Experimental Investigation on Mechanical Properties of Hybrid Fibre Reinforced Concrete

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Abstract- *Hybrid fiber reinforced concrete can be defined as concrete that reinforced by two or more types of fibers. As the Cement concrete is week in tension, to improve such type of weakness numerous studies on fibre reinforced concrete have been performed. The fibre can make the failure mode more ductile by increasing the tensile strength of concrete. As there is a high cellulose content and low micro-fibril angle impart desirable mechanical properties for banana fibers and addition of steel fibers in concrete significantly increases its flexural toughness, the energy absorption capacity, ductile behavior prior to the ultimate failure, reduced cracking, and improved durability both fibers are used separately and in combination and done a laboratory tests to assess the workability, compressive, split tensile and flexural strengths conducted on concrete with different fibers such as banana fibre, steel fibre with different proportions of M30 grade. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516:1959. The compressive strength is usually obtained experimentally by means of a compressive test. The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cylinders are used to determine tensile strength of concrete.*

Keywords- Hybrid fibre, Banana fibre, steel fibre, compressive, flexural, split tensile strength test.

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age. The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials (whatever may be their qualities) of concrete and the knowledge that virtually any combination of the constituents leads to a mass of concrete have bred contempt. Strength was emphasized without a thought on the durability of structures. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction. This is particularly true of concrete structures which were constructed since 1970 or thereabout by which time (a) the use of high strength rebars with surface deformations (HSD) started becoming common, (b) significant changes in the constituents and properties of cement were initiated, and (c) engineers started using supplementary cementitious materials and admixtures in concrete, often without adequate consideration.

Concrete is weak in tension and has a brittle character. The concept of using fibers to improve the characteristics of construction materials is very old. Use of continuous reinforcement in concrete increases strength and ductility but requires careful placement and labour skill. Alternatively, introduction of fibers in discrete form in plain or reinforced concrete may provide a better solution. When concrete cracks, the randomly oriented fibers start functioning, arrest crack formation and propagation, and thus improve strength and ductility. The presence of micro cracks at the mortar- aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibers in the mix. Such a concrete is called fiber reinforced concrete (FRC).

It is possible to make several classifications among fiber types. Fibers can be divided into two groups, Those with elastic moduli lower than the cement matrix, such as cellulose, nylon, and polypropylene and those with higher elastic moduli such as asbestos, glass, steel, and carbon.

Among all the fibers Steel fibers have been used in pavements, in shotcrete, and in a variety of other structures. Banana fibers are renewable and obtained from natural resources that present several advantages, including low density, acceptable specific strength properties, good sound abatement capability, low abrasivity, low cost, high biodegradability and existence of vast resources. In addition, at the end of their life cycle these can be incinerated for energy recovery, because they have a good calorific value. New application areas become available as new fiber types and new FRC production techniques are developed.

OBJECTIVES OF THE STUDY

Hybrid fiber reinforced concrete can be defined as concrete that reinforced by two or more types of fibers. As the Cement concrete is week in tension, To improve such type of weakness numerous studies on fibre reinforced concrete have been performed. The fibre can make the failure mode more ductile by increasing the tensile strength of concrete. As there is a high cellulose content and low micro-fibril angle impart desirable mechanical properties for banana fibers and addition of steel fibers in concrete significantly increases its flexural toughness, the energy absorption capacity, ductile behavior prior to the ultimate failure, reduced cracking, and improved durability both fibers are used separately and incombination and done a laboratory tests to assess the workability, compressive, split tensile and flexural strengths conducted on concrete with different fibers such as banana fibre, steel fibre with different proportions of M30 grade. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516:1959. The compressive strength is usually obtained experimentally by means of a compressive test. The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cylinders are used to determine tensile strength of concrete

II. REVIEW OF LITERATURE

The beneficial influence of SFs in concrete depends on many factors such as type, shape, length, cross section, strength, fiber content, SFs bond strength, matrix strength, mix design, and mixing of concrete. Typical load-deflection curves for plain concrete and FRC are shown in Figure (ACI 544.IR, 1996). The addition of SFs in the conventional reinforced concrete (RC) members has several advantages such as

- SFs increase the tensile strength of the matrix, thereby improving the flexural strength of the concrete.
- The crack bridging mechanism of SFs and their tendency to redistribute stresses evenly throughout the matrix contribute to the post-cracking strength and restraining of the cracks in the concrete.
- Increase ductility of the concrete.
- SFRC is more durable and serviceable than conventional RC (Rapoport et al., 2001; Grzybowskiand Shah, 1990; Grzybowski 1989).

