To Study the Behavior of High Strength Concrete Beam Reinforced with Hybrid Fiber Subjected to Cyclic Loading

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Abstract— The use of two or more types of fibers in a suitable combination may potentially improve the overall properties of concrete and also result in performance concrete. The combining of fibres, often called hybridization, is investigated in this paper for a M50 grade concrete. Control and two-fiber hybrid composites were cast using different fibre proportions of steel and polypropylene. Reinforced HSC beams containing fibres of two different types in hybrid forms were constructed and tested under cyclic loading to investigate the possibility of obtaining ductile and energy dissipating Reinforced HSC beams to be used in seismically active area. compressive test, Split tensile strength and Flexural strength using cyclic loading were performed and results were extensively analyzed to associated with above fibre combinations. Based on experimental studies, the paper identifies fiber combinations that demonstrate maximum Compressive strength, split tensile strength and flexural strength of concrete.

Key words: Compressive strength, Hybrid fibre, Split tensile strength, Flexural strength, Cyclic loading, Workability

I. INTRODUCTION

Concrete is characterized by quasi-brittle failure the nearly complete loss of loading capacity, oncefailure is initiated. This characteristic, which limits the application of the material, can be overcome bythe inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic andnatural) and can be practiced among others that remedy weaknesses of concrete, such as lowgrowth resistance, high shrinkage cracking, low durability, etc. Fiber reinforced concrete (FRC) is a fibre einforcing cementitious concrete composite, and by adding discrete short fibers randomly in concrete it exhibits many substantially improved engineering properties in compressive strength,tensile strength, flexural strength etc. The fibers are able to prevent surface cracking through bridging action leading to an increased impact resistance of the concrete. The combination of two or moredifferent types of fibres (different fibre types and/orgeometries) is becoming more common, with theaim of optimizing overall system behaviour. Theintent is that the performance of these hybridsystems would exceed that induced by each fibretype alone. That is, there would be a synergy.Banthia and Gupta [2004] classified these synergies into three groups, depending on themechanisms involved:

1) Hybrids based on the fibre constitutive response,in which one fibre is stronger and stiffer and provides strength, while the other is more ductileand provides toughness at high strains [Banthia and Gupta 2004].
2) Hybrids based on fibre dimensions, where one fibre is very small and provides microcrack controlat early stages of loading; the other fibre is larger, to provide a bridging mechanism across macrocracks.
3) 3.Hybrids based on fibre function, where one type of fibre provides strength or toughness in the hardened composite, while the second type provides fresh mix properties suitable for processing.

The usefulness of fiber reinforced concrete in various Civil Engineering applications is thus indisputable. Hence this study explores the feasibility of hybrid fiber reinforcement; aim is to do parametric study on compressive strength, flexural strength using cyclic loading, tensile strength study etc. withg iven grade of concrete, proportions and percentage of steel.

II. OBJECTIVES

1) 1.To find the optimum percentage of hybrid fibre can be added to the high strength concrete to increase the ductility of the element.
2) 2. To find the behaviour of the element made of high strength concrete reinforced with hybrid fibre subjected to the cyclic loading.
3) 3. To investigate the mechanical properties like split tensile strength and compressive strength of hybrid fibre reinforced concrete beam

III. EXPERIMENTAL INVESTIGATION

A. *Material Used*

In this experimental study, Cement, sand, coarse aggregate, water, steel fibers and polypropylene fibres were used.

Cement: Ordinary Portland cement of 53 grade wasused in this experimentation conforming to I.S-1226 :1987 Coarse aggregates: Locally available, maximum size 20 mm, specific gravity 2.65.

Sand: Locally available sand zone I with specific gravity 2.61, water absorption 1% and fineness modulus 2.72, conforming to I.S. – 383-1970.

Water: Potable water was used for the experimentation.

Chemical Admixture Type: Super Plasticizer

Steel Fibers: - In this experimentation, Hook end Steel fibers (L=60 mm, dia=0.5 mm) were used.

