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"A COMPARATIVE STUDY ON MECHANICAL PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE WITH CONTROLLED CONCRETE"

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Abstract:
Concrete is a widely used construction material for building of various civil engineering structures. Concrete will give better durability and also its costs during construction as well as maintenance are very low. It is very good in sustaining compression loads. But when it comes to the tensile property it is very weak .Addition of fibers in the concrete has been come in to practice to overcome the problem. . In fiber reinforced concrete the fibers are added to the concrete mix so that those are discontinuous fibers will be uniformly distributed in the mix. They will improve the concrete in all directions. But to get more improvement in the mechanical properties work has been done by combining two different types of fibers knows as hybridization. The experimental work has been carried out for M_{20} mix proportion and the mechanical properties are tested by hybridizing the concrete with steel and glass fibers .fibers are hybridized and added in the percentages of 0.5%, 1%, 1.5% and the results are compared with controlled concrete. Steel fibers having aspect ratio 50 are added by volume of the mix and glass fibers having 40mm are added by weight of cement equally. The test results have shown improvement in the strength properties as the fibers are added in the mix with maximum values at 1.5% in comparison with controlled concrete. The variations are discussed below.

Key words: *hybrid concrete, steel fiber, glass fiber, compressive strength, tensile strength, flexural strength, impact strength, Sorptivity.*

1. INTRODUCTION:

As India is a one of the developing country construction industry plays an important role in it. For the construction of buildings and also for developing infra structures the most commonly used material is concrete. Concrete is a homogenous mix developed from mixing of various ingredients like cement ,coarse aggregates ,fine aggregates along with water .The variations in strength of concrete can be achieved by changing the proportions of ingredients appropriately during the mix along with some special characterized materials usually called as admixtures. Due to its high compressive strength, better durability characteristics along with low construction as well as maintenance cost it has been used in large amounts for various civil engineering applications. As we all know that concrete is very strong in compression but when it comes to the tensile property it is very weak and tends to fail because of its deficiencies such as low tensile strength, low strain at fracture. The weakness of concrete is due to the presence of micro cracks at mortar aggregate interface.

A special type of concrete has been developed known as Fiber reinforced concrete as the resolution for weakness properties in concrete. In FRC the fibers are added to the concrete mix so that those are discontinuous fibers will be uniformly distributed in the mix. Thus due to the addition of fibers there will be improvement in concrete in all directions. Because of fiber inclusion in the concrete mix fibers acts as crack arrester so that there will be a restriction for the development of cracks. The addition of two or more different fibers in the concrete mix is termed as Hybridization. The different fibers are chosen based on their inherent properties i.e. if two different fibers are added in the mix one fiber should strong and stiff properties whereas the other should possess flexibility and ductility. Thus due to the combination there will be improvement in initial crack stress, ultimate strength and toughness after cracking. Thus hybridization results in bridging of both micro cracks and macro cracks in the different stages by choosing an appropriate fiber to the concrete mix.

The addition of fibers to construction materials had been started from the olden days. In order to strengthen the bricks horse hair and straws were used to add in those days .the use of fiber in concrete has been founded by Porter in 1911.asbestos fiber saw its use in early 1900. Mr.Ranjith Kumar.R et al(2013)[1] has done experiments on strength of concrete by adding steel and glass fibers having different aspect ratios with 2% of weight of cement. They concluded that as the aspect ratio is increased strength properties have been increased and the

maximum results are for fibers having aspect ratio 100. Kavita S Kene et al (2012)[2] has studied on cubes and cylinders of sfrc having 0% and 0.5%volume fraction. Steel fibers of hook end and having different aspect ratios and glass fibers having 12mm were used. They concluded that due to the fiber addition workability will be decreased and improvement in compressive and tensile strength is found. Compressive strength of cylinders and compressive strength of cubes are found nearly in the ratio of 3:4. Chandra mouli K.et al (2010)[3] has studied on the addition of glass fibers in concrete. Glass fibers are added at 0.03% of volume of concrete for different grades and concluded that there will be 20 to 25% improvement in compressive strength and 15 to 20% in tensile and flexural strengths due to the addition. Avinash Gornale et al (2012)[4] has worked on addition of glass fibers to concrete and concluded that there is increase in strength properties for different mixes. Wakchaure M. R et al (2014)[5] has studied compressive strength and flexural strength by hybridizing with steel and glass fibers and compared with normal concrete. They concluded that at optimum percentage addition the mix will gain maximum strength.

The main objective of this work is finding the optimum percentage of addition of fibers where the mechanical properties of hybrid fiber reinforced concrete will be improved, to analyse the impact properties after the addition of fibers and comparing that to normal concrete. To study the durability characteristic feature like water absorption capacity before and after hybridization of concrete.

