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Mechanical Properties of Fiber Reinforced High Strength Concrete and Comparing them with Normal Conventional Concrete

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Abstract— *The study on the mechanical properties of fiber reinforced high strength concrete(FRHSC) and comparing them with normal high strength concrete(HSC) gives us the result of increasing strength by adding different percentage(%) of fibers in M70 grade concrete mix. The reason for less use of FRHSC is its high cost of fibers and it also employs higher cement content which results in increasing water absorption capasity of the concrete mix. In this study , material properties of an FRHSC containing sisal, nylon, polypropylene fibers are determined which include compressive strength, split tensile strength and flexural strength. this fibers are relatively cheaper and mostly used fibers in concrete which are recently investigated by a few researchers. In this experimental work, there is no replacement of any material. In this study, influence of addition of 0.5, 1 and 1.5% fibers in different volume fraction in M70 grade HSC is investigated. Experimental results showed that the addition of fibers up to 1.5% together with mineral admixtures improved the compressive strength, split tensile strength and flexural strength. The improvement in the strain corresponding to maximum compressive strength, split tensile strength and flexural strength results was observed at all fibers and comparing them with normal conventional concrete results.*

Keywords*: high strength concrete, fiber reinforced high strength concrete, silica fume, compressive strength, split tensile strength, flexural strength*.

1.INTRODUCTION

High-strength concrete columns can hold more weight and therefore be made slimmer than regular strength concrete columns, which allows for more useable space, especially in the lower floors of buildings. High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall cost of the structure.

A high-strength concrete is always a high-performance concrete, but a high performance concrete is not always a high-strength concrete. ACI defines a high-strength concrete as concrete that has a specified compressive strength for design of 6,000 psi (415MPa) or greater. Other countries also specify a maximum compressive strength, whereas the ACI definition is open-ended.

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of concrete materials.This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibres. The results also pointed out that the micro fibres is better in impact resistance compared with the longer fibers and In this study, the dynamic behavior of fiber reinforced high strength concrete is investigated,which showed good results .therefore, use of FRHSC is one of te good substitutes of conventional synthetic fibers.

Certainly, to investigate the influence of several engineering materials parameters on performance HSC, it is essential to have sufficient knowledge about material properties including compressive strength, split tensile strength, flexural strength. The HSC mix was prepared by adding 10% silica fume, 10% fly ash and super plasticzer to attain good strength of the concrete.

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2.EXPERIMENTAL PROGRAM

Experimental program include selection of material for the preparation of high strength concrete (with and without fibers),specimen size and thier preparation and specimen testing setup, for determining the mechanical properties, in afterword section.

2.1 BATCHING AND MIXING OF FRHSC:

The proportioning of the quantity of cement, cementitious material like Flyash, fine aggregate and coarse aggregate has been done by weight as per the mix design. Water, super plasticizer were measured by volume. All the measuring equipments are maintained in a clean serviceable condition with their accuracy periodically checked.

The mixing process is carried out in electrically operated concrete mixer. The materials are laid in uniform layers, one on the other in the order - coarse aggregate, fine aggregate and cementitious material. Dry mixing is done to obtain a uniform color. The fly ash is thoroughly blended with cement before mixing. Self Compacting characteristics of fresh concrete are carried out immediately after mixing of concrete using EFNARC specifications].

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The workability properties of Normal Concrete (NC) Viz., slump was maintained in the range of 75 – 100 mm and compaction factor was 0.9. In higher strength concretes, these are maintained by adjusting the mineral and chemical admixtures.

2.2 Curing of test specimens:

After 24 hours of casting, the specimens were removed from the moulds and immediately dipped in clean fresh water. The specimens were cured for 3 days, 7 days and 28 days respectively depending on the requirement of age of curing. The fresh water tanks used for the curing of the specimens were emptied and cleaned once in every fifteen days and were filled once again. All the specimens under immersion were always kept well under water and it was seen that at least about 15 cm of water was above the top of the specimens.