Polypropylene Fibers: Fibrillated 20 mm cut length fibers were used.

Different proportions of steel and polypropylene fibers are shown below table:

NOTATION	% OF STEEL FIBRE	%OF PP FIBRE
CONVENTIONAL CONCRETE	—	—
HFRC SO.75PP0.25	75	25
HFRC SO.5PP0.5	50	50
HFRC SO.25PP0.75	25	75

Table 1: Different Proportions of Fibres

B. Concrete Mix Proportion

Material	Quantity
Cement	422 kg/m^3
Sand	621 kg/m^3
Coarse aggregate	1284 kg/m^3
water	kg/m^3

Table 2: Mix Proportion

C. Specimen Details

Cube moulds of 150x150 x150 mm and cylindrical moulds of 150 mm diameter and 300 mm long are used for casting the specimen for compressive strength and split tensile strength test respectively. For flexure test using cyclic loading, specimen size of 200x150x1200 mm is cast. Specimens were cured for 28 days. 3 specimens of compressive strength test are cured for 7 days and 14 days to obtain the compressive strength after 7 days and 14 days respectively.

D. Testing

Flexural test were carried out on 8 beams,out of that each of 2 beams are tested for hybridization ratio HFRC S0.75PP0.25, HFRC S0.5PP0.5, HFRC S0.25PP0.75. For all hybridization ratio fiber volume 1% by volume of concrete is kept constant.

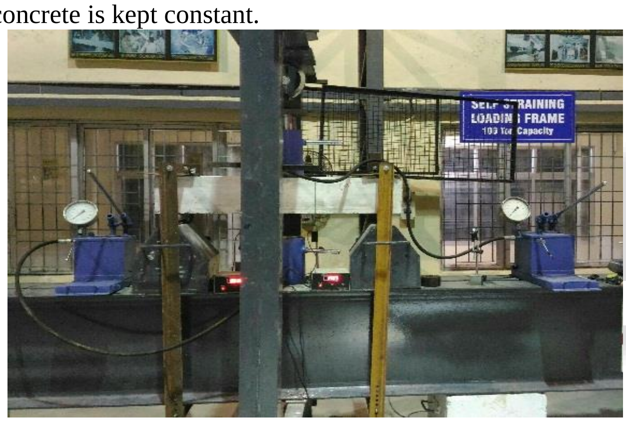

Fig: 1: Test setup

The beams were kept on UTM as shown in fig.1 the end of the beams where tied using steel frames to avoid moving of beam during reverse cyclic loading and the beams were tested under gradually applied loading in the increasing manner in cyclic and reverse cyclic loadings UTM machine for flexural strength. Ultimate load and modes of failure of beams were noted. Compressive strength and split tensile strength are carried out on cubes and cylinders respectively, tested under compression testing machine.

IV. Discussions and Results

In present study cube compression test, split tensile test, flexural test on beams, and on plain and varying hybridization ratio of steel and polypropylene fibers reinforced concrete at 1%fiber volume fraction by volume of concrete are carried out. The experimental results and discussion for various tests are described below.

A. Compressive Strength

The results of compressive strength test at 28days are given in table No.1. It is seen that at 1%volume fraction of fibers by volume of concrete the compressive strength of Hybrid fiber reinforced concrete (HFRC) with 50-50% (Steel-polypropylene) hybridization ratio is maximum. Fiber addition with equal percentage assures maximum availability of fiber in thefibrous matrix of concrete as regard to volume. Maximum availability of fibers are advantageous as under the axial load cracks occur in microstructure of concrete, fiber reduces the crack formation and development. Because of high strength and stiffness, Metallic fibers (steel) are responsible to arrest the macro cracks also modulus ofelasticity of steel fibers is more hence provide ductility to the concrete. Concrete is very alkaline and as such it will corrode steel fiber very quickly so that non-metallic fibers(polypropylene) are used for effective reinforcement. Use of non-metallic fiber is to arrest only a micro cracks developed due to shrinkage. Modulus of elasticity of PP fiber is less than steel fiber hence PPFRC undergoes brittle failure after loading. Due to hybridization of steel and polypropylene (50-50%) mix provide better response to arrest micro and macro cracks hence improve thecompressive strength of concrete as compare to plain concrete and all other combination of hybridization ratio.