MATERIALS AND METHODS:

Cement: This experimental study has been carried by using of ordinary Portland cement (OPC) 53 Grade of ultra tech company. The different properties of cement are given below in table 1,

Table 1: cement properties

Sl.no	Properties	Opc 53(g)
1	Specific Gravity	3.15
2	Normal consistency	34%
3	Soundness	6mm
4	Initial setting time	40 min
5	Final setting time	4hr 30min

Coarse Aggregates:

Locally available Coarse aggregate of passing through 20mm sieve and retained on 4.75mm sieve were used for this study. Materials are brought from LAHOTI CRUSHERS in Shahabad road from Kalaburagi. Preliminary tests were conducted on coarse aggregate and its results are formulated in the following table 2.

Table 2: coarse aggregates properties

Sl.no	Properties	Results
1	Shape of aggregate	Angular
2	Specific gravity	2.78
3	Water absorption	16%
4	Fineness modulus	4.5

Fine aggregate:

The river sand with Zone II specification passing through 4.75mm sieve as per IS 383-1978.Sand is brought from Bheema river bed near Shahapur, its physical properties are irregular in size.The preliminary tests are conducted and the results are tabulated as below table 3

Table 3: Fine aggregate properties

Sl no	Different properties	Results
1	Specific gravity	2.60
2	Water absorption	1%
3	Fineness modulus	2.5
4	Type and zone	River sand and Zone II

Water: Portable water is used for investigating this project during both for casting as well as for curing.

Steel fibers: In this present study the crimped steel fibers which are having a length of 25 mm, 0.5 mm dia, 500-700 Mpa tensile strength are used.

Glass fibers: In this study chopped strand mat glass fiber having length of 40 to 50 mm, density of 450/300 GSM (Grams per square meter) and tensile strength of 108 Mpa were used.

Concrete mix design:

The mechanical properties of hardened concrete are studied by casting cube, cylinder, and prism specimens. For impact test L/4 of cylinder specimens were casted. For M_{20} concrete mix proportion specimens were cast and tested after 28 days of curing. Materials for the mix

proportion were calculated as per IS 456-2000 using Indian Standard Mix Design (IS: 10262, 2009) for grade like M_{20}.The fibers are added in mix with different proportions such as steel fibers are added by volume and glass fibers are added by weight of cement in concrete mix. The percentage addition is shown below.

Table: 4 Different variations of fibers in the mix

Fiber added in concrete mix (%)	Steel Fibers by Volume of Concrete (%)	Glass Fibers by Weight of Cement (%)
0	0	0
0.5	0.25	0.25
1	0.50	0.50
1.5	0.75	0.75

1. RESULTS AND DISCUSSIONS:

Fresh concrete: slump cone test and compaction factor test are done on fresh concrete for knowing the workability of HFRC concrete and the values are tabulated below in table 5.

Table 5: Slump and compaction factor test results

Sl.no	% of fibers	Slump values in mm	Compaction factor
1	0	96	0.96
2	0.5	90	0.92
3	1.0	87	0.91
4	1.5	84	0.87

In the fig.1 as addition of fibers is increasing there is a decrease in the slump values. It is so because as the fibers are added the bleeding will be reduced and the mix will become harsh. From this we can conclude that as the percentage of fiber content is increased the workability will be decreased.

It can be observed from graph in fig.2 that as the fiber content in the mix increase compaction factor values decreases. From this we can conclude that the workability of the mix decreases as the content of the fiber in the concrete increases.

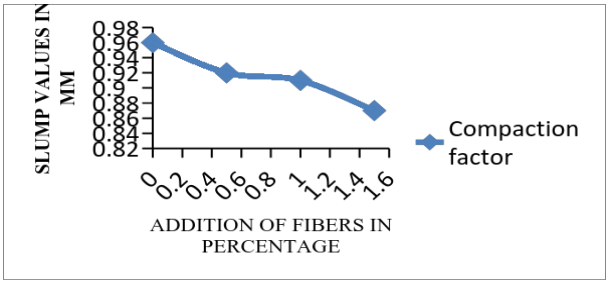

Fig 1: graph of slump cone test

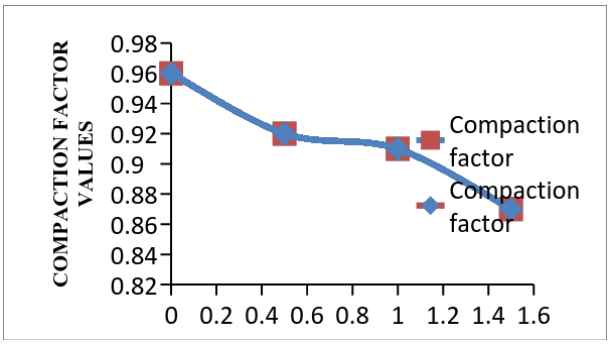

Fig 2: graph of compaction factor values

Hardened concrete: Compressive strength, Split tensile strength, Flexural Strength, Impact strength and Sorptivity of concrete were tested on Cubes, Cylinders and Prisms with different percentages of steel and glass for M20 mix are tabulated. The strength of concrete has been tested after 28 days of normal curing.

