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Strength Parameters of Hybrid Fiber Reinforced Concrete (HFRC)

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Abstract: ***Concrete is very strong and versatile mouldable construction material. It consists of cement, sand, aggregate mixed with water and with or without adding admixtures. As usual there are some disadvantages in concrete. They are of brittle in nature and less ductile in nature and is weak in tensile strength. Due to its initial cracks the durability of concrete is questioned. To solve this disadvantage the short discrete fibers that are uniformly distributed are added to concrete which will reduces the initial cracks and also to increase the strength of concrete another type of fibers added to concrete . so, adding of two fibers to concrete is known as Hybrid Fiber Reinforced Concrete (HFRC). In the present work the two fibers which are used are steel fibers and polypropylene fibers. Here one fiber will reduce the initial cracks and another fiber will increase the strength and durability of concrete. The fibers that are added to concrete are in equal portions with hybrid ratio of 0%,0.5%,1%,1.5%. A grade of concrete M_{30} is prepared as per the IS 10262:2009 reference code and then cube, cylinders are prepared and tested for Tensile strength, Flexural strength. The Hybrid ratio of 1.5% gives better results when compared to conventional concrete.***

Keywords: Concrete, Cement, Brittle, Ductile, Steel Fiber, Polypropylene Fiber, Tensile Strength, Flexural Strength

1. Introduction

As we know Concrete is Tension weak building material and also less initial crack resistance material. These cracks gradually develop with time, There by damaging the water proof agents and exposing the concrete to atmosphere. The exposing of concrete to atmosphere declines the strength of concrete and makes the reinforcement corrosion. To oppose these initial cracks in the concrete a small short discrete uniformly distributed fibers are added to concrete. The fiber mix in the concrete eventually increases the mechanical properties of concrete like Compressive Strength, Tensile Strength, Flexural Strength, Creep and Impact Resistance. In addition to increase of mechanical properties of concrete it also makes the concrete more homogenous and also transforms the concrete Brittle to more Ductile in nature.

Most of the fibers that are used for Fiber Reinforced Concrete are of one type only. The initial cracks in concrete are of micro size, under constant applied load the cracks grow from micro size to macro size. These macro cracks results in reducing the durability and also strength of concrete. Therefore for optimum results different types of fibers are added to concrete which is eventually called as Hybrid Fiber Reinforced Concrete (HFRC).

2. Experimental Work

Material Properties:

Cement:
The present experimental work is done by using Ordinary Portland Cement (OPC) of 53 Grade as per **IS 12269-1970** reference code book. The preliminary tests are conducted on the cement and resulted are tabulated below.

Table 1: Properties of Cement

S. No	*Properties*	*Results*
1	Specific Gravity	3.12
2	Soundness of cement	8mm
3	Normal consistency	35 %
4	Initial setting time	40 min
5	Final setting time	310 min

Fine Aggregate:
For present work locally available sand is used which is passing through 4.75 mm sieve as per **IS 383-1978** Reference code . Primary tests like Specific gravity, Water absorption ,Fineness modulus are tested and tabulated below.

Table 2: Properties of Fine Aggregate

S. No	*Properties*	*Results*
1	Specific gravity	2.62
2	Water absorption	2%
3	Type of sand	River sand
4	Zone	ll
5	Fineness modulus	2.0

Coarse Aggregate:
For present work locally available Coarse aggregate of 20mm down size and which retained in 4.75 mm size sieve is used. Primary tests like Specific gravity, Water absorption and Fineness modulus are conducted and results are tabulated below.

Table 3: Properties of Coarse Aggregate

S. No	*Properties*	*Results*
1	Specific gravity	2.72
2	Water absorption	15%
3	Shape of aggregate	Angular
4	Fineness modulus	4.0

Water:
Locally available water which is potable and available in laboratory is used for both casting and curing of specimen.

Steel Fibers:
Steel fibers are short discrete uniformly distributed of steel with aspect ratio from 30 to 150 and also with different cross sections. The diameter of steel fiber is 0.25 to 0.75 mm. In present work steel fibers with flat end is used. Steel fibers are brought from KASTURI COMPOSITES PVT.LTD, AMARAVATHI, NAGPUR, MAHARASTRA. The properties of steel fibers are tabulated below.

Table 4: Properties of Steel Fibers

Type of steel fiber	Crimped
Material	Low carbon drawn flat wire
Length of fiber	25mm
Aspect ratio	50
Tensile strength	500-750 mpa
Appearance	Clear, bright, flat end crimped steel fiber

Polypropylene Fibers
Polypropylene fiber is composed of crystalline and non crystalline regions. The fiber appearance is of fibrillated bundles, mono filament. The fibers are of different lengths 12mm, 24mm, 40mm cut length is available. Polypropylene fibers are brought from KASTURI COMPOSITES PVT .LTD, AMARAVATHI ,NAGPUR, MAHARASTRA. The specifications of polypropylene fibers are listed below.

Table 5: Properties of polypropylene fibers

Geometry of fiber	Fibrillated
Length of fiber	12mm
Tensile strength	500-750 mpa

Fibers Mix in Concrete:
The percentage of mix in concrete are of 0%, 0.5%, 1% and 1.5% (50% 0f each steel and polypropylene) . Adding percentages are tabulated below.

