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A Comparative Study on Destructive and non-Destructive Tests Using Crimped Steel Fiber Rein forced Concrete

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ABSTRACT

plain concrete has very poor tensile strength, impact strength, ductility, and crack resistance, it is necessary to solve these issues. It has long been recognized that adding small, tightly spaced, uniformly dispersed fibres to concrete will work as a crack arrester and increase its mechanical and durability properties significantly. It will be treated as Fiber Reinforced Concrete. In the current study, investigations into fiber-reinforced concrete are conducted, mostly using crimped steel fibres. A water cement ratio of 0.42 is used when designing concrete of grade M-35 in accordance with IS:10262-2009. Size Cube Specimens 150 x150 x150mm are cast by adding different fiber dosages such as 0.5%, 1%, 1.5%, 2% by volume for steel fibers. Among these dosages of steel fibers, for 1.5% fibre ratio, the maximum compressive strength at 28 days is attained. These prisms, cubes, and cylinders were cast and cured. The specimens are kept for curing for 7 days, 28 days, 56 days, and 90 days. Destructive tests like compressive strength, tensile strength, and flexural strength are used to determine the structural behaviour of the specimen. Non-Destructive Tests like UPV test, Rebound hammer test etc, and durability tests like water absorption and sorptivity The test results indicate that a small quantity of fibres can be added to standard concrete to increase its performance. Finally, it is discovered that 1.5% is the optimum dosage for steel fibres.

Keywords—Concrete, Crimped steel fiber, Destructive and Non-Destructive Tests, Durability, Ductility, Optimum dosage

INTRODUCTION

The advancement of technology and increased field of applications of concrete and mortars, the strength, workability, durability, and other characters of the ordinary concrete need modifications to make it more suitable for different situations. Workability depends on water content, shape and size of aggregate, cement content and other admixtures if any. Concrete that has been reinforced with fibrous material (FRC) has a higher structural integrity. It has uniformly distributed, short discrete fibres that are randomly orientated. Steel fibers used are straight, hooked, paddled, deformed, crimped, irregular, stranded, twisted steels. The higher fiber percentage mixtures for information in applications where the additional strength or toughness may justify the special techniques required. The role of randomly distributing discontinuous fibers is to bridge across the cracks that develop provides some post- cracking ductility. The primary function of fibres as reinforcement is to influence and regulate tensile cracking in concrete. Steel fibre reinforced concrete (SFRC) is a composite material like conventional concrete, but with fibres as an ingredient of the mixture. The addition of fibres to concrete has improved its flexural strength, toughness, ductility, impact resistance, fatigue strength, and crack resistance. Furthermore, the deformation at peak tension is substantially larger than that of ordinary mortar Fibres help in altering the behavior of concrete after cracking has started. The crack bridging behavior of fibres improves matrix ductility. The fundamental advantage of SFRC is its superior resistance to cracking and crack propagation; thus, fibre composites retain increased extensibility and tensile strength, both at first crack and at ultimate stress. As a result, the fibre composite will exhibit distinct post-cracking behavior and ductility that is not observed in ordinary concrete, where tension after crack is insignificant.

CSF01 meets ASTM C1116 and C1018, Standard Specifications for Fibre Reinforced Concrete and Shotcrete, as well as ASTM A820, Type I, Standard Specification for steel fibres for fibre reinforced concrete. Crimped Steel Fibre (CSF01) is a low carbon and cold drawn steel wire fibre that provides temperature and shrinkage crack control, enhanced flexural reinforcement, higher shear strength, and increased crack resistance in concrete. It is designed to be easy to mix, place and finish. Crimped Steel Fibre, at the recommended dosage rates, will reduce the measured slump of concrete; however, no additional water should be provided.

Table 1: Properties of Crimped Steel Fiber

Material	Cold draw steel
Appearance	Bright & clean
Fiber type	Crimped steel
Aspect ration	60
Length	30 mm
Diameter	0.5 mm
Density	7800 kg/m^3
Youngs modulus	200 Gpa
Tensile strength	750-1100 N/mm^2

Figure 1. Crimped Steel Fibers

LITERATURE REVIEW

- **Bayramov et al(2020):**He performed a compression and splitting tensile test for different steel fibre reinforced concrete specimens. Both the compression and tensile strengths increase as the fibre aspect ratio increases from 55 to 65, they decline instead when L/D rises from 65 to 80.
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- **Abdul Ghaffar, Amit S. Chavhan, Dr. R. S. Tatwawadi [2014],** The purpose of this research is based on the investigation of the use of steel fibers in structural concrete to enhance the mechanical properties of concrete. The objective of the study was to determine and compare the differences in properties of concrete containing without fibers and concrete with fibers. This investigation was carried out using several tests, compressive test and flexural test. A total of eleven mix batches of concrete