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# A Comparison Study of Behaviour of Concrete Reinforced with Steel Fiber

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Abstract - As Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardened. These cracks are major cause of weakness in concrete particularly in large on site applications leading to subsequent fracture and failure and general lack of durability. Fiber reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. Fiber- reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented â€“ each of which lend varying properties to the concrete. It is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In addition, the character of fibre-reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities. In this experimental investigation, an attempt has made to find out strength related tests like Compressive Strength, Split Tensile Strength, Flexural Strength using hooked end Steel Fibers with to volume fraction of 1.0%,2.0% and 3.0% (for both crimped and hooked fibre) and for aspect ratio and considered for M30 Grade of concrete. Number of specimens were casted, cured and tested. The real contribution of the fibers is to increase the toughness of the concrete, under any type of loading and permit the fiber reinforced concrete to carry significant stress over a relatively large strain capacity in the post cracking stage. The results of the tests showed that the strength properties are enhanced due to addition of fibers. The experiential results shown that the addition of steel fibre improves the crack arresting capacity of concrete.the addition of steel fibre prove that there is significantly enhancing the energy absorbing capacity of specimens. This paper presents an overview of the mechanical properties of Steel Fiber Reinforced Concrete (SFRC), its advantages, and its applications.
Keywords - Fiber Reinforced Concrete (FRC), Mechanical properties, Steel Fiber Reinfoced Concrete(SFRC).

## INTRODUCTION

Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle. These two weaknesses have limited its use. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardened. These cracks are major cause of weakness in concrete particularly in large on site applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers Concrete is used extensively as a construction material because of its versatility. This drawback can be overcome by providing steel in tension zone. This technique called “Reinforced Cement Concrete”, improves the load carrying capacity of concrete members. At the same time durability of concrete is also important. Durability is mainly affected due to cracks developed by creep and shrinkage. This can be avoided by using certain chemical admixtures. But once a crack develops in the member there are no barriers to stop the propagation of such cracks.

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In an attempt to control the so formed cracks has led to the development of Fibre Reincorced Concrete (FRC), obtained by dispersing in concrete, very small sized reinforcement called fibres. The small closely spaced fibers so used act like crack arresters, substantially improve the static and dynamic strengths. To increase the tensile strength of concrete many endeavours have been made, one of the effective and most regularly utilized ways is giving steel reinforcement. Steel bars, however, strengthen concrete against local tension only. Cracks in strengthening concrete develop unreservedly until experiencing the bar. Therefore, the requirement for multidirectional and firmly divided steel support emerges there, that can't be for all intents and purposes conceivable. Fiber support is one of the ways, which gives the answer for this sort of issue.

Steel Fibre Reinforced concrete (SFRC) is defined as concrete made with hydraulic cement containing Fine and coarse aggregate and discontinuous discrete fibre. In SFRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties. SFRC is being increasingly used to improve static and dynamic tensile strength, energy absorbing capacity and better fatigue strength.Generally, for structural applications, steel fibres should be used in a role supplementary to reinforcing bars. Steel fibres can reliably inhibit cracking and improve resistance to material deterioration as a result of fatigue, impact, and shrinkage, or thermal stresses. A conservative but justifiable approach in structural members where flexural or tensile loads occur, such as in beams, columns, or elevated slabs (i.e., roofs, floors, or slabs not on grade), is that reinforcing bars must be used to support the total tensile load. This is because the variability of fibre distribution may be such that low fibre content in critical areas could lead to unacceptable reduction in strength. In applications where the presence of continuous reinforcement is not essential to the safety and integrity of the structure, e.g., floors on grade, pavements, overlays, and shotcrete linings. The improvements in flexural strength, impact resistance, and fatigue performance associated with the fibres can be used to reduce section thickness, improve performance, or both.At the same time, it should be noted that fibre-reinforced concrete is used more and more often as the material for structural elements.

## PROBLEM STATEMENT

- Concrete is brittle material and low tensile strength.
- Using steel rebar in concrete is expensive, required skilled manpower and time consuming.
- Using steel fiber can produce same amount of effect on different properties as steel rebar on concrete.
- Properties may be on compression, flexure, tensile strength, Elasticity, Crack strength etc.

