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Study of Behavior of Steel Fiber Concrete

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ABSTRACT

In this modern age, civil engineering constructions have their own structural and durability requirements. Fiber Reinforced Concrete (FRC) is a composite material made primarily from hydraulic cements, aggregates and discrete reinforcing fibers. Fiber incorporation in concrete, mortar and cement paste enhances many of the engineering properties of these materials such as fracture toughness, flexural strength, resistance to fatigue, impact, thermal shock and spalling. The SFRC is a composite material made of cement, fine and coarse aggregates and discontinuous discrete steel fibers. Recently developed an analytical model to predict the shear, torsional strength and bending torsion behavior of fiber reinforced concrete beam with experimental substantiation. However, very little work has been reported in combined torsion and shear. Similarly to beam with conversional reinforcement, the presence of shear may significance influence on torsional strength of fiber concrete beams. Present investigate the mechanical properties like as shear strength, and torsion strength of concrete with different types of steel fiber with constant volume fractions and different aspect ratio.

Introduction

Concrete consumption is around 10 billion tons per year, which is equivalent to 1 ton per every living person. Production of Cement and Steel has environmental hazards due to emission of CO_2 and dust particles in the atmosphere. Hence prudent use of cement and steel has distinct economic and environmental impacts.

Plain concrete is a brittle material. Under impact and dynamic loading plain concrete exhibits extensive cracking and undergoes brittle failure. The concrete is weak in tension and hence to overcome this problem cement concrete is reinforced using steel bars and thus called as reinforced cement concrete (R.C.C.) In this modern age, civil engineering constructions have their own structural and durability requirements. Every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has became mandatory.

Fiber Reinforced Concrete (FRC) is a composite material made primarily from hydraulic cements, aggregates and discrete reinforcing fibers. Fiber incorporation in concrete, mortar and cement paste enhances many of the engineering properties of these materials such as fracture toughness, flexural strength, resistance to fatigue, impact, thermal shock and spalling. The use of fiber reinforcement is not a particularly recent idea. During ancient times, fibers extracted from organic material were used. Fiber Reinforced Concrete started to come to its modern industrial use during the 1960's. Nowadays, it is commonly applied in shotcrete, pavements, industrial floors, bridge decks and precast elements.

Technically, it is possible to produce FRC of very high tensile strength using high fiber content but it is not feasible for structural applications due to practical reasons. For e.g. the use of high fiber content leads to severe reduction of the workability of the fresh concrete. FRC is limited to applications where crack distribution and reduction of crack widths is the main purpose. However, the combined use of FRC and re-bars may yield synergetic effects due to improved bond properties. The use of FRC as a building material has been the target of extensive research during the last decade but still the resulting impact on existing building codes is sparse fibers. Here, we will mainly discuss Steel Fiber Reinforced Concrete (SFRC).

The SFRC is a composite material made of cement, fine and coarse aggregates and discontinuous discrete steel fibers. The SFRC possess many excellent dynamic performances such as high resistance to explosion and penetration as compared to traditional concrete. When used in structural applications, SFRC should only be used in a supplementary role to inhibit cracking, to improve resistance to impact or dynamic loading and resist material disintegration.

The mechanical properties of SFRC are influenced by the type of fiber, aspect ratio, and volume fraction of fibers and the size of the aggregates. Among the various types of fiber currently available, steel fibers are most widely used. Considerable research had been carried out to evaluate mechanical properties such as tensile, compressive, flexural, and impact strength of steel fiber reinforced cement composites.

Recently, research interest has been directed toward understanding the tensional phenomenon as well. Several reports of investigations have appeared describing the improvement in strength under pure torsion and combine torsion and bending of concrete when fiber is includes. Recently developed an analytical model to predict the shear, torsional strength and bending torsion behavior of fiber reinforced concrete beam with experimental substantiation. However, very few work has been reported in combined torsion and shear. Similarly to beam with conversional reinforcement, the presence of shear may significance influence on torsional strength of fiber concrete beams.

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The objective of this paper is to investigate the mechanical properties like as shear strength, and torsion strength of concrete with different types of steel fiber with constant volume fractions and different aspect ratio.