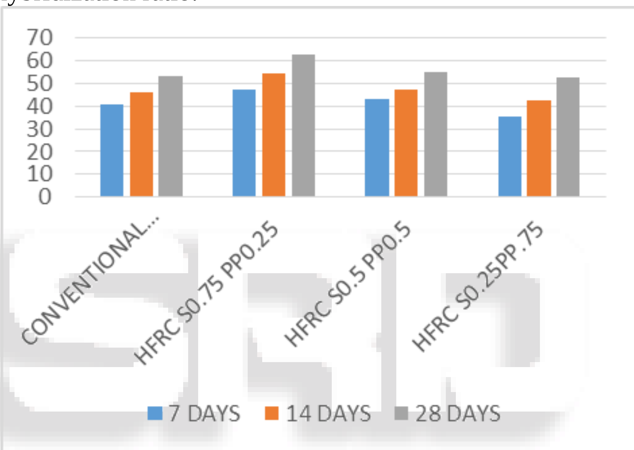

Fig. 2: Compressive strength test

B. Split Tensile Test

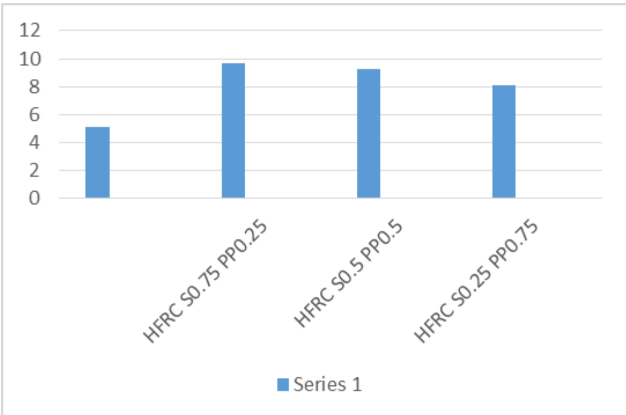

Fig. 3: Split Tensile Tes

The results of split tensile strength test at 28 days are given in graph. The increase in split tensile strength due to incorporation of steel fiber is greater than polypropylene fiber. High modulus of elasticity of steel fiber makes the concrete more ductile. Tensile strength of ductile material is higher than brittle materials. Therefore gradual increase in % of steel fibers for different hybridization ratio split tensile strength of concrete also increases. Once thesplit occurs and continues the steel fibers provide bridging effect across the split portion. The split portion of the matrix transfer the stresses from matrix to the fibers and thus steel fibers are gradually supports the entire load. Stress transfer also improves the tensile strain capacity of the fiber reinforcedoncrete and increase the split tensile strength.

C. Cyclic Loading

Cyclic loading is the application of repeated or fluctuating stresses, strains, or stress intensities to locations on structural components. The degradation that may occur at the location is referred to as fatigue degradation.by applying the repeated loading on the beam as the cyclic and reverse cyclic loads by increasing the loads per cycle. Thereby, the loads applied on the cycles will be 20KN, 40KN, 60KN and till failure occurs respective. It is also seen that the addition of polypropylene fibers increase the flexural strength. Flexural strength primary increase due tofiber intersecting the cracks in the tension half portion of the specimen. This fibers accommodate the crack face separation by process of stretching thefibers, thus providing additional energy absorbing capacity. It also provides stress relaxing mechanismat the tip of the cracks during micro cracks formation.The modulus of rupture of steel fibers is more as compare to polypropylene fibers. Therefore steel fibers are effective to arrest the macro cracks and undergoes ductile failure while Polypropylene fibers are only effective to arrest the micro cracks and undergoes brittle failure. Therefore steel and polypropylene combination also shows better performance during flexural strength by cyclic loadingtest.

