ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 12, pp.75922-75925, December, 2018
DOI: https://doi.org/10.24941/ijcr.32577.12.2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EFFECT OF TTTSFRC ON TENSILE STRENGTH OF CEMENT CONCRETE

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ARTICLE INFO

Article History:
Received 12th September, 2018
Received in revised form
25th October, 2018
Accepted 25th November, 2018
Published online 29th December, 2018

Key words:

Twin Twisted steel fiber Reinforced Concrete (TTSFRC), Tensile strength.

ABSTRACT

As on date the most widely used construction material is still Reinforced cement concrete. Concrete is strong in compression and week in tension, steel is placed in concrete where ever tension is anticipated, the process become cumbersome time consuming and expensive process. Fiber reinforced concrete has emerged as consequence which offers improved tensile strength in addition to compressive resistance. Tiny Twin Twisted steel fiber with more frictional resistance are added in concrete matrix to improve tensile strength of concrete. In these paper, experimental results of Compressive strength and Tensile strength of different grade concrete with different dosages of micro steel fibers are presented.

Citation: Murali Krishna, N. and Prashanth Kumar, R., 2018. "Effect of TTTSFRC on tensile strength of cement concrete", *International Journal of Current Research*, 10, (12), 75922-75925.

INTRODUCTION

Concrete is strongly compression and weak in tension and has a brittle character. As a reason steel is placed at appropriate location in all concrete structural elements to resist tensile stresses where ever they occur due to structural action. However, a constructional material which can resist both compression and tension, if at all available and can be produced is most desirable on any day. Such a material shall also be economically viable easily producible comfortable in handling and placement and yet durable like RCC. TTTSFRC is the material matrix that exactly fits the above requirement.
The concept of using fibers to improve the characteristics of construction material is very old. In olden days horse hair was used to increase strength and ductility of the concrete. Over a course of time use of various types of fibers like steel fibers, glass fibers, poly propylene fibers were used in the concrete to improve tensile strength and ductility. The role of randomly distributed discontinuous fibers is to bridge across the cracks that develop provides some post cracking ductility. If the fibers are sufficiently strong well bonded to material and permit the concrete to carry significant stress over a relatively large strain capacity in the post cracking stage.

Advantages of TTTSFRC concrete

Reinforced cement concrete structures need careful supervision during its construction process. It requires professional bar benders.

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Fabrication of bars according to the drawings is also a time-consuming job and need skilled manpower. The strength contribution of concrete in tension zones is ignored. Using TTTSFRC concrete these problems can be reduced because the TTTSFRC concrete either needs no rebars or need very less reinforcement. Using TTTSFRC concrete is economical since full concrete is effective in taking applied force. In the present-day scenario of infrastructural advancements and the need for urbanization, TTTSFRC concrete can prove to be a very economical replacement for RCC.

Functional mechanism of TTSFRC

TTTSFRC with its unique twist, is unlike any other reinforcement known earlier and is a substantial improvement over the fibers of any type. When concrete is stressed or bent, a flat fiber will slide out with minimal friction – so the force required for it to pullout is generally small. Adding deformation, like a hooked end or corrugation, adds friction and increases force required to pull it out, but only marginally TTSFRC twist increases the frictional resistance just like removing a corkscrew from a cork with twisting it. Each TTSFRC locks like a tiny screw, instead of slipping like a nail. But the additional force required is so large that it changes the failure mechanism from simply pulling out to a torsional or untwisting mode. TTSFRC must actually untwist or snap before it fails. This requires considerably large energy than mere frictional pullout and results in a fundamental increase in performance to levels realized never before. Also with TTSFRC, the farther you twist the stronger it gets since the required energy to untwist becomes even greater.

Present work and initial results: Nine types of sample are made in each mix type and their properties are studied by conducting laboratory tests.

Material Properties: The details of materials used are as follows:

1. ***Cement:*** OPC of 53 grade having specific gravity of 3.15
2. ***Fine aggregate:*** Robo Sand.
3. ***Coarse aggregate:*** Machine crushed well graded angular granite aggregate of normal size 20mm from local source are used. The specific gravity is 2.84. It is free from impurities such as dust, clay and organic matter.
4. ***TTSF:*** Twin twisted tiny steel fibers. Two tiny wires were Twisted together and cut into pieces of 20mm to form a Twisted fiber of 0.5mm dia and 20mm length.
5. **Mix Design:** The concrete mix proportions for M-20 and M25 grade as per IS: 10262-2009[10, 12] are given in Table 2.

