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Strength Characteristics of hybrid fibre reinforced concrete

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ABSTRACT

Extensive research is currently going on to evaluate and quantify advantages of fiber added concrete in general civil applications. Different fiber additives can be combined with concrete to design for specific applications and optimize mechanical properties. Hybrids include the combination of micro synthetic fibers with steel fibers or micro synthetic fibers with macro synthetic fibers. A compromise to obtain good fresh concrete properties (including workability and reduced early-age cracking) and good toughness of hardened concrete can be obtained by adding two different fiber types, which can function individually at different scales to yield optimum performance.. In this paper the optimum dosage of fibers to get maximum strength for the M 30 grade concrete is found and the properties of concrete i.e workability, compressive Strength, flexural strength are found.

KEYWORDS: : workability, compressive strength, flexural strength, recron fibres, steel fibres

Introduction

In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself. In this the fiber will help in the better way to improve the properties of concrete. Fibers help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks. Concrete is widely used in structural engineering with its high compressive strength, low cost and abundant raw material. But common concrete has some shortcomings, for example, shrinkage and cracking, low tensile and flexural strength, poor toughness, high brittleness, low shock resistance and so on, that restrict its applications. To overcome these deficiencies, additional materials are added to improve the performance of concrete.

Here the fibers come in to picture. Mechanism involved in the process of crack propagation is described in the figure below.

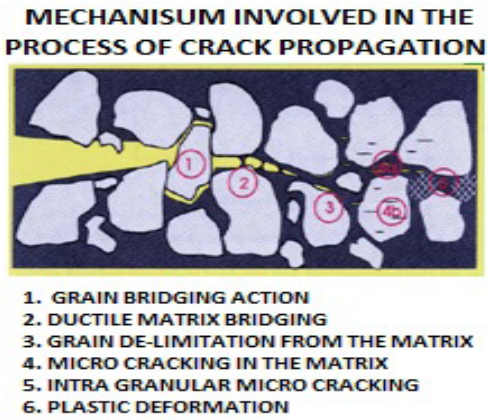


Fig.1 Mechanism involved in the process of crack propagation

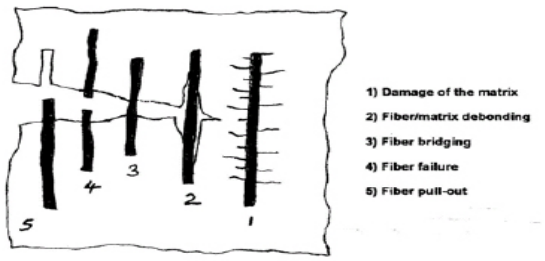


Fig.2 Basic concept of crack

Today Fiber Reinforced Concrete is very widely used, with annual production now approaching about 100 cubic meters. The principal applications are slabs on grade, shotcrete, and precast members, as well as a number of specialty applications. Until now, most of the production of FRC has been for "non-structural" applications, with the fibers added primarily for control of cracking due to plastic or drying shrinkage. However, there is now increasing use of fibers as the primary reinforcement in truly structural application.

Recent studies performed on a high-performance fiber-reinforced concrete in a bridge deck found that adding fibers provided residual strength and controlled cracking. There were fewer and narrower cracks in the FRC even though the FRC had more shrinkage than the control. Residual strength is directly proportional to the fiber content. FRC is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions.

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular, triangular or flat in cross-section. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter.

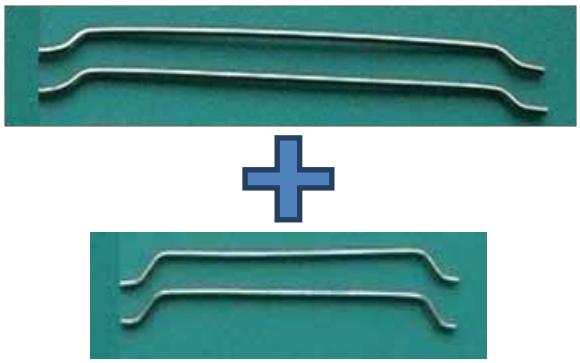
The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers which are too long tend to "ball" in the mix and create workability problems. Hybrids include the combination of micro synthetic fibers with steel fibers or micro synthetic fibers with macro synthetic fibers.

- In this combination one type of fiber will improve the fresh and early properties of the mix such as workability, and control the effect of plastic shrink cracks growth in the mix and the second type will lead to improved mechanical properties of the mix.

Hybrid steel fiber can be divided into three combination.

- The first type is based on the fiber constitutive response in which one of the fibers is stronger and stiffer and which provides stiffer and reasonable for first cracks strength and also ultimate strength.

- While the second type of fiber is relatively flexible and leads to improvement in toughness and strain capacity in the post cracking zone.



- The second type of combination is based on the combination of different aspect ratio.
- Short fiber bridges micro cracks, controls the growth of the cracks and also delays the coalescence in the fiber reinforced concrete.
- Long fibers prevent the propagation of macro cracks and then improve the fracture toughness of the composites.
- The third type is based on the fiber function.

OBJECTIVE

To find optimum dosage of fibers to get maximum strength for the M 30 grade concrete. To find out effect of variation in percentage of fibers on properties of concrete i.e Workability, Compressive strength, Flexural strength.

SCOPE

- Fibers can be mixed and tested with different chemicals with different proportion.
- Problem in Self Compacting Concrete is less shearing resistance, it can be solved by use of Fiber.
- Retrofitting of existing structure can be done with the help of Fibers.
- With the use of natural fiber, structure can be constructed with less cost.
- Fiber can be used in making of Bricks.
- Construction of Rigid pavement may become economic.