## OBJECTIVES OF THE PRESENT STUDY

The specific objectives of the present study areas below.

1. Inclusion of fibres delays the occurrence of first tensile crack. This increases tensile strain capability Of the matrix.
2. To find the appropriate percentage of steel fiber for making the best mix of concrete.
3. To evaluate the workability characteristics in terms of compaction factor, slump and Vee-bee degree for M20 and M40 grades of concrete along with Hooked end Steel Fibres (0.0 - 1.5%).
4. It gives the member a well defined post cracking behavior resulting in an increase of post-crack ductility.
5. To evaluate the effect of end hooked steel fibers on concrete mechanical behaviour consisting compressive strength, split tensile strength, flexural strength, and ductility.
6. To examine the effect of fiber volume fraction on SFRC material performance.
7. To make a comparison for the performance of concrete with and without steel fibre reinforcement on the material levels both graphically and qualitatively.
8. Minimize the loss of lives, property and time of the nation.

## 1. LITERATURE REVIEW

N.N.Li has found that wax and oil are separated by centrifugation. Chill rates more than 100 times those used in conventional processes can be employed to achieve large capacity. Plate-type crystals give highest initial settling rate and wax compaction. Crystal needles can be changed into aggregates for improving centrifugation efficiency by using modifiers.

Wang, Y. et al. (2018): Wang's study investigates the effects of waste engine oil on asphalt binder properties, laying the foundation for understanding the potential environmental benefits and challenges associated with its incorporation.

Siddiqui, M.N. et al. (2019): Siddiqui explores the rheological behavior of asphalt binders containing crumb rubber, emphasizing the need for a comprehensive understanding of the mechanical properties for the successful implementation of reclaimed pavement.

Panda, B.B. et al. (2020): Focusing on the environmental impact, Panda assesses the feasibility of using waste engine oil and crumb rubber in pavement materials, highlighting the importance of sustainable practices in reducing ecological footprints.

Ahmed, S. et al. (2017):

Ahmed's work addresses the challenges of waste engine oil disposal and its potential as a rejuvenating agent in asphalt mixtures, contributing insights into the economic and environmental aspects of reclaimed pavement.

Kamran Mohi Ud Din Bhat, Mohd Zeeshan Khan et al [7] Concrete is the most widely used manmade construction material used on earth and is only second to water as the most utilized substance on the planet. A composite mixture obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone, and when placed in forms, allowed to cure hardens into a rock like mass known as cement concrete. The strength, durability and other properties of concrete depend on properties of its ingredients, on proportion mix, the method of compaction and other controls during placing, compaction, and curing.

Tomasz Błaszczyński et al [8] Fibre-reinforced concrete is the concrete with addition of short fibres targeting the improvement of the propriety of this material. Its durability is basely connected with the long-term dynamic loading. The main characteristic in that case are the critical stresses. The object of this article is steel fibre reinforced concrete (SFRC). For both materials (concrete and SFRC) are also different levels of critical stresses: initiation $\sigma i$ and critical $\sigma cr$. Test findings during compression

## 2. METHODOLOGY :

The experimental study aims to understand the material behaviour of SFRC. To predict the effect of impact load on concrete slab different approaches such as experimental and numerical methods could be used. Experimental research gives a realistic insight to the problem and results, while numerical model is another direction of the research activities to study the behaviour of structural members in which with the aid of simulation tools the real behaviour can be represented under ideal condition. Experimental work could be impractical or expensive; however the significant development in the computer technology development in the recent years makes the numerical techniques more popular for obtaining detailed results. This provides researchers with the opportunity to extend the application of the numerical models to perform parametric studies by virtual experiments. On the other hand, it is important to validate the numerical results with an experiment.

It is worth mentioning that a numerical modelling of RC slabs that are loaded under impact loads is a concept that has not yet been accurately established. Furthermore, current codes are unable to suggest a clear and realistic approach for the design of slabs under impact load. However, a verified method for studying and predicting possible failure mode is a crucial requirement.

The material experiment will be conducted to give a sight into the real material behaviour of the SFRC and study its mechanical behaviour using the hooked-end SFRC & Crimped SFRC and also make the results available to other researchers for future research works

## 3. MATERIALS:

### STEEL FIBRES

Steel fibres of Hooked end type fibres and crimped fibres are used for this. The volume fraction of steel fibres are 1%,2% & 3%. Respectively.