Table 1. Materials Required for 1 cum. of Concrete

Grade	Cement	Fine aggregate	Coarse Aggregate	Water Cement Ratio
	(Kg/m^3)	(Kg)	(Kg)	(Kg/m^3)
M-20	380	1019	868	190
M-25	400	996	848	200

Compressive Strength Procedure: Specimens were demoulded 24 hours after casting. After demoulding, the specimens were cured in water until the day of testing. The average compressive strength test results for different ages (7, 28 and 90 days) were determined by using three specimens for each age. The axis of the specimen was carefully aligned with the center of thrust of the plate, after cleaning of bearing surface of compression testing machine. No packing was used between faces of the test specimen and platen of testing machine. The load applied was increased continuously, without shock, at rate of approximately 140 kg/cm2/min until the resistance of the specimen to the increasing load broke down and no greater load could be sustained. The compressive stress calculated in kg/cm2 from the maximum load sustained by the cube before failure. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section.

$$\text{Compressive Strength (MPa)} = \frac{P}{A}$$

Where, P = load applied to the specimen (cube) in Newton.
A = cross sectional area of the specimen in millimeter**.**

Splitting Tensile Strength Procedure: Split tensile strength on cylinders was carried out according to the procedure given in IS:516-1956. Immediately after removal of cylinder specimens were kept on the surface, water, and grit shall be removed from the surfaces, which are to be in contact with the packing strips and the bearing surfaces of the testing machine was wiped clean. The cylinder was placed horizontally in the centering with packing skip (wooden strip)/ or loading pieces carefully positioned along the top and bottom of the plane of loading of the specimen. The wooden pieces were placed on top of the cylinder and bottom of the cylinder, so that the specimen is located centrally. The load was applied without shock and increased continuously at a normal rate with the range 1.2N/mm2/min to 2.4N/mm2/min until failure of the specimen. The maximum load applied was recorded at failure and the appearance of concrete and unused features in the type of failure was observed. The test results are presented in Table form,

Then the splitting tensile strength of the specimen was calculated by using the following formula,

$$f_{ct} = \frac{2P}{\pi \times L \times d}$$

Where,

P= Maximum load in Newtons applied to the specimen,
L = Length of the specimen in mm
d = Cross sectional dimension of the specimen in mm

Flexural Strength Test: Beams were tested after 28 days and 90 days curing. The bearing surfaces of the supporting and loading rollers are wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers (38 mm dia.). The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould along two lines spaced at 13.3 cm apart (Two Point Method). The load is increased until the specimen fails, and the maximum load applied to the specimen during the test is recorded.

The flexural strength of the specimen shall be expressed as the modulus of rupture fb, which, if „a" equals the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/cm2 as follows:

$$\text{Flexural strength, fb} = \frac{P \times l}{bd^2}$$

When „a" is greater than 20.0 cm for 15.0 cm specimen or greater than13.3 cm for a 10.0
cm specimen

$$\text{Flexural strength, fb} = \frac{3P \times a}{bd^2}$$

When a is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for

a 10.0 cm specimen.
b= measured width in cm of the specimen,
d= measured depth in cm of the specimen at the point of failure,
l= length in cm of the span on which the specimen was supported,
P= maximum load in kg applied to the specimen.

M20, M25 and M30 mix designs were carried out as per IS 10262:2009, cubes of 150mm size and, cylinders of 150mm dia. and 300 height and beams of 100mm x 100mm x 500mm were cast with different percentage of TTSF which are tabulated below.

RESULTS AND DISCUSSION

Result tensile test was conducted after 28days of curing, it has been observed that there is no much difference in performance (by addition of Robo sand) due to replacement of River sand with Robo sand.

Addition of TTSF into Concrete mix have shown considerable increase in the performance of specimens in Tension.

There was 33.8% increase is ultimate tensile strength of TTSFRC-3 compared with CC-1 with M20 concrete & 25.3% increase in ultimate tensile strength of M25 mix with 1% of TTTSF compared with CC-1 mix with M25 grade.

Table 2. details of the mix used

Sample ID	Details of the Mix used
CC-1	Cement concrete using Normal River Sand
CC-2	Cement concrete using with Robo Sand
TTSFRC-1	Cement concrete using with Robo Sand & 0.5% of Twisted TTSF
TTSFRC-2	Cement concrete using with Robo Sand 1.0%
TTSFRC-3	Cement concrete using with Robo Sand 1.5%
TTSFRC-4	Cement concrete using with Robo Sand 2.0%
PSFRC-1	Cement concrete using with Robo Sand 1.5% and 0.25 ø mm
PSFRC-2	Cement concrete using with Robo Sand and 0.50 ø mm
TTSFRC-5	Cement concrete using Normal River Sand 1.5%

Table 3. Results of M20 grade concrete

M20				
Designation	Average compressive strength (Mpa)		Average split tensile strength (Mpa)	
	First Crack	Ultimate Strength	First Crack	Ultimate Strength
CC-1	25.60	27.64	2.30	2.35
CC-2	27.50	29.40	2.30	2.45
PSFRC – 1	26.35	31.25	2.25	3.9
PSFRC -2	26.10	33.40	2.50	4.10
TTSFRC -1	27.50	32.50	2.85	4.30
TTSFRC-2	27.80	35.65	2.60	6.50
TTSFRC -3	28.50	37.0	2.90	7.17
TTSFRC -4	28.00	36.50	2.84	7.13

