 days

5.2 SPLIT TENSILE STRENGTH

The split tensile strength of the cylinder at the 7 days and the 28 days are provided in the Table 5.2.

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 5.2 Split tensile strength of the cylinders

Specimen	Spilt tensile Strength (N/mm^2)			
	mean load in kN	7 days	Mean load in kN	28 days
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	381	5.40	626	8.87

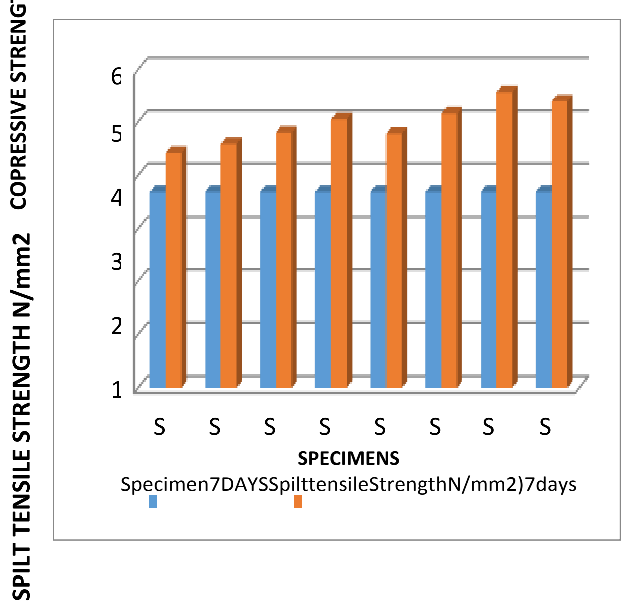

Figure 5.3 Split tensile strength test 7 days

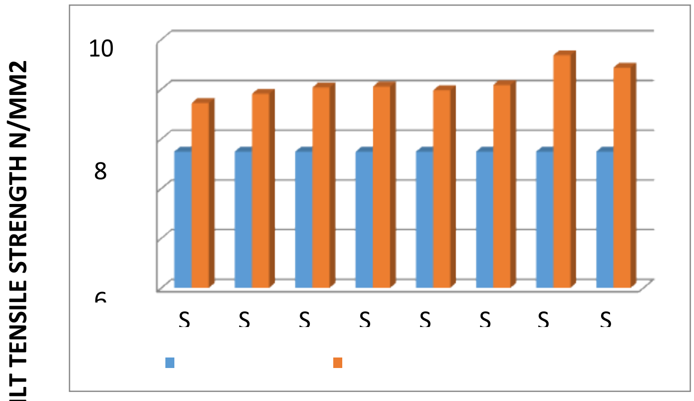

Figure 5.4 Split tensile strength test 28 days

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 tensile strength.Inthisproject,thestrength of fiberreinforcedconcretewas investigated with partial replacement of cement with rice husk ash and fly ash. Steel fiber and Glass fiber was added in the order of 0.25%,0.5% and 0.75% by volume of concrete and 0.25% ,0.5% by weight of cement. Rice husk ash was used to replace Ordinary Portland Cement by 20% and fly ash 20% by weight of cement proportions. Totally 48 cube specimens of size 150 mmx150 mmx 150 mm were casted to conducted compression strength and totally 32 cylindrical specimens of size 300mmx 150 mm were casted to test split tensile 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. The 20% replacement of Rice Husk Ash and 20% of fly ash with cement, 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 9.37N/mm2 at 28 days.

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