H.T Luo investigated flexural performance of hybrid fiber reinforced concrete beam with longitudinal reinforcement ratio of 1.08% and conformed that ductility of beam is improved due to addition of steel fiber based on load-deflection curves.

A.N. Dancygier and Z. Savir studied the influence of steel fiber on flexural performance of high strength concrete beam with low longitudinal reinforcement ratio, which proved that steel fiber enhances brittleness of beam compared to that of beam with minimum longitudinal reinforcement ratio. Compared to steel fiber reinforced concrete, the hybrid fiber with different type and size can improve effectively strength and toughness of concrete, form hybrid effect during different fiber, play respective beneficial influence from different level. However, few researches on flexural performance of hybrid fiber reinforced RC beam were studied.

Researches on influence of hybrid fiber on beam flexural ductility were blank if beam was made of minimum longitudinal reinforcement ratio and fibers. Researches on FRSCC are a new development trend, which have advantages on both SCC and FRC, fiber content of FRSCC is mainly determined by workability, but fiber content of FRC is determined by mechanical behavior. When steel fiber content maintains constant, the tensile strength, flexural strength and flexural toughness of steel fiber reinforced SCC were improved compared to that of steel fiber reinforced NC.

Based on the investigation on the workability of hybrid fiber reinforced self-compacting concrete (HFRSCC)' a series of hybrid fiber reinforced SCC beams with low longitudinal reinforcement ratio are tested to evaluate the hybrid fiber influence on load-deflection curve, beam flexural ductility. Steel fiber reinforced SCC beams were made in order to compare the load, ductility with hybrid fiber reinforced SCC beams.

Chihuahua Jiang, et al (2014) in this field, the effects of the volume fraction and length of basalt fiber (BF) on the mechanical properties of FRC were Analyzed. The outcomes indicate that adding BF significantly improves the tensile strength, flexural strength and toughness index, whereas the compressive strength shows no obvious gain. Furthermore, the length of BF presents an influence on the mechanical properties.

M. Vijayanand, et al (2010) the present study proposes to study the flexural behavior of SCC beams with steel fibers. An experimental program has been contrived to cast and test three plain SCC beams and six SCC beams with steel fibers. The experimental variables were the fiber content

(0vf%, 0.5VF% and 1.0VF %) and the tensile steel ratio (0.99%, 1.77% and 2.51%).

V.M.C.F. Cunha, et al. (2011) the author establishes numerical model for the ductile behavior of SFRSCC. They have presumed SFRSCC as two-phase material. By 3-D smeared crack model, the nonlinear material behavior of self-compacting concrete is applied. The mathematical model presented good relationship with experimental values.

Mustapha Abdulhadi, et al. (2012) the author prepared M30 grade concrete and added polypropylene fiber 0% to 1.2% volume fraction by weight of cement and tested the compressive and split tensile strength and obtained the relation between them.

M.G. Alberti. Et al (2014) in this paper the mechanical attributes of a self-compacting concrete with low, medium and high-fiber contents of macro polyolefin fibers are considered. Their fracture behavior is compared with a manifest self-compacting concrete and also with a steel fiber-reinforced self-compacting concrete.

Chihuahua Jiang, et al (2014) in this field, the effects of the volume fraction and length of basalt fiber (BF) on the mechanical properties of FRC were Analyzed. The outcomes indicate that adding BF significantly improves the tensile strength, flexural strength and toughness index, whereas the compressive strength shows no obvious gain. Furthermore, the length of BF presents an influence on the mechanical properties.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Steel fibre
6. Banana fibre

I. Cement

Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to I.S 4031-1988.The O.P.C is classified into three grades, those are 33grade, 43grade and 53 grade, depending upon the strength of the cement in this experiment 43grade cement is used.

II. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

III. Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size.Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

IV. Steel fibre

Steel fiber (SF) is the most popular type of fiber used as concrete reinforcement. Initially, SFs are used to prevent/control plastic and drying shrinkage in concrete. Further research and development revealed that addition of SFs in concrete significantly increases its flexural toughness, the energy absorption capacity, ductile behavior prior to the ultimate failure, reduced cracking, and improved durability (Altun et al., 2006). This paper reviews the effects of addition of SFs in concrete, and investigates the mechanical properties, and applications of SF reinforced concrete (SFRC)

V. Banana fibre

Banana (musasapientum) is a tropical humid lowland crop, after the harvest of fruit huge quantities of biomass (pseudo stem, leaves, etc.) are generated and discarded as waste due to non-industrial utilization. Banana fibers are generally lignocellulose material, consisting of helically wound cellulose micro-fibrils in amorphous matrix of lignin and hemicelluloses. A high cellulose content and low micro-fibril angle impart desirable mechanical properties for banana fibers. Composition of banana stem fibers Pseudo-stem fibre is a best fibre and it can be extracted after the fruit bunch was harvested by using an extractor machine. To improve its surface morphology and fibre mechanical properties, chemical treatment is applied. The extracted fibres were then treated in 5% sodium hydroxide (NaOH) solution four hours, under total immersion condition to avoid oxidation of the fibre, after which it was washed in overflowing tap water until neutral pH is attained. Alkali treatment increases surface roughness resulting in better mechanical bonding and the amount of cellulose exposed on the fibre surface.

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. M30 grade of concrete is used for the present study.

V. TESTS ON FRESH CONCRETE

WORKABILITY OF CONCRETE

The slump test result gives a measure of the behavior of a self-compacted inverted cone of concrete under the action of gravity. It measures workability or dampness of concrete. Slump test is performed as per IS 1199:1959. The apparatus used in slump test are Slump cone and tamping rod.

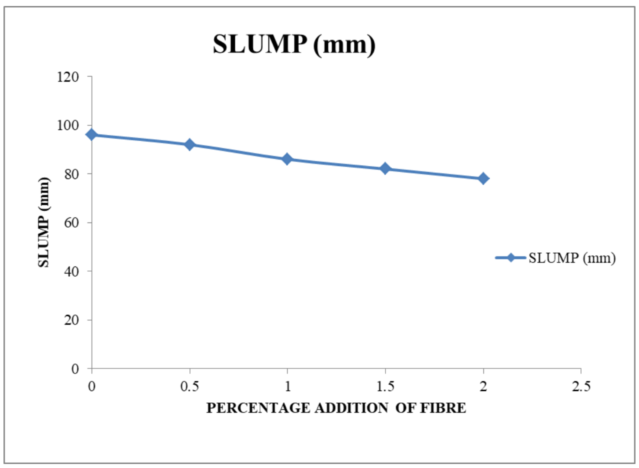

Fig 5.1shows the slump values for different percentages of fibres

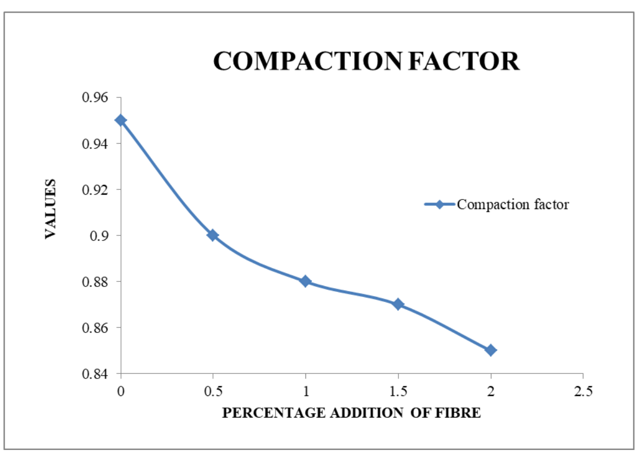

Fig 5.2 shows the compaction factor test values for different percentages of fibres

VI. TESTS ON HARDENED CONCRETE

6.1 COMPRESSIVE STRENGTH TEST

Because it is simple to perform, the compressive strength test is the most common test performed on hardened concrete. The quality of concrete's compressive strength is one of the most desirable characteristics.150x150x150 mm size mould is used for the casting of compressive test specimen, after the 24 hours of casting of specimens remove the cubes from moulds and the cubes are placed in curing tank up to one day before the testing. During testing on a UTM with a capacity of 300T, the load is delivered to the cubes at a continuous rate of 140kg/sq.cm/minute. The specimen is placed in the UTM with the cast faces facing the opposite to the observer. The specimen's ultimate load is defined as the load at which it fails. At the ages of seven and twenty-eight days, this test was conducted. The average load of three specimens is used to calculate strength for each mix.