2.3 Mix proportions for HSC:

The mix proportion of M70 grade of concrete designed on the basis of Nan Su method for different maximum sizes of aggregates 12.5mm . For the mix proportions obtaine, highlights the details of various parameters including total aggregate – cement ratio (A/C), water – cement ratio (w/c), coarse aggregate - fine aggregate ratio (CA/FA) and fine aggregate – total aggregate ratio (S/a) for various aggregate sizes

Table 1 Parameters of M70 grade HSC mix proportions

MIX TRAIL NO	A/C	w/c	w/p	CA/FA	S/a
1	2.42	0.38	0.269	0.935	0.520
2	2.43	0.366	0.257	0.914	0.514

Fig 1. Mixing of concrete

Fig 2. Demoulding of concrete

3. EXPERIMENTAL RESULTS

3.1 Compressive strength:

The results of the mechanical properties obtained based on the specimens tested as per Indian standard test procedures (as per IS: 516) are discussed. M 70 are the variables of investigation. The details of the compressive strengths of M70 grade are shown in Table 2

Table 2 Compressive strength

MIX TRAIL RESULTS	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
TRAIL	36.20	49	71.49

Fig 3 Testing of specimen

3.2 split tensile strength:

The results of the mechanical properties obtained based on the specimens tested as per Indian standard test procedures (as per IS: 516) are discussed. M 70 are the variables of investigation. The details of the split tensile strengths of M70 grade are shown in Table 3

Table 3 split tensile strength

MIX TRAIL RESULTS	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
TRAIL	2.80	5.90	8.6

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Fig 4.Testing of specimen

3.3 Flexural strength:

The results of the mechanical properties obtained based on the specimens tested as per Indian standard test procedures (as per IS: 516) are discussed. M 70 are the variables of investigation. The details of the split tensile strengths of M70 grade are shown in Table 4

Table 4. flexural strength

MIX TRAIL RESULTS	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
TRAIL	3.375	6.16	9.415

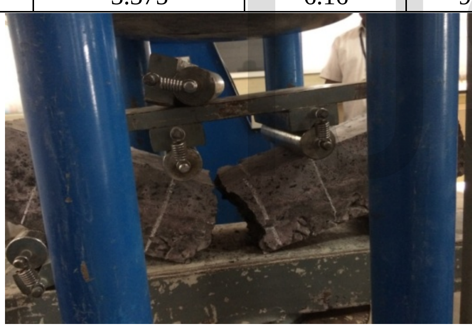

Fig 5. Testing of specimen

Table 5 compressive strength of FRHSC:(sisal fibers)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	44	58.3	78
1%	47	66.3	85.4
1.5%	52.1	69.8	92.4

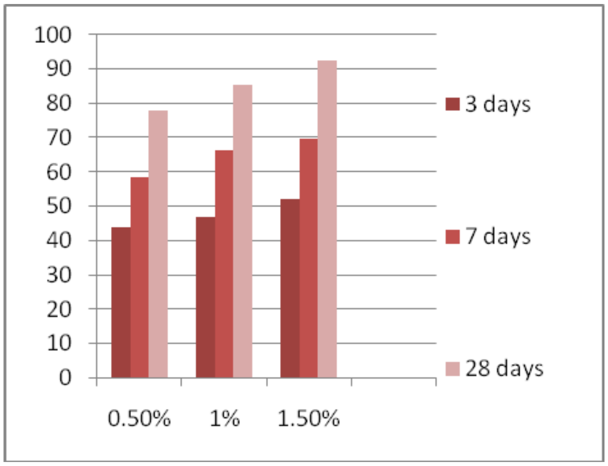

Fig 9. Compressive strength graph(sisal fiber)

Table 6 compressive strength of FRHSC:(nylon fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	42.3	58.1	76
1%	44.7	64	83.6
1.5%	52.1	69.6	87.2

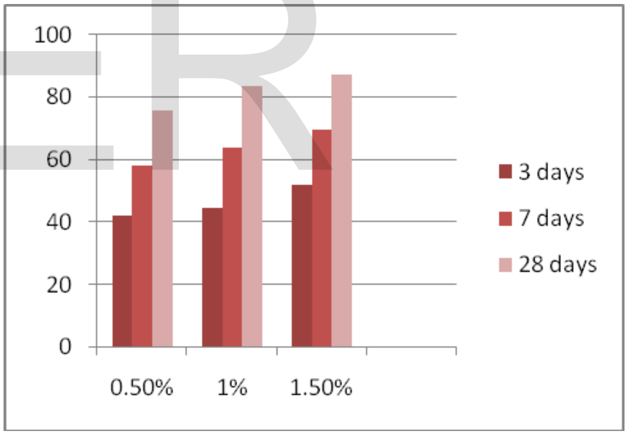

Fig 10.Compressive strength graph(nylon fiber)

Table 7 compressive strength of FRHSC:(polypropylene fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	45	62.5	81
1%	49.2	72	88.3
1.5%	53.6	75.3	93.7