Methodology:

In the beginning all the basic tests are conducted on all ingredient material of concrete, viz. cement, fine aggregate, coarse aggregate, water and steel fibers. ACC 43 grade cement conforming to IS 12269 – 1987 is used. River sand is used as fine aggregates, obtained from local river bed. Crushed black trap basalt is used conforming to IS 383 – 1970 of size 10 to 20 mm is used. Sulphonated Naphthalene formaldehyde polymer is used as superplasticizer having brand name as MasterPlast SPL – 9. The dose of superplasticizer is % of weight of cement.

Three type of steel fibers, hook ended (HK – 80/60) aspect ratio 80, hook ended (HK – 50/30) aspect ratio 50, crimped (CR – 50/30) aspect ratio 50, straight fibers (SF – 50/80) aspect ratio 50 and straight fibers (SF 80/130) aspect ratio 80, all conforming to ASTM A type I are used for the experimental work.

The experimental investigation consisted of casting and testing 36 steel fiber reinforced concrete beams under combined effect of shear and Torsional loading, out of 36, 18 beams are without reinforcement & remaining 18 with reinforcement.

The size of each beam is 100 mm x 150 mm x 1000 mm. The variables include the over reinforced state of the cross section and volume fraction of the fiber. The volume fraction of the fiber content is constant of 2.5 % weight of cement.

The proportioning of concrete is maintained constant throughout the investigation. A concrete mix targeting a compressive strength of 25 MPa is used. Figure 1 shows the cross sectional details of the beam Concrete consumption is around 10 billion tons per year, which is equivalent to 1 ton per every living person. Production of Cement and Steel has environmental hazards due to emission of CO_2 and dust particles in the atmosphere. Hence prudent use of cement and steel has distinct economic and environmental impacts.

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The proportioning of concrete is maintained constant throughout the investigation. A concrete mix targeting a compressive strength of 25 MPa is used. Figure 1 shows the cross sectional details of the bealoading arrangement. An effective cover of 15 mm is provided for the transverse reinforcement.

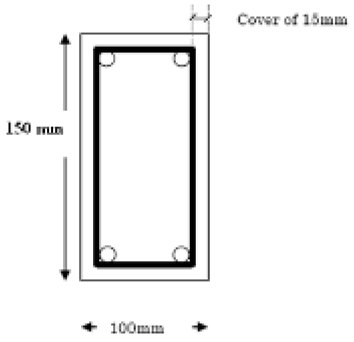

Fig.1 Cross Section of Beam

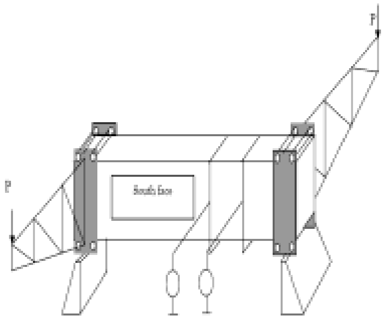

Fig. 2 3D- view of Test Setup

The cured beams are white washed a day before testing to facilitate the crack identification. One end of the beam is supported on rollers, while the other end is supported on rigid support. This type of test setup facilitates free rotation of roller end and provides stability to the test specimen during testing. Specially made twist arms or twist angles are placed at both supports of the beam having an arm length of 0.60 m. Load on the twist arm is applied through a Hydraulic jack and the loading is monitored cement, the through a proving ring attached to the jack. Absolute care has taken, such that, the plane of loading and twisting arm are perpendicular to the longitudinal axis of the beam. This avoids any possibility of bending of the beam instead of twisting and as a result the beam between the two supports is subjected to pure torsion. The complete test setup is schematically presented in Photo.4.1. shows the actual test set up. Load is applied at an eccentricity of 0.66 m from the center of the beam. For every applied load, the corresponding dial gauge readings are noted which were placed at L/3 distance from ends and considering average value of the two reading.

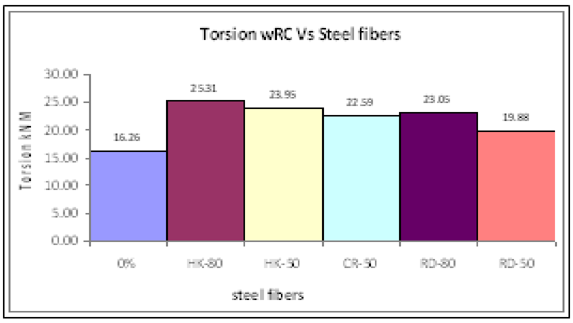

Fig. 3 Typical setup of Torsion & Shear Test

Observations and Results:

Comparative Statement for PCC and different types of steel fibers without reinforcement (w-RC):

Table I

Type of fiber	Torsion (kNm)	Moment (kNm)	Shear Failure Load (kN)
0%	16.26	2.87	4.35
HK-80	25.31	3.84	5.82
HK-50	23.95	3.19	4.84
CR-50	22.59	2.95	4.47
SF-80	23.05	3.35	5.08
SF-50	19.88	2.87	4.35

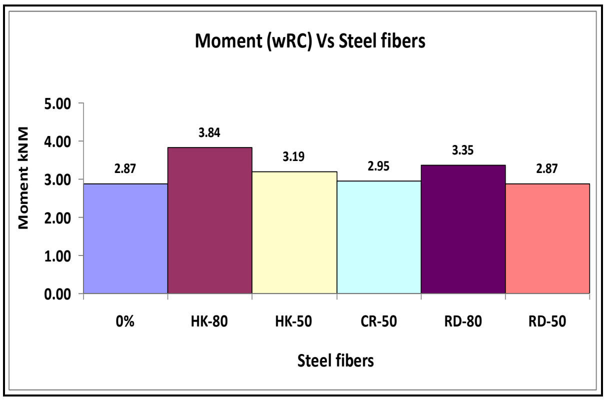

Fig. 4 Comparative Chart of Torsional Moment-wRC Vs Types of steel fiber

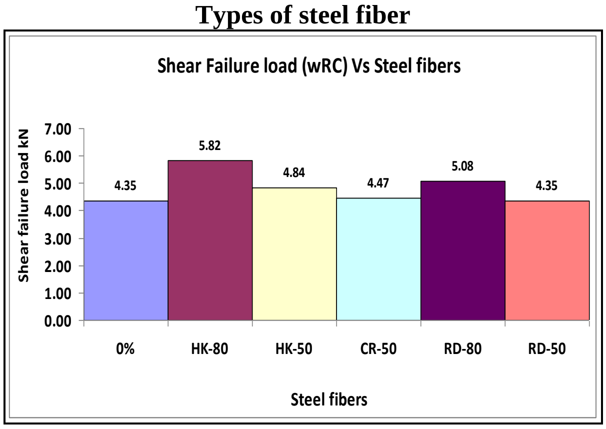

Fig. 5 Comparative Chart of Shear Failure Load-wRC Vs Types of steel fiber

Fig. 6 Comparative Chart of Torsion-wRC Vs Types of steel fiber

Comparative Statement for PCC and different types of steel fibers with reinforcement (RC):

Table II

Type of fiber	Torsion (kNm)	Moment (kNm)	Shear Failure Load (kN)
0%	20.33	2.63	3.98
HK-80	31.66	4.08	6.19
HK-50	27.58	3.68	5.57
CR-50	25.76	3.27	4.96
SF-80	28.03	3.52	5.33
SF-50	24.41	3.03	4.59