Table 4. Results of M25 grade concrete

M25				
Designation	Average compressive strength (Mpa)		Average split tensile strength (Mpa)	
	First Crack	Ultimate Strength	First Crack	Ultimate Strength
CC-1	29.00	30.60	2.60	2.85
CC-2	29.50	32.75	2.58	2.73
PSFRC – 1	27.35	35.70	2.83	3.25
PSFRC -2	27.00	34.50	2.75	3.50
TTSFRC -1	28.50	37.50	2.88	6.25
TTSFRC-2	28.00	38.35	3.10	7.00
TTSFRC -3	29.35	38.00	3.06	7.15
TTSFRC -4	29.00	37.50	2.95	7.30

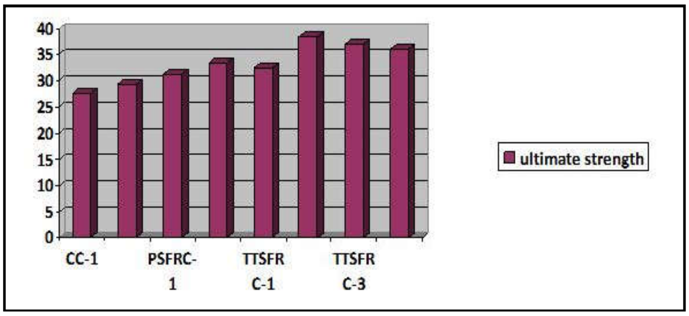

Figure 1. Ultimate compressive strength of M 20 grade mix

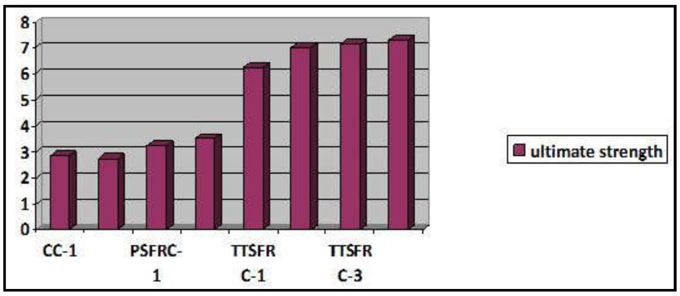

Figure 2. Ultimate tensile strength of M 20 grade mix

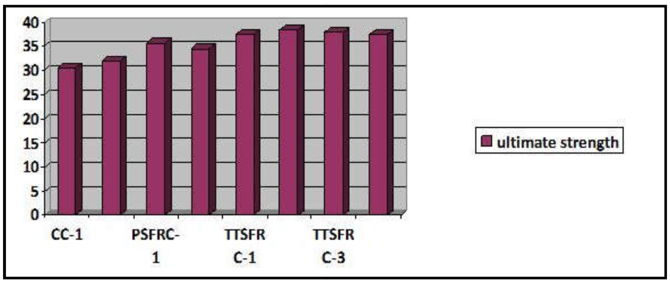

Figure 3: Ultimate compressive strength of M 25 grade mix

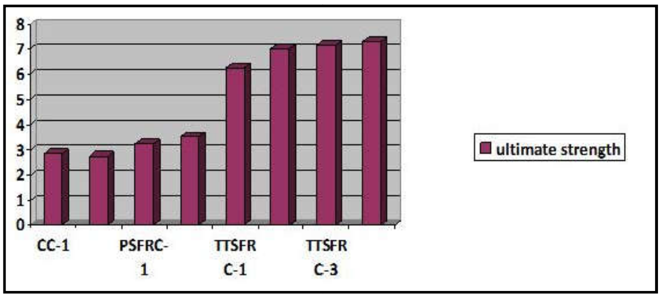

Figure 4. Ultimate tensile strength of M 25 grade mix

Conclusion

The result obtained from compressive test and split tensile tests are tabulated in Table 3 & Table 4, graphs are plotted to observe the behavior of mixes.

- Replacing river sand with robo sand as fine aggregate has not shown any effective difference of compressive strengths of mixes.
- Addition of twin twisted fibre to the mixes has shown remarkable increase in compressive strength and tensile strength of mixes.
- Concrete mixes with 1.5% of fibre have shown better performance in compression and tension compared to 0.5%, 1% and 2%.

- From the test results of Compressive and Split Tensile strength it can be seen that by using TTSF there is some increase in compressive strength and remarkable increase in tensile strength.
- TTSF addition improved post crack load carrying capacity.

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