### CEMENT

Cements may be defined as adhesive substances capable of uniting fragments or masses of solid mater to a compact whole. Portland cement was invented in 1824 by an English mason, Joseph Aspin, who named his product Portland cement because it produced a concrete that was of the same colour as natural stone on the Isle of Portland in the English Channel.

Raw materials for manufacturing cement consist of basically calcareous and siliceous (generally argillaceous) material. The mixture is heated to a high temperature within a rotating kiln to produce a complex group of chemicals, collectively called cement clinker. Cement is distinct from the ancient cement. It is termed hydraulic cement for its ability to set and harden under water. Briefly, the chemicals present in clinker are nominally the four major potential compounds and several minor compounds. The four major potential compounds are normally termed as Tricalcium silicate (3CaO.SiO2), declaim silicate (2CaO.SiO2), tricalcium aluminates (3CaO.Al2O3) and tetra calcium aluminoferrite (4CaO. Al2O3.Fe2O3).

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Fine Aggregate

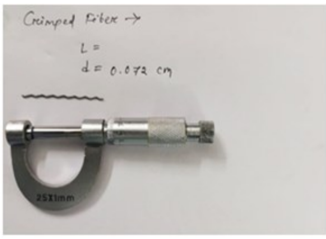
River sand passing through 4.75 mm sieve and conforming to grading zone II of IS: 383-1970 was used as the fine aggregate. Normal river sands are suitable for high strength.
concrete. Both crushed and rounded sands can be used. Siliceous and calcareous sands can be used for production of HSC

WATER

The Requirements of water used for mixing and curing shall conform to the requirements given in IS: 456-2000. However use of sea water is prohibited.

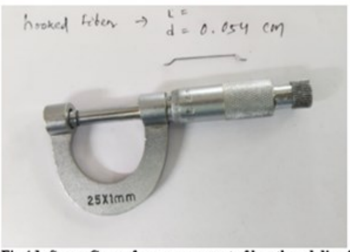
## 4. PROCESS ADOPTED

1. Cubic, cylindrical and beam specimen of M30 SFRC with 1%,2% and 3% steel fiber by volume with steel fiber types of having aspect ratio 65 and 49 for Hooked end fibre and crimped fibre.
2. Cube of Size 150mmx150mmx150mm, cylinder of size 150mmx300mm and beam of size 100mmx100mmx500mm is adopted for testing.
3. Axial compression Test is done in cube samples to determine axial compressive Strength.
4. Splitting tensile test is done in cylindrical samples to determine splitting tensile strength.
5. Point load test is done in beam sample to determine modulus of elasticity, first crack strength and maximum deflection




Least Count of Screw Gauge – 0.001 cm
L = 35 mm
D = 0.72 mm

Fig 4.2: Screw Gauge for measurement of length and dia of crimped fiber.




Least Count of Screw Gauge – 0.001 cm
L = 35 mm
D = 0.54 mm

Fig 4.1: Screw Gauge for measurement of length and dia of hooked fiber.

The American Society for Testing and Materials (ASTM) Standard C 150, Specification for Portland cement, provides for the following types of Portland cement:

Coarse Aggregate

Crushed granite stone with a maximum size of 20 mm was used as the coarse aggregate

A. Experimental Results

Compressive Strength Test: -

The tests were carried out to obtain compressive strength, split tensile strength, flexural strength of M30 grade concrete. The specimens are tested for 7 & 28 days for 0%, 1% 2%, and 3% of Crimped type steel fibers. The specimens are tested for 7 & 28 days for 0%, 1% 2%, and 3% of Hooked type steel fibers. Effect of variation of steel fibers on Compressive Strength