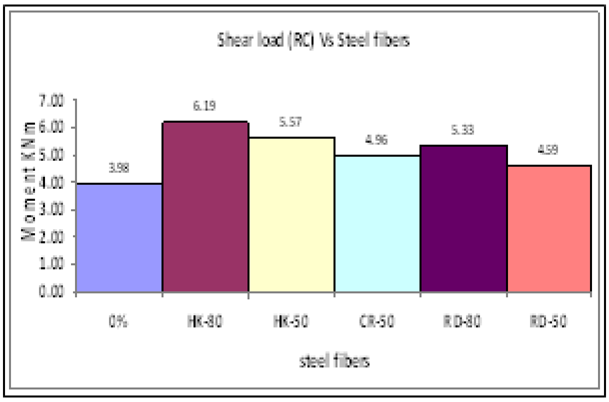

Fig.7. Comparative Chart of Torsional Moment-RC Vs Types of steel fiber

Fig. 8 Comparative Chart of Shear Failure Load-RC Vs Types of steel fiber

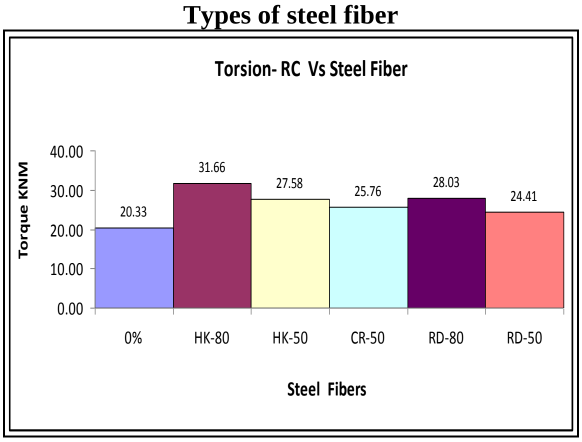

Fig. 9 Comparative Chart of Torsion-RC Vs Types of steel fiber

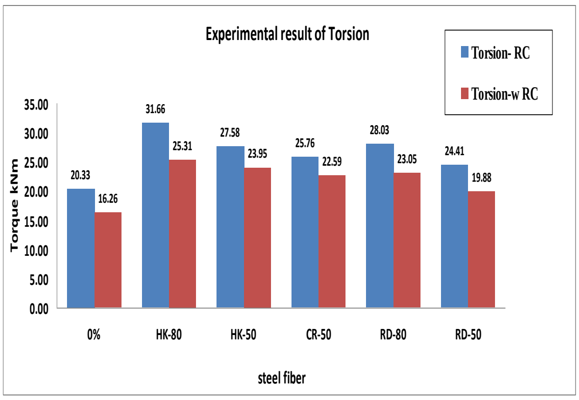

Fig. 10 Comparative Chart of Shear Failure Load-RC Vs Types of steel fiber

Discussion:

1. In general, the significant improvement in various strengths is observed with the inclusion of hooked end steel fibres in the plain concrete as compared to crimped & straight types of steel fiber.

From comparative statement of same aspect ratio:

Torsion strength:

i) For without reinforced members (from Table I), strength comparison between same aspect ratio HK-80 & SF-80 is 25.31 kNm and 23.05 kNm respectively and HK-50, CR-50 and SF-50 is 23.95 kNm, 22.59 kNm and 19.88 kNm respectively

ii) For with reinforced members (from Table: II), strength comparison between same aspect ratio HK-80 & SF-80 is 31.66 kNm and 28.03 kNm respectively and HK-50, CR-50 and SF-50 is 27.58 kNm, 25.76 kNm and 24.41kNm respectively

b}Torsional Moment:

i) Without reinforced members (from Table:I), strength comparison between same aspect ratio HK-80 & SF-80 is 3.84 kNm and 3.34 kNm respectively and HK-50, CR-50 and SF-50 is 3.19 kNm, 2.95 kNm and 2.87 kNm respectively

ii) For with reinforced members (from Table:II), strength comparison between same aspect ratio HK-80 & SF-80 is 4.08 kNm and 3.52 kNm respectively and HK-50, CR-50 and SF-50 is 3.68 kNm, 3.52 kNm and 3.03 respectively

a) Shear strength:

i) For without reinforced members (from Table:I), strength comparison between same aspect ratio HK-80 & SF-80 is 5.82 kN and 5.08 kN respectively and HK-50, CR-50 and SF-50 is 4.84 kN, 4.47 kN, and 4.35 kN respectively

ii) For with reinforced members (from Table:II), strength comparison between same aspect ratio HK-80 & SF-80 is 6.19 kN and 5.33 kN respectively and HK-50, CR-50 and SF-50 is 5.57 kN, 5.33 kN and 4.59 kN respectively

Conclusion:

From above discussion it is conclude that, shear strength and Torsional strength are improved by addition of fibers irrespective of fiber type and aspect ratio.

There is marginal improvement in torsion and shear strength of concrete with change in aspect ratio.

The resistance of RC and plain concrete dose not shows pronounced effect on shear and torsion strength. The reinforcement placed in the beams is in longitudinal direction; because of this the contribution of reinforcement in resistance is very less. But the addition of fibers in both type i.e. with or without reinforcement shows improvement in the shear and Torsional strength.

Torsional moment resistance of the hook end type fibers with and without reinforcement is very good as compare to other types of fibers, but there is very small improvement in the reinforcement due to addition of reinforcement.

Also it is observed that for same aspect ratio the hook ended fibre showing pronounce improvement in all properties of concrete as compare crimped & straight fiber. There is decrease in the strength with decrease in aspect ratio of same fiber type. The straight fibers having less strength as compared with hook end and crimped fibers. This is obvious that the hook end and crimped fiber because of their shape having good bond and anchorage in the matrix resulting in more strength.

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