EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF HYBRID FIBRE REINFORCED CONCRETE USING STEEL AND BANANA FIBRES

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Abstract - *This Experimental study investigates the behaviour of strengthened concrete reinforced with banana fibres and steel fibres to improve the strength and practices of concrete. Banana plant (Scientific name: Musa sapientum) not only produces the delicious fruit but it also provides the textile fibre. This paper mainly focuses the banana fibre-based composites which have wide applications in construction. These banana fibres have good physical and mechanical properties and can be employed more productively. Banana fibres are economical, ecological and perishable. In this investigation, different percentages of banana fibres 0.5%, 1%, 1.5%, and 2%) having 40mm length of banana fibres and 50mm length of steel fibres are used. Ordinary Portland cement of grade 43 and M25 grade concrete were used. At various periodical intervals, the banana fibre and steel fibre reinforced concrete are tested for compressive strength, split tensile strength, flexural strength test.*

***Key words*: Steel fibres, Banana fibres, Hybrid fibres, Compressive strength, flexural Strength, Tensile strength.**

1. INTRODUCTION

Concrete is weak in tension and possesses brittle characteristics. The concept of using fibres to enhance the characteristics of construction materials is very old. Use of continuous reinforcement (primary) and fibre reinforcement (secondary) in concrete, increases strength and durability properties of concrete. When concrete cracks, the randomly oriented fibres start functioning, capture crack development and dissemination, and thus enhance strength and durability.

The presence of fibres in the concrete opposes the cracks development in the concrete mix, in which the fibres provide essential strength under existing loads against failures due to cracks. By opposing the development of cracks generation due to internal deficiencies of concrete can leads to an increase in the development of static and ideal properties of the Concrete.

The experimental study was conducted on these agricultural waste of Banana fibres as a fibrous combination of concrete material. The research experiments carried on the mixture of two or more kinds of FRC such as steel and Banana Fibres generally encourage the performance of the concrete. The action of Hybrid Fibre Reinforced Concrete (HFRC) depends on the aspect ratio, shape, and distribution of fibres in concrete mix. The fibre reinforced concrete has a wide range of applications in concrete technology it is primarily restricted to only road paving and industrial ground laying. nowadays it is applied to barrages, subways, canal laying, covering, safety vaults, flare-up resistance buildings.

1.1 MATERIALS

The materials are utilized in the existing investigation is as per the following.

1.1.1 Ordinary Portland Cement (OPC). Physical properties OPC are fineness, Specific Gravity, Fine's modulus, Initial and final setting time,

1.1.2 FINE AGGREGATES: It is defined as the material which is having a smaller size of less than 4.75mm, and it is naturally available in the river bed is used as fine aggregates. And also, the sand is excavated from the river, lake, or sea-shore. If we use seashore sand, it may cause efflorescence, due to chloride content in the sand it may cause corrosion of the reinforcement, so that it should be washed thoroughly before we use.

1.1.3 COARSE AGGREGATES: Constructive aggregate (coarse aggregate), or simply "aggregate", is the material retained on 4.75mm size sieve is termed as coarse aggregates, these are natural gravels obtained from the quarries of pits. In this pit, the alluvial or glacial action causes to deposition of flint, quartz, schist, and igneous rocks.

1.1.4 HYBRID FIBRES (BANANA AND STEEL FIBRES):

Banana Fibres: The Banana fibres are the naturally occurring fibres and also, scientifically called as Musa-Sapient fibres. The fibres are having very high strength among all the natural fibres and it is similar to bamboo fibres due to their ability to spin, the fineness tensile strength is best.

Fig 1.1 Banana Fibre

Alkali treatment of Banana fibres

The Banana fibres are extracted with the help of machinery after fruits are harvested from the Banana tree, then its fibres are subjected to alkali treatment of its surface to enhance its physical properties, the fibres are immersed in the 5% of sodium hydroxide (NaOH) solution until 4 hours to protect against oxidation of fibres, these protected fibres are then washed with clean water until the fibres get neutralized PH value.