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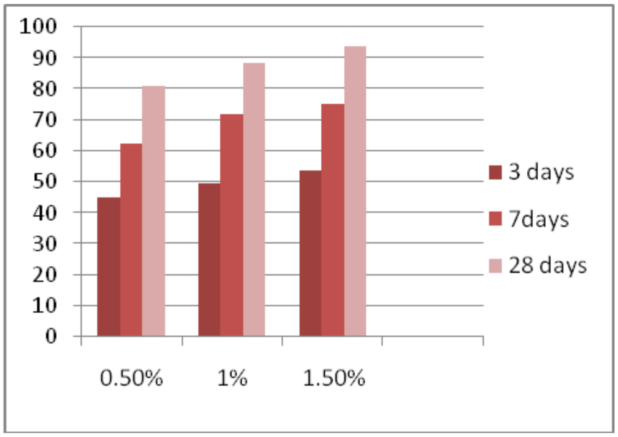

Fig 11.Compressive strength graph(polypropylene fiber)

Table 8 split tensile strength of FRHSC:(sisal fiber}

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	3.771	6.759	9.96
1%	4.052	7.638	10.759
1.5%	4.94	8.538	11.554

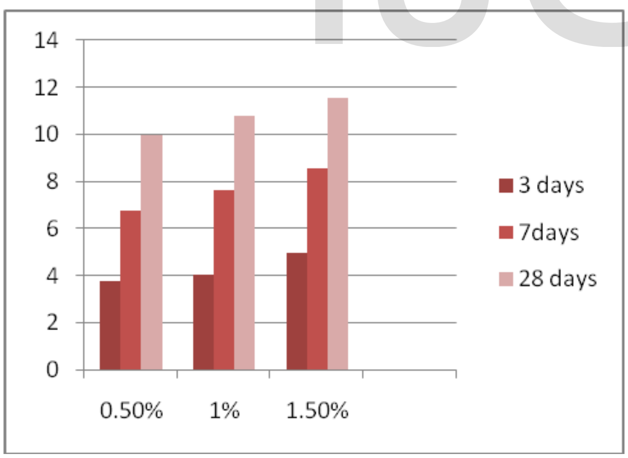

Fig12.Split tensile strength graph (sisal fiber)

Table 9 split tensile strength of FRHSC:(nylon fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	3	6.466	9.49
1%	3.921	7.516	10.249
1.5%	4.720	7.516	10.480

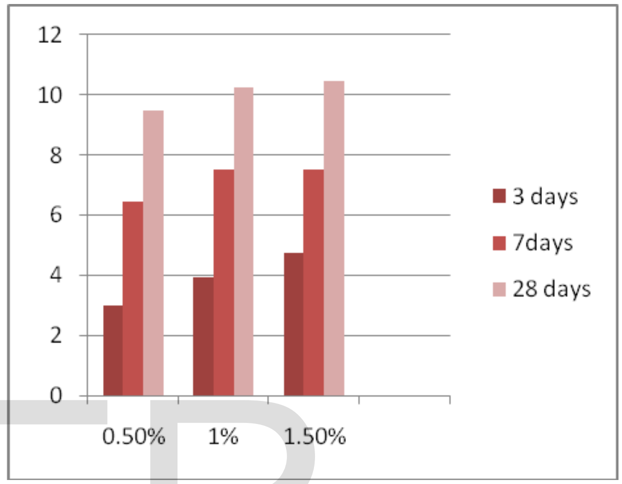

Fig 13.Split tensile strength graph(nylon fiber)

Table 10 split tensile strength of FRHSC:(polypropylene)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	3.579	6.328	9.20
1%	4.374	7.450	10.804
1.5%	5.165	8.266	11.6927

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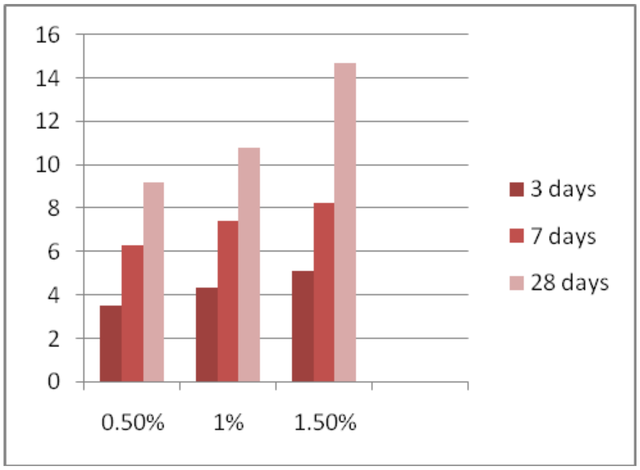