Experimental Program

Specimens In this experimental work, concrete specimens were cast with and without fibres. The specimens considered in this study consisted of cubes of 150mm size, and beams of 100 mm × 100 mm × 500 mm size.

- Fresh concrete was cast in steel moulds with hand compaction. i) 150 mm cubes (for compressive strength as per IS 516-1959 (Reaffirmed 1999);
  (ii) 100 x 100 x 500 mm beam specimens (for flexural Test) as per IS 516-1959 (Reaffirmed 1999)
- Three specimens each were tested in the case of compressive strength, flexural strength and modulus of elasticity experiments. In the case of flexural tests three beam specimens were used,
- Mixing, Casting & Curing Details
- All ingredients are weighed and volume separately as per the mix details. The uniformity of concrete and proper distribution of fibres mainly depends on the mixing procedure. Cement and aggregates are mixed thoroughly by using rotary mixer machine and then fibres are added manually mixed with water. The steel fibres are 30 mm in length within aspect ratio 42 and the recron fibres used were 12 mm in length.
- The steel fibre are used 1% by volume of concrete and recrons are used 0.20%, 0.25%, & 0.30%.

In this total fibre volume fraction the proportion of steel and recron'3s fibre fraction is as follows

Steel %	Recron'3s %
1	0.20
1	0.25
1	0.30

Recron 3s fibres are Polyester staple fibres for mixing in concrete and mortar for improving certain properties of the concrete and mortar. Fibres have special triangular shape for better anchoring with other ingredients of the mix.

- The fibres are made from polyemerisation of pure teraphthalic acid and Mono Ethylene Glycol using catalyst. Recron 3s fibres are available in 6mm and 12mm length.

While the mixing operation is in progress, 80% of water is added first and mixed for about 5 min then the remaining water is added and mixed thoroughly. For each mix, a total of 3 cubes of 150 x 150 x 150 mm and 100 x 100 x 500 beams, After 24 hrs the specimens are demoulded, immersed in water all mixes are tested for workability in terms of slump,vee-bee, compacting factor (CF) and flow table test as per Indian Standard IS:. The main purpose of these tests is to check the consistency and the uniformity of concrete from batch to batch. Slump values are not so consistent indicating the fact, that this is not a good measure of workability for FRC. It is in general noticed that conventionally popular tests like slump and compacting factor tests are not as appropriate and accurate in determination of workability of fibre reinforced concrete as they are for plain concrete this is essentially because of interlocking of fibres there by affecting normal workability due to concrete ingredients. Still upon vibration the fibre reinforced concretes exhibited the needed workability for placement.

Test results

1. Workability Results

	Slump (mm)	Flow test	C.F.(cm)	V.B. test(sec)
Normal	36	43	0.96	5.48
Recron 0.20%	34	45.75	0.931	5.89
Recron 0.25%	30	41.25	0.9375	6.38
Recron 0.30%	20	40.25	0.949	7.2
Hbrid(1+ 0.20%)	23	39.75	0.919	6.38
Hbrid (1+0.25%)	15	36.5	0.927	8.03
Hbrid(1+ 0.30%)	15	35.42	0.923	8.46

2. Compressive Strength

COMPRESIVE STRENGTH OF RECRON FIBRE CONCRETE(N/mm2)				
	7DAY	28DAY	% increase 7 DAY	% increase 28 DAY
Recron 0.20%	28	38.66	12.72	15.58
Recron 0.25%	37.03	44	49.07	31.54
Recron 0.30%	34.66	41.92	39.53	25.32
Normal	24.84	33.45	-	-

COMPRESIVE STRENGTH OF HYBRID FIBRE CONCRETE(N/mm2)				
	7DAY	28DAY	% increase 7 DAY	% increase 28 DAY
Hbrid 0.20%	35.32	40.89	42.19	22.24
Hbrid 0.25%	40.32	46.22	62.32	38.18
Hbrid 0.30%	35.48	43.84	42.83	31.06
Normal	24.84	33.45	-	-

Workability

Workability of concrete is inversely proportional to fiber content. As per the results of the workability test it can be conclude that amount of fiber reduced the workability.

Sample	Flexure Strength 28 days	
	Tone	N / mm2
Normal Mix (M30)	1.10	4.32
Recron – 0.20%	1.41	5.62
Recron – 0.25%	1.71	6.82
Recron – 0.30%	1.39	5.54
Hbrid – 0.20%	1.51	6.02
Hbrid – 0.25%	1.75	6.98
Hbrid – 0.30%	1.46	5.82

From the graph result it is said that amount recron fiber and steel fiber reduces the workability. Slump value is reduced as recron and hybrid fiber content increase and flow value also reduces with amount of fiber increases.

Compressive strength

Compressive strength is the key factor in the analysis. From the test result we find that maximum compressive strength can be achieved when amount of fiber in concrete is 0.25% in recron and amount of fiber is 1% steel and 0.25% of recron.

Percentage increase in compression strength can be analyzed from the graph as increase in the strength is maximum at recron 0.25% and hybrid 1+0.25% at 7 days and 28 days.

Flexure strength

Flexure strength phenomenon is also same as the compressive strength of concrete. Normal concrete fails in flexure without taking deflection but Fiber Reinforced concrete fails after taking sufficient amount of deflection. It is maximum at recron 0.25% and Hybrid 1+0.25% but area under the load vs deflection curve increases as the fiber content increases.

Flexure graph denoted that flexure strength is more in the Hybrid fiber due to amount of steel fiber. As the steel fiber is ductile in nature flexure strength is more in hybrid fiber.

Other discussion

- With the use of secondary reinforcement (Fibers) can improve the properties of plain concrete such as compressive strength, Flexural strength (Ductility).
- Hybrid fiber reduce the propagation of macro and micro cracks. Synthetic fiber resist small micro cracks and Steel fiber resist macro cracks.

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