Compressive strength test

Table 6: Compressive strength results

sl. no	Fibers (%)	Compressive strength of HFRC in n/mm²	% variation compressive strength of HFRC over controlled concrete
1	0	27.596	0
2	0.5	30.253	10.96
3	1	31.692	14.84
4	1.5	32.359	17.25

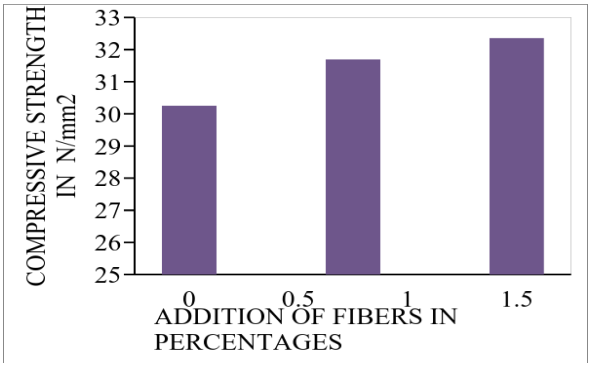

Fig 3: graph of compressive strength results

From the above fig.3 it is clear that at 0.5% addition of fibers the compressive strength is 30.253 N/mm2.As the percentage of fibers is increased to 1 % and to 1.5 % the compressive strength is 31.692 N/mm2, 32.359 N/mm2 respectively. When compared with controlled concrete the increase in the compressive strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 10.96%, 14.84%, 17.25% respectively.

Tensile strength test

Table 7: Tensile strength test results

Sl .no	fibers (%)	Tensile strength of hfrc in n/mm²	% variation tensile strength with controlled concrete
1	0	2.33	0
2	0.5	2.48	6.43
3	1	2.56	9.87
4	1.5	2.61	12.01

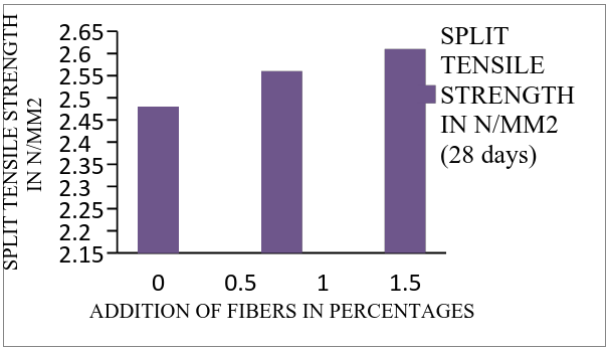

Fig 4: graph of tensile strength results

From the above fig.4 it is clear that at 0.5% addition of fibers the split tensile strength is 2.48 N/mm2.As the percentage of fibers is increased to 1 % and to 1.5 % the compressive strength is 2.56 N/mm2, 2.61 N/mm2 respectively. When compared with controlled concrete the increase in the split tensile strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 6.43%, 9.87%, 12.01% respectively

Flexural strength test

Table 8: Flexural strength results

sl .no	fibers (%)	flexural strength of hfrc in n/mm²	% variation flexural strength over controlled concrete
1	0	3.692	0
2	0.5	3.816	3.35
3	1	4.122	11.64
4	1.5	4.312	16.7

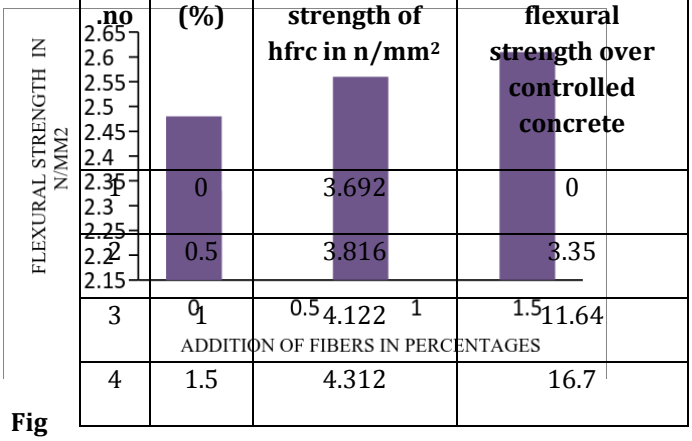

Fig 5: graph of flexural strength results

From the above fig.5 it is clear that at 0.5% addition of fibers the flexural strength is 3.816 N/mm².As the percentage of fibers is increased to 1 % and to 1.5 % the flexural strength is 4.122 N/mm², 4.312 N/mm² respectively. When compared with controlled concrete the increase in the flexural strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 3.35%, 11.64%, 16.7% respectively.