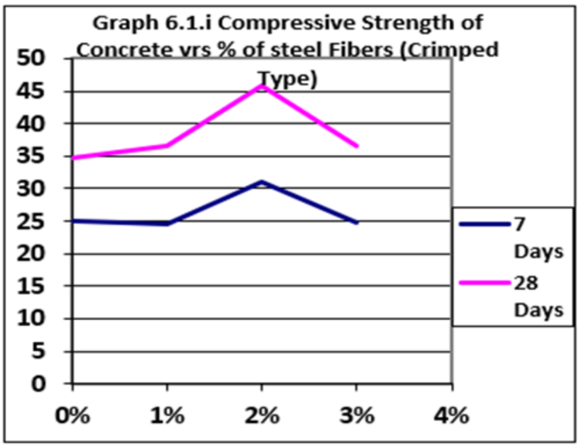



**Fig 6.1.i Compressive Strength of Concrete vrs % of steel Fibers (Crimped Type)**

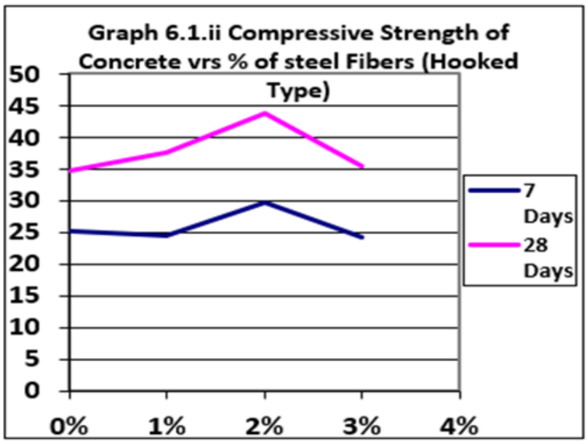



**Fig 6.1.ii Compressive Strength of Concrete vrs % of steel Fibers (Hooked Type)**

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Table 6.1 Average Compressive Strength, Mpa for Concrete Cube Samples.

| Sl No | Steel Fiber Type | Steel Fiber Percentage | Average Compressive Strength, Mpa | |
|---|---|---|---|---|
| | | | 7 Days | 28 Days |
| 1 | Control | 0 % | 25.10 | 34.66 |
| 2 | Crimped | 1 % | 24.51 | 36.59 |
| 3 | Hooked | 1 % | 25.51 | 37.55 |
| 4 | Crimped | 2 % | 31.12 | 45.77 |
| 5 | Hooked | 2 % | 29.82 | 43.85 |
| 6 | Crimped | 3 % | 24.88 | 36.59 |
| 7 | Hooked | 3 % | 24.17 | 35.54 |

Split Tensile Strength: -

After curing, cylinder specimens are tested to determine the split tensile strength of concrete. The Split tensile strength of cylinder specimens after 7 and 28 days of curing are determined and given in table below.

**Table 6.2** Average Split Tensile Strength, Mpa of Cylinder Samples.

| Sl No | Steel Fiber Type | Steel Fiber Percentage | Average Split Tensile Strength, Mpa | |
|---|---|---|---|---|
| | | | 7 Days | 28 Days |
| 1 | Control | 0 % | 1.88 | 2.51 |
| 2 | Crimped | 1 % | 2.32 | 3.68 |
| 3 | Hooked | 1 % | 2.27 | 3.54 |
| 4 | Crimped | 2 % | 3.35 | 4.81 |
| 5 | Hooked | 2 % | 3.20 | 4.57 |
| 6 | Crimped | 3 % | 2.93 | 4.29 |
| 7 | Hooked | 3 % | 2.72 | 3.89 |

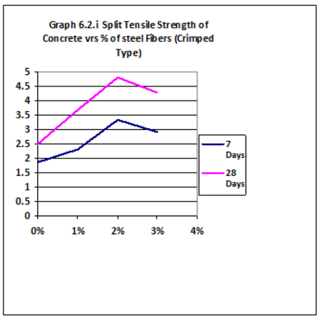


**Fig 6.2.i** Split Tensile Strength of Concrete vrs % of steel Fibers (Crimped Type)

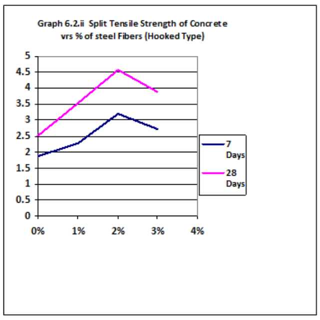


**Fig 6.2.ii** Split Tensile Strength of Concrete vrs % of steel Fibers (Hooked Type)

Flexural Strength: -

After curing, prism specimens are tested to determine the flexural strength of concrete. The flexural strength of prism specimens after 7 & 28 days of curing are determined and given in the table below