Fig 14.Split tensile strength(polypropylene fiber)

Table 11 flexural strength of FRHSC:(sisal fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	4.67	7.64	11.875
1%	6.185	9.43	13.14
1.5%	7.48	11.615	14.705

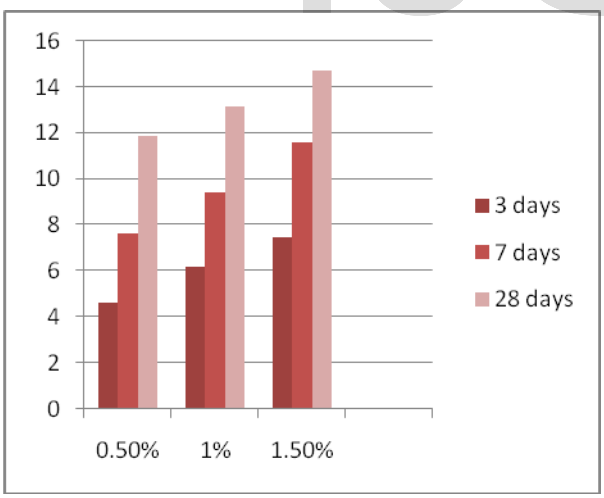

Fig 15.Flexural strength(sisal fiber)

Table 12 flexural strength of FRHSC:(nylon fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	4.38	7.155	10.045
1%	5.97	8.435	11.71
1.5%	6.58	11.185	13.9

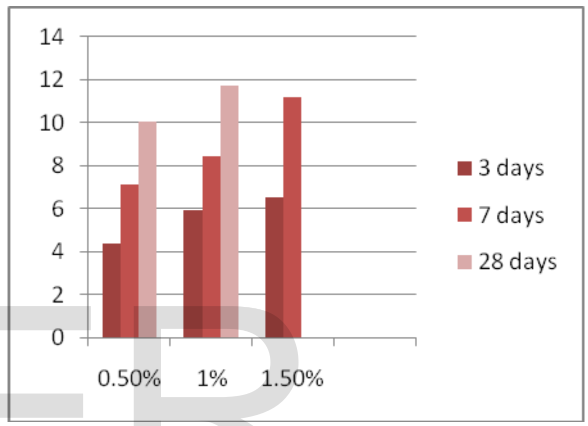

Fig 16.Flexural strength(nylon fiber)

Table 13 flexural strength of FRHSC:(polypropylene fiber)

% OF FIBERS ADDED	3 DAYS STRENGTH N/mm²	7 DAYS STRENGTH N/mm²	28 DAYS STRENGTH N/mm²
0.5%	**4.945**	**7.18**	**12.09**
1%	**6.545**	**9.935**	**13.185**
1.5%	**7.715**	**11.78**	**15.51**

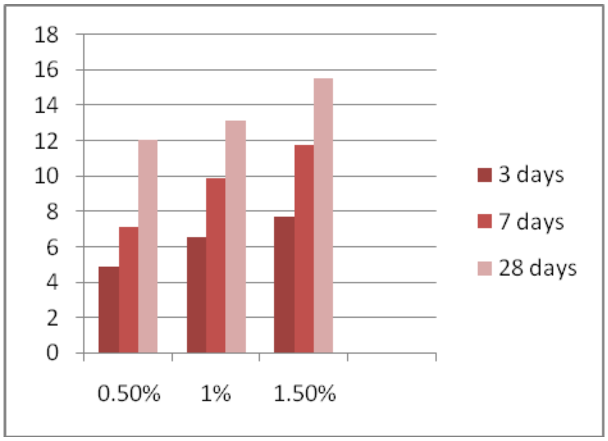

Fig 17. Flexural strength (polypropylene fiber)

V.CONCLUSION:

Based on the systematic and detailed experimental study conducted on FRHSC mixes with an aim to develop performance mixes, the following are the conclusions arrived.

- Polypropylene has high strength when compared to the remaining fiber.
- Sisal fiber has less strength when compared to the polypropylene fiber and more strength comparitive to the nylon fiber.
- Nylon fiber has less strength when compared to the remaining two fibers.
- While comparing the compressive strength, FRHSC gave 20 N/mm² more than conventional concrete.
- While comparing the split tensile strength, FRHSC gave 3 N/mm² more than conventional concrete.
- While comparing above flexural strength, FRHSC gave 5 N/mm² more than conventional concrete.
- while adding the fiber to the concrete mix ,the absorption of water increases more than the conentional concrete.

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