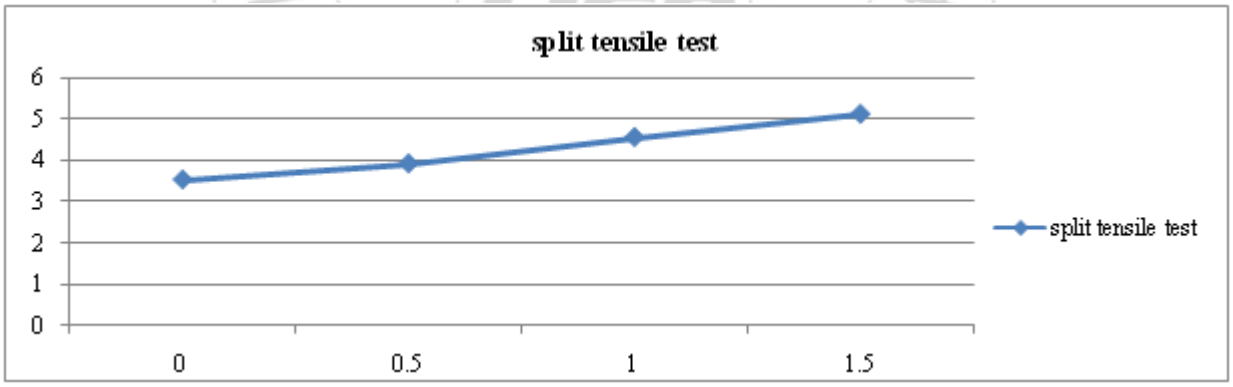
Table 6: Percentage variations of fiber mix

Percentage of fiber added in concrete mix (%)	Steel fibers by volume of concrete (%)	Polypropylene fiber by weight of cement (%)
0	0	0
0.5	0.25	0.25
1	0.5	0.5
1.5	0.75	0.75

3. Tests on Hardened Concrete

A. Split Tensile Test
For getting the Tensile test results cylinders are casted which are having dimensions of 300mm length and 150mm diameter. Cylinders are casted for M_{30} Grade of concrete with different percentages of addition of fibers. The cylinders are demoulded after 24 hours of casting and are to be cured for 28 days in curing tank . After completion of the 28 days cylinders are removed from moulds and kept for drying in atmosphere. Then the cylinders are taken to compressive testing machine and tested . The average of three values are taken in to consideration for getting the accurate value. The formula for calculating the tensile test is

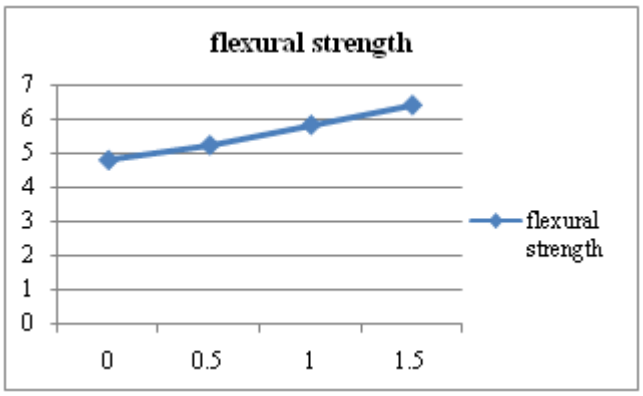
$f_t = {}^{2p}/_{\pi dl}$ where
p = compressive load at failure
d = Diameter of the cube
l = Cube length



Graph 1: Tensile test results of concrete for 28 days

B. Flexural Strength
Flexural strength of a concrete is determined by casting beams with dimensions 100mm x 100mm x 500mm . Prisms are casted for concrete grade of M_{30} with different percentages of addition of fibers. Prisms are demoulded after 24 hours and are kept for curing for 28 days in curing tank. After completion of the curing the prisms are kept dried in open atmosphere and taken for testing to Universal Testing Machine (UTM) which is having 1000 KN capacity of load failure. Flexural strength can be carried out by given formula.

$f_{bt} = {}^{pl}/_{bd^2}$ where
p = Failure load
l = Length of specimen
b = Breadth of specimen
d = Depth of the specimen



Graph 2: Flexural strength of concrete for 28 days

4. Conclusions

From the present work i can be concluded that

1) Tensile strength of concrete increases with increase in the hybrid ratio of addition of fibers . The hybrid ratio of 1.5% of addition of fibers gives the rise in the tensile strength more.
2) The percentage increase of Tensile strength with addition of fibers with hybrid ratios 0.5%, 1%, 1.5% are 10.22%, 27.12%, 45.56% respectively.
3) We can see that with increase in the addition of fibers to the mix in the concrete there is increase in the flexural strength of the concrete.
4) The percentage increase in flexural strength in the addition of fibers with hybrid ratio 0.5%, 1%, 1.5% are 9.55%, 19.45%, 34.65% respectively.
5) Overall we can see that with increase in the addition of fibers with hybrid ratio 1.5% increases the mechanical properties of the concrete. so, the addition of fibers to the concrete gives the better results when compared to conventional concrete.

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