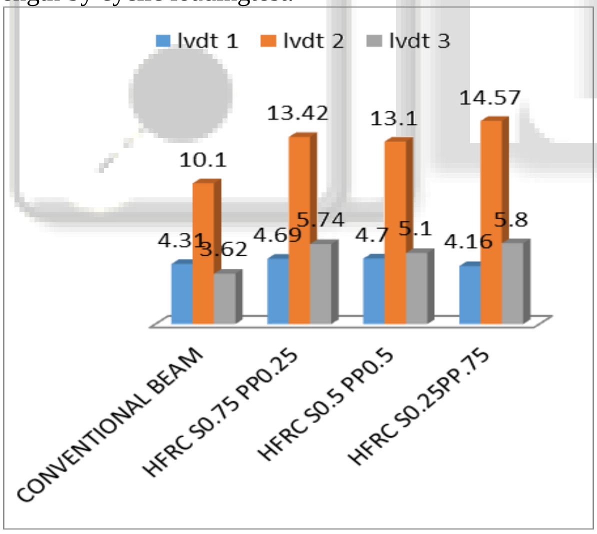

Fig. 4: comparison of Deflection of Beams using Cyclic Loading

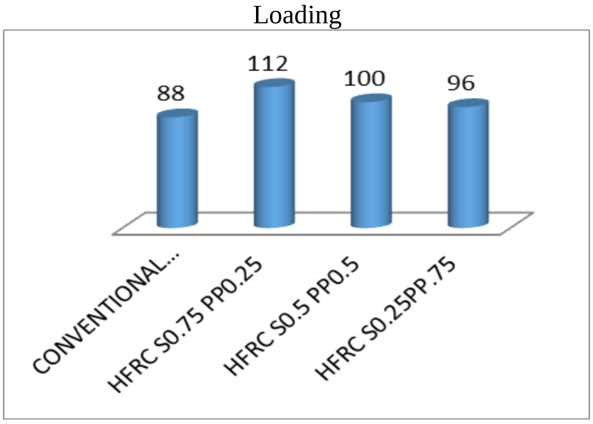

Fig. 5: Ultimate loads of beams (KN)

V. CONCLUSION

Compressive strength of HFRC S0.75 PP0.25 after 28days for (steel-polypropylene) hybridizationratio is maximum. It is increased by 9.4% with respect to normal conventional concrete (i.e. Hybridizationratio 0-0 %). At 28 days Compressive strength of HFRC S0.5 PP0.5 (i.e. Hybridization ratio 50-50 %) isincreased by 2.37% with respect to normal concrete & compressive strength of HFRC S0.25 PP0.75 (i.e. Hybridization ratio 25-75%) decreased by 1.2% with respect to normal concrete.The maximum compressive strength reaches in the HFRC S0.75P0.25, i.e., 75% steel fibres and 25% polypropylene fibres because of the high elastic modulus of steel fibre and the low elastic modulus of polypropylene fibre work in perfect combination.

Split tensile strength of HFRC S0.75 PP0.25 concrete for 28days increases with increasing contribution of steel fiber in hybridization ratio. Split tensile strength of HFRC S0.75 PP0.25 (i.e. Hybridization ratio75-25%) is maximum. Split tensile strength of HFRC S0.75 PP0.25 increases19.7% & Split tensile strength of HFRC S0.5 PP0.5 (i.e. Hybridization ratio 50-50%) increases 8.16% with respect to normal concrete respectively.

Flexural strengthusing cyclic loading of HFRC S0.75 PP0.25 increases 24.8% than conventional concrete flexural strength of HFRC S0.5 PP0.5 is increases 15.4% than conventional concrete beam.It can be observed that, under cyclic loading,cracks occur in microstructure of concrete and fibres limit the formation and growth of cracks.

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