Impact strength test

Table 9: Impact strength test results

sl .no	Fibers fraction (%)	first visible crack in no. of blows	Final failure in no. of blows
1	0	4	15
2	0.5	7	29
3	1	9	48
4	1.5	16	61

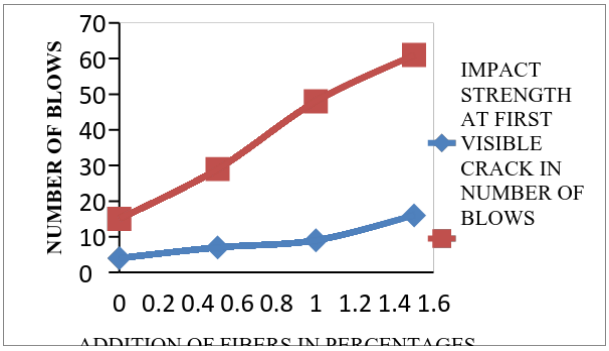

Fig 6:graph of impact strength results

From the above figure 6.6, it is clear that the number of blows required for the failure of impact specimen had been increasing when the percentage of fibers in concrete mix is increased. The number of blows required for visible crack for 0.5% is 7 and for failure is 29.As the fiber percentage is increased to 1% and1.5% the number of blows required to initial crack and also final failure are noted as 9,16 and also 48,61 respectively. Thus from the above results it resembles that as fiber percentage in concrete mix increases the impact resistance of concrete increases.

Sorptivity

Table 8:Sorptivity test results

Sl. No	fibers (%)	Dry weight in grams	Wet weight in grams	Sorptivity value in 10^-8mm/min^0.5
1	0	8108	8112	3.10
2	0.5	9036	9044	6.390
3	1.0	8624	8630	4.74
4	1.5	8642	8655	8.03

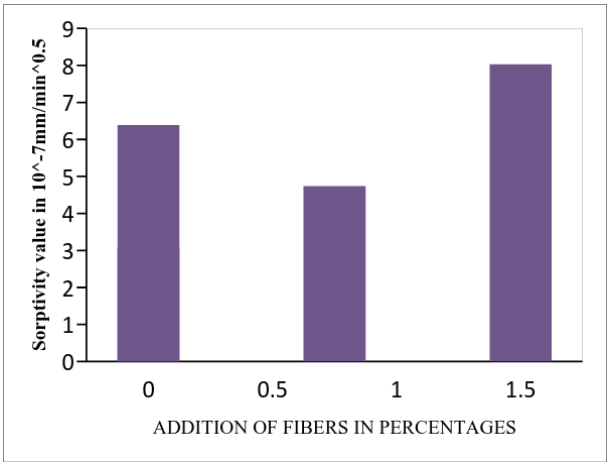

Fig 7:graph of sorptivity test results

CONCLUSIONS:

1. As the fibers content in the mix increases there is a decrement in the workability of the concrete. The compressive strength is increased as the fiber content is increased .when the HFRC is compared with controlled concrete the percentage increase in compressive strength of 0.5%,1%1.5% addition is 10.96%, 14.84%, 17.25% respectively.
2. Tensile strength has increases with addition of fibers in the mix.. The maximum strength is obtained at 1.5% fiber addition i.e.2.61 N/MM^2.when compared to controlled concrete the percentage of split tensile strength increases is 12.01 %.
3. Flexural strength has increases with addition of fibers in the mix. The maximum strength is obtained at 1.5% fiber addition i.e.4.312 N/MM^2.when compared to controlled concrete the percentage of split tensile strength increases is 16.7 %.There is a better improvement in the flexural strength than tensile strength due to the fiber addition.
4. The impact resistance has shown a great improvement when the fibers are added in the mix. It resembles that as fiber percentage in concrete mix increases the impact resistance of concrete increases.
5. The sorptivity values increases as the fiber content in the concrete mix increases but at 1% addition of fibers to the mix there is a decrement in the values. The maximum value is obtained for 1.5% addition of fibers in the mix. this may be due to the presence of more fibers in the mix.

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