Table 6.3 Average Flexural strength MPa of SFRC.

| Sl No | Steel Fiber Type | Steel Fiber Percentage | Average Flexural Strength, Mpa | |
|---|---|---|---|---|
| | | | 7 Days | 28 Days |
| 1 | | 0 % | 1.45 | 2.36 |
| 2 | Crimped | 1 % | 4.42 | 7.2 |
| 3 | Hooked | 1 % | 4.37 | 6.64 |
| 4 | Crimped | 2 % | 6.53 | 8.70 |
| 5 | Hooked | 2 % | 6.10 | 8.32 |
| | Crimped | 3 % | 4.38 | 7.18 |
| 7 | Hooked | 3 % | 3.78 | 6.21 |

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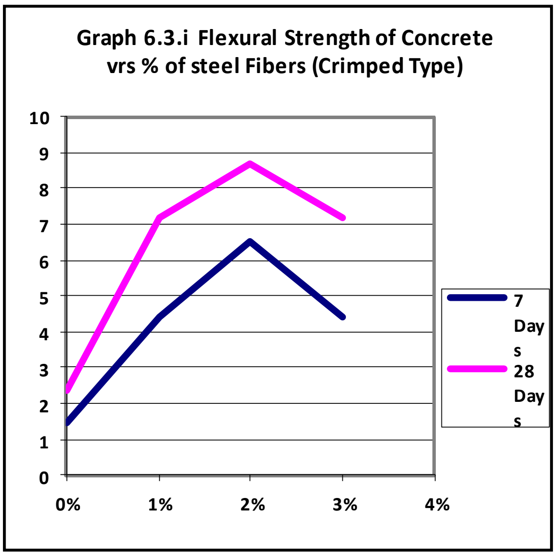
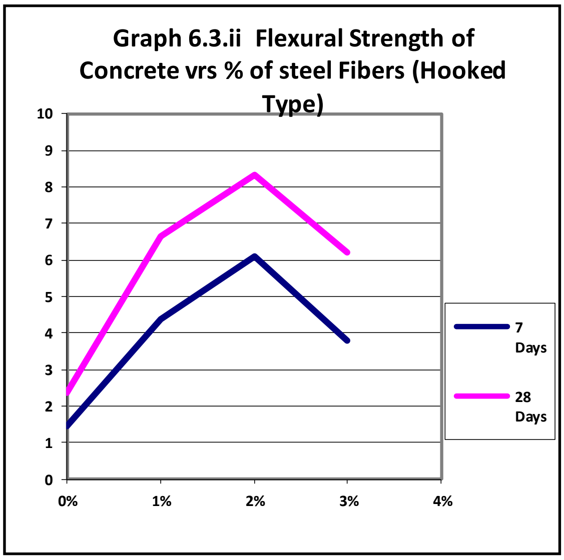


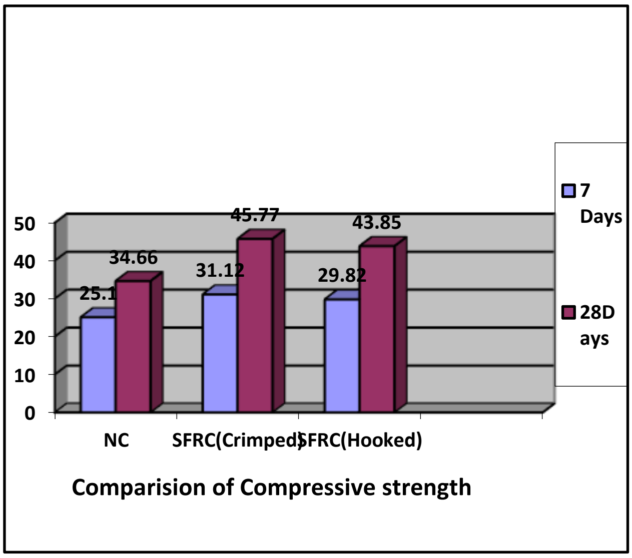




Fig 6.4. Comparision of Compressive Strength of SFRC (Crimped vrs Hooked)