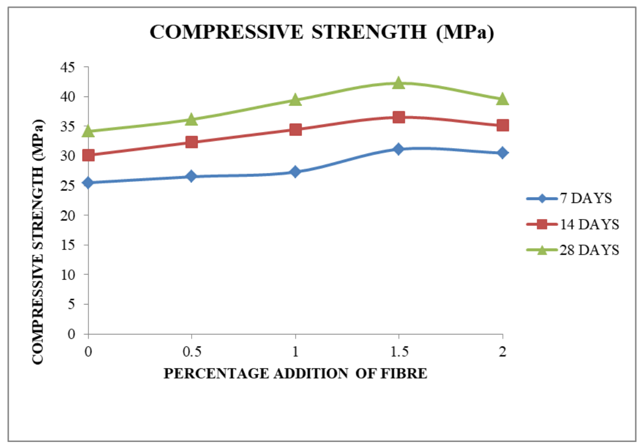

Fig 6.1 shows the summarized results of compressive strength for different curing periods

6.2 SPLIT TENSILE STRENGTH

The cylinder specimen is of the size 150 mm diameters and 300mm height was cast to determine the split tensile strength of concrete. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction. The cylinder specimens are tested at 28 days.

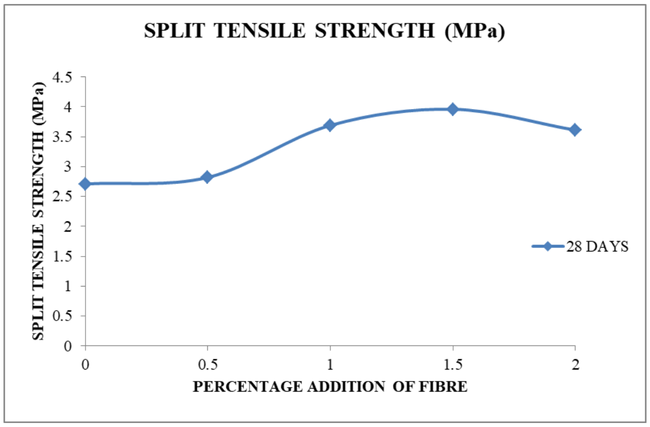

Fig 6.2 shows the variation in split tensile strength for % Hybrid fibers at 28 days

6.3 FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

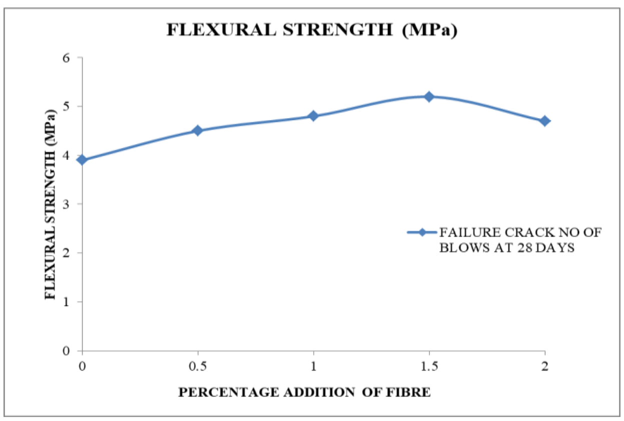

Fig 6.3 shows the variation in flexural strength for % Hybrid fibers at 28 days

6.4 IMPACT STRENGTH

Impact is testing an object's ability to resist high-rate of loading. It is a test for determining the Impact energy absorbed in fracturing a test specimen at high velocity. Impact resistance is one of the most important properties for a part designer to consider.

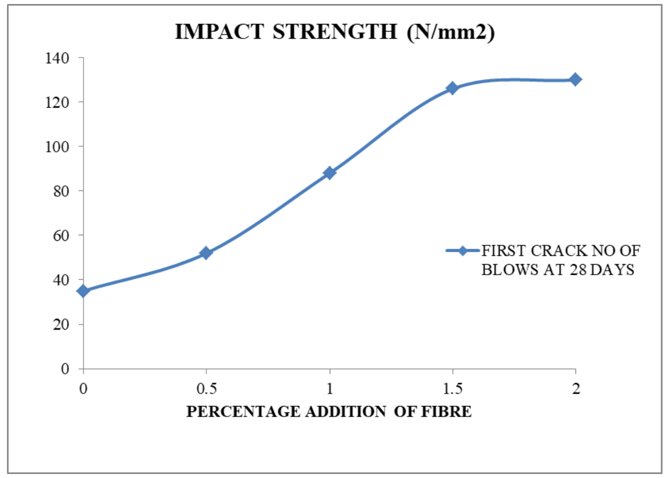

Fig 6.4 shows the impact strength at first crack no of blows (28) days

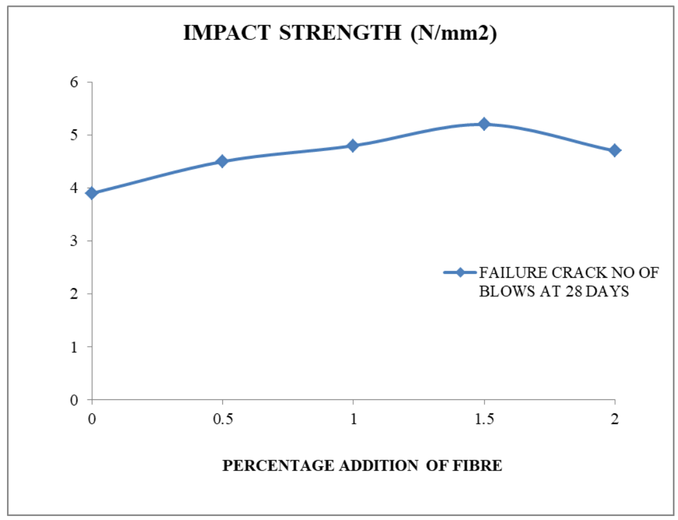

Fig 6.5 shows the impact strength at failure no of blows (28) days

From the above figures obviously at as the rate of fibers expands the number of blows required to disappointment the example additionally increments. From this we can clearly observed that as there is an augmentation in the fiber content there is likewise an addition in the effect valve or quality. In this manner sway quality increments with the expansion of expansion of filaments in the blend. At the point when contrasted and controlled cement the expansion in the effect quality with fiber expansion in rates of 0.5%, 1%, 1.5% separately.

VII. CONCLUSIONS

The purpose of this study was to investigate the use of Nano silica and crumb rubber in concrete as a waste material by assessing their effect in concrete specimens cured under normal water. The following conclusions are made based on the laboratory experiments carried out in this investigation.

1. It has been observed that workability decreases linearly at rate of 10 % for every 0.5% addition of combined fibers. From the laboratory results obtained during the experimental work it is observed that the strength of concrete reinforced with fibers significantly higher than the normal concrete.
2. Compressive strength of concrete increases linearly with increase of % combination of fibers up to 1.5% and decreases thenceforth. Hence 1.5 % of fiber i.e 0.75% steel fiber and 0.75% of banana fiber is the optimum limit for the concrete.
3. Compressive strength of hybrid fibre reinforced concrete contrast with conventional cement on account of expansion of fibers. The greatest increment in compressive strength observed at having mixture proportion 1.5 % i.e. 0.75 % steel fiber and 0.75 % banana fiber and When contrasted and controlled cement the expansion in the compressive strength with fiber expansion in rates of 0.5%, 1%, 1.5% is 5.88%, 15.43%, 23.74% separately.
4. The flexural strength exhibited improvement with steel fibers and banana fibres having mixture proportion 1.5 % i.e. 0.75 % steel fiber and 0.75 % banana fibre. The highest flexural strength of sample 0.75 % steel fiber and 0.75 % banana fibre was found 5.2 N/mm2 and the percentage increment in strength was about 33.33% at 28 days greater than conventional concrete.
5. From the results, it is evident that with the increase of fiber content the tensile nature of the concrete also increases results in higher values compared to that of plain concrete. From the laboratory experimental results it can be infer that for 0.5% addition of fibers there is very minimal increment in results from that point addition of fibre percentage i.e 1%, 1.5% there may increment in quality when contrasted and controlled concrete the expansion in the split elasticity with fiber expansion in rates of 0.5%, 1%, and 1.5% is 4%, 36.09%, and 46.12% separately.
6. Impact quality of hybrid fibre reinforced concrete increases linearly with the increment fibre content.
7. The ideal rate of fibre content is 1.5%. Addition of fibers up to 1.5% gives prominent results in all quality parameters contrast with other blend extent.

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