Steel Fibre: The steel fibres are present in this practical study is having dia 1mm and hook-ended types. also has an aspect ratio of 50. Because the aspect ratio is described as the length of fibre to its dia of the fibre, which is having a mass of 7900 kg/cum.

Fig 1.2 Steel Fibre

2. OBJECTIVE AND SCOPE OF WORK

It is very essential to adopt locally available resources in structure with practical knowledge. Up to now, the HFRC is restricted to the application of aviation fields and programmed manufacturing companies. The objectives of the study are

- To obtain the compressive strength of conventional concrete and hybrid-fibre reinforced concrete with 0.5% of Banana fibres is kept constant and varying steel fibres as 0.5%, 1%, 1.5%, 2%.
- To obtain the split tensile strength of conventional concrete and hybrid-fibre reinforced concrete with 0.5% of Banana fibres is kept constant and varying steel fibres as 0.5%, 1%, 1.5%, 2%.
- To obtain the flexural strength of conventional concrete and hybrid-fibre reinforced concrete with 0.5% of Banana fibres is kept constant and varying steel fibres as 0.5%, 1%, 1.5%, 2%.
- To observe the behaviour of hybrid concrete with 0.5% of Banana fibres is kept constant and varying steel fibres as 0.5%, 1%, 1.5%, 2%. compared to conventional concrete.

2.1 METHODOLOGY

- In this project work to ensure the strength of concrete, cement is added with the hybrid fibres which enhances potential of hybrid fibre reinforced concrete.
- In this project work addition of cement with 0.5% of Banana fibres keeping it as constant and steel fibres varying up to 2% by volume of cement.
- The appropriate mix design is calculated which is suitable to achieve desired strength. The Ordinary Portland cement of 43 Grade is used in this study.
- The various practical tests are conducted on construction materials to obtain the physical characteristics of materials.
- During the dry mix, the fibres are uniformly distributed over the concrete, and Cubes, Cylinders, and Beams are cast and subjected to curing to achieve the desired strength.

3. MIX DESIGN FOR M25

a) Target strength = 25+1.65*4=31.6

b) Water-cement ratio water cement ratio = 0.4 to 0.45 assume water/cement = 0.4

c) Selection of water requirement for

75mm slump = 186+3/100*186 = 191.58 litres

d) Cement requirement water/cement = 0.4, C = 191.58/0.4 = 478.95 kg/m3

e) Volume proportion of Coarse aggregate and fine aggregates

-Coarse Aggregates = 1148.10 kg/m3

-Fine aggregates = 728.722 kg/m3

-Mix proportion for M25 = [1: 1.5 :2.4]

4. Test Results and Discussion

4.1 Compression Test

Fig.4.1 Compression Testing Machine

To describe the quality control over the concrete the compression strength is the most essentially required parameter, because the concrete strength is obtained by testing the cured concrete, for various days of the period, only we can obtain by compressive strength test. The compressive strength mainly depends on the load applied to the surface area.

Table 4.1 Compressive Strength Test Results

CONCRETE CUBES	COMPRESSIVE STRENGTH FOR 7 Days (N/mm2)	COMPRESSIVE STRENGTH FOR 28 Days (N/mm²)
Conventional Cubes	14.94	25.18
0.5% Banana and 0.5% steel fibre	17	27.83
0.5%Banana and 1% steel fibre	19.7	30.66
0.5%Banana and 1.5% steel fibre	20.89	31.7
0.5%Banana and 2% steel fibre	21.03	33.47

The above Table 4.1 shows that the comparison between compressive strength of conventional concrete and fibre reinforced concrete as 0.5% of banana fibre kept constant and varying steel fibres as 0.5%, 1%, 1.5%, and 2% and the compressive strength is obtained as 12%, 24%, 28%, and 28.94%, respectively for 7 days of cured samples. Similarly, 9.5%, 17.87%, 20.56%, and 24.76% respectively compressive strength is obtained for 28 days of cured samples as compared to nominal concrete.

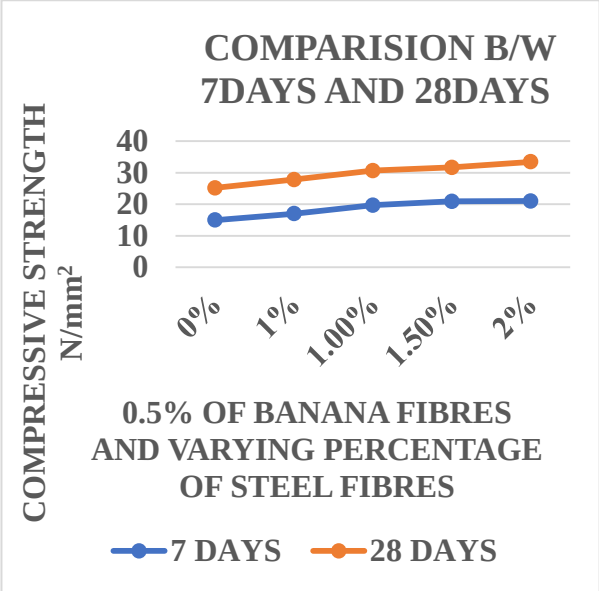

Fig 4.2 Variation in the Compression strength of hybrid fibres and Normal concrete

The above graph plotted between compressive strength of samples for 7days and 28 days by observing this chart the strength is linearly increased as the reinforcement of fibre increased up to 2%.

4.2 Flexural strength test

Fig 4.3 Universal Testing Machine

The below Table 4.2 represents the results obtained by the UTM for 28 days of flexural strength varying reinforcement of concrete by hybrid fibres up to 2%. This results in successive improvement of flexural strength of the beam.

Table 4.2 Flexural strength test results (For 28 Days Curing)

CONCRETE BEAM	APPLIED LOAD (KN)	LENGTH OF FRACTURE (mm)	FLEXU-RAL STRENGTH (N/mm²)
Conventional beam	35.6	32.5	1.120
0.5%Banana and 0.5% steel fibre	36.8	33.5	1.142
0.5% Banana and 1% steel fibre	37.3	34.5	1.148
0.5%Banana and1.5% steel fibre	38.5	34.5	1.216
0.5%Banana and 2% steel fibre	38.78	34.5	1.232

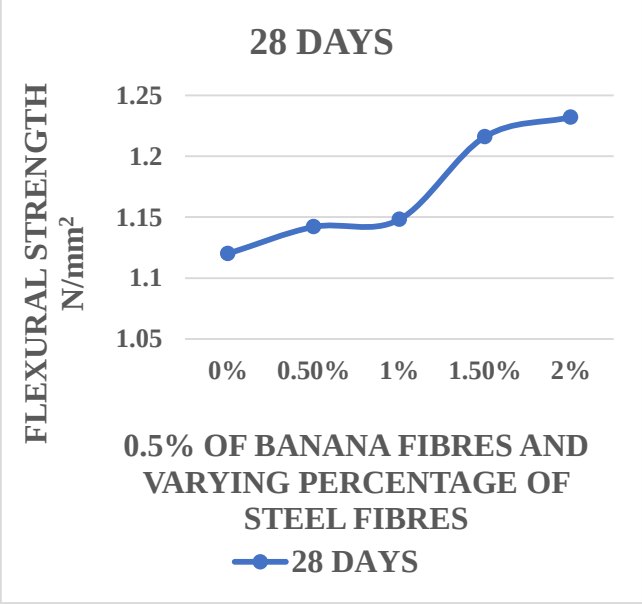

Fig 4.4 Variation in the flexural strength of hybrid fibre reinforced concrete

The above graph represents the flexural strength of the sample to the varying percentage of hybrid fibres up to 2% of steel fibres and 0.5% of Banana fibres. by this graph, we noticed that the flexural strength of the concrete varies gradually up. The above Fig 4.4 shows the variation in the flexural strength of hybrid concrete Beams with 0.5% of Banana fibres maintained constant and steel fibres varying up to 2%. The above graph reports, that there is an enhancement in flexural strength for 28days is 0.022N/mm², 0.028N/mm², 0.096N/mm², and 0.112N/mm², for 0.5%, 1%, 1.5%, and 2%, of steel fibres respectively as compared to flexural strength of Nominal Concrete.

4.3 SPLIT TENSILE STRENGTH TEST.

The tensile strength of concrete is determined as the capacity of cylindrical sample to with stand against the applied load under compression testing machine until it splits across its diameter of cylindrical sample. The standard dimension of cylindrical sample is 150mm in diameter and 300mm in height. Split tensile strength is one of the basic and essential properties of concrete.

Fig 4.5 Split tensile strength test of cylinders

Table 4.3 Split Tensile Strength Test Results

CONCRETE CYLINDER	TENSILE STRENGTH FOR 7 Days (N/mm2)	TENSILE STRENGTH FOR 28 Days (N/mm²)
Conventional cylinder	2.12	3.01
0.5%Banana and 0.5% steel fibre	2.35	3.09
0.5%Banana and 1% steel fibre	2.52	3.4
0.5%Banana and 1.5% steel fibre	2.82	3.75
0.5%Banana and 2% steel fibre	2.96	3.92

The above table 4.3 shows the results of the split tensile strength test of the cylindrical sample tested under CTM. For 7days and 28 days of cured cylinders, it resulted in enhancement of tensile strength for varied hybrid fibre reinforcing up to 0.5% of Banana fibres maintained constant and varying steel fibres up to 2%. The above Table3.15 reports, that there is an enhancement in split tensile strength for 7days is 9.78%, 15%, 24%, and 28.3% for 0.5%, 1%, 1.5%, and 2% of steel fibres respectively, as compared to nominal concrete, similarly split tensile strength for 28 days is 2.58%, 11.47%, 19.7%, and23.21% for 0.5%, 1%, 1.5% and 2% of steel fibres respectively, as compared to nominal concrete.

The below Fig 4.6 shows the Variation in the compression strength of hybrid concrete Cylinders with 0.5% of Banana fibres maintained constant and steel fibres varying up to 2%. The above graph reports, that there is an enhancement in Tensile strength of 7days is 0.23N/mm², 0.4N/mm², 0.7N/mm², and 0.84N/mm², for 0.5%, 1%, 1.5%, and 2%, of steel fibres respectively as compared to Nominal Concrete. Similarly, Tensile strength of 28 days is 0.08 N/mm², 0.39 N/mm², 0.74 N/mm², and 0.91 N/mm² for 0.5%, 1%, 1.5%, and 2% of steel fibres respectively, as compared to nominal concrete.

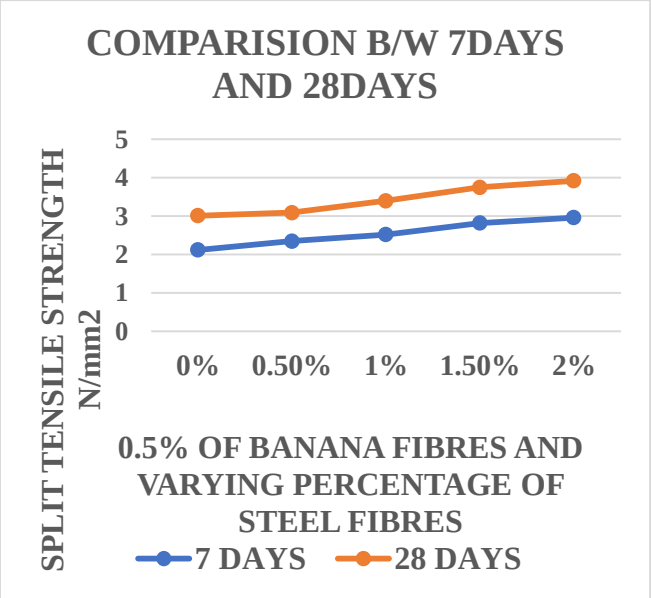

Fig 4.6 Variation in the Split tensile strength of cylinders

4.4 DISCUSSIONS

- There is an enhancement in compression strength of hybrid fibre strengthened concrete as compared to nominal concrete. By addition of cement with hybrid fibres indicates the enhancement of compressive strength by maintaining a constant ratio 0.5% of Banana fibres and linearly varying steel fibres as 0.5%, 1%, 1.5%, and 2%. The compressive strength is obtained for 7days and 28 days samples.
- The compressive strength of the 7days Fibres reinforced sample reveals there is an increment of 28.95% as compared with nominal concrete, and for 28 days Fibres reinforced sample's strength was revealed by 24.76%.
- The flexural strength was obtained for 28days of curing with varying percentages of hybrid fibre reinforced concrete up to 2% through the volume of cement. The outcomes of flexural strength for 28 days resemble that uniformly distributed HFRC improved flexural strength by 9.89%.
- For 7 Days of cured HFRC samples the minimum tensile strength is 9.78% attained at 0.5% of banana fibres and 0.5% of steel fibres and maximum tensile strength is 28.3% is attained at 0.5%of banana fibres and 2% of steel fibres.
- For 28 Days of cured HFRC samples the minimum tensile strength is 2.58% attained for 0.5% of banana fibres and 0.5% of steel fibres and maximum tensile strength is 23.21% is attained for 0.5%of banana fibres and 2% of steel fibres.
- The workability of concrete is getting altered due to the enriched quantity of steel fibres. That is the

reason it is limited only for the industries flooring, air navigation fields, and Tunnel sections.

- The HFRC enhances the ductile character and empowers the potential of structures in seismic zone.

5. CONCLUSIONS

- As compared to normal concrete, Hybrid Reinforced Concrete gives high compressive strength by varying steel fibre percentage (percentage of Banana fibre is maintained constant, i.e., 0.5% and steel fibre varies from 0.5% to 2%).

- The compressive strength of hybrid fibre reinforced concrete is more as compared to conventional concrete. As there is increase in fibres content in concrete it will increase the compressive strength.

- The compressive strength of hybrid fibres reinforced concrete with 0.5% of banana fibres and 0.5%, 1%, 1.5% & 2% of steel fibres is 12%, 24%, 28%& 28.94% more compared to conventional concrete at 7 days respectively.

- The compressive strength of hybrid fibres reinforced concrete with 0.5% of banana fibres and 0.5%, 1%, 1.5% & 2% of steel fibres is 9.5%, 17.87%, 20.56% & 24.76% more compared to conventional concrete at 28 days respectively.

- As compared to nominal concrete, hybrid fibres reinforced concrete gives high tensile strength with 0.5% of Banana fibres and varying the percentage of steel fibres. As there is increase in fibres content in the concrete it will increase the tensile strength.

- The Tensile strength of hybrid fibres reinforced concrete with 0.5% of banana fibres and 0.5%, 1%, 1.5% & 2% of steel fibres is 9.78%, 15%, 24% & 28.3% more compared to conventional concrete at 7days respectively.

- The Tensile strength of hybrid fibres reinforced concrete with 0.5% of banana fibres and 0.5%, 1%, 1.5% & 2% of steel fibres is 2.58%, 11.47%, 19.7% & 23.21% more compared to conventional concrete at 28 days respectively.

- As compared to nominal concrete, hybrid fibres reinforced concrete gives high flexural strength with 0.5% of Banana fibres and varying the percentage of steel fibres. As there is increase in fibres content in the concrete, it will increase the flexural strength.

- The flexural strength of hybrid fibres reinforced concrete with 0.5% of banana fibres and 0.5%, 1%, 1.5% & 2% of steel fibres is 1.92%, 2.4%, 7.8% & 9.89% more.

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