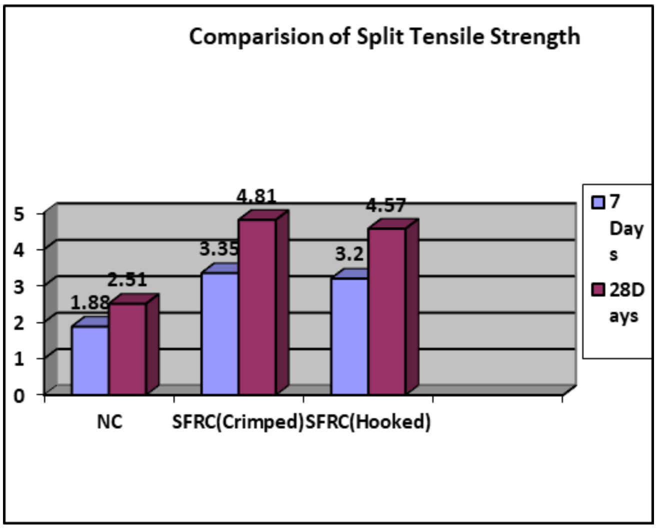
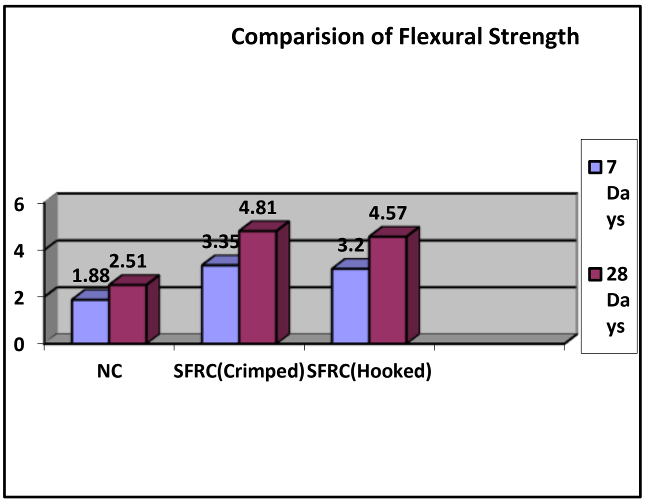



Fig 6.5 . Comparision of Split Tensile Strength of SFRC (Crimped vrs Hooked)



## RESULTS

Compressive strength test

Compressive strength test is done by the 15cm×15cm×15cm cubes. By conducting compressive strength test on NC & SFRC and the test carried out the curing durations of 7 and 28 days. The compressive strength of NC at 7 days is 25.10MPa and 28 days is 34.66MPa. The maximum compressive strength of 2% SFRC(using Crimped type fiber) at 7 days is 31.12MPa and 28 days is 45.77MPa. The maximum compressive strength of 2% SFRC(using Hooked type fiber) at 7 days is 29.82MPa and 28 days is 43.85MPa.

Split tensile strength test

Split tensile strength test is done by the (150mm dia×300mm ht) of NC & SFRC cylinders were casted and test carried out the curing durations of 7 and 28 days. The split tensile strength of NC at 7 days is 1.88MPa and 28 days is 2.51MPa. The maximum split tensile strength of 2% SFRC(using Crimped type fiber) at 7 days is 3.35MPa and 28 days is 4.81MPa. The maximum split tensile strength of 2% SFRC(using Hooked type fiber) at 7 days is 3.20MPa and 28 days is 4.57MPa.

Flexural strength test

Flexural strength test is done by the (50cm×10cm×10cm) of NC & SFRC prisms were casted and test carried out the curing durations of 7 and 28 days. The flexural strength of NC at 7 days is 1.45MPa, and 28 days is 2.36MPa. The maximum flexural strength of 2% SFRC(using Crimped type fiber) at 7 days is 6.53MPa and 28 days is 8.70MPa. The maximum flexural strength of 2% SFRC(using Crimped type fiber) at 7 days is 6.10MPa and 28 days is 8.32MPa.

Scope for Future Study:

For use of fibers as a structural material, it is necessary to investigate the behavior of reinforced fiber under flexure, shear and the same exposed to an elevated temperature. Some tests relating to durability aspects such as water permeability, resistance to penetration of chloride ions durability in marine environment etc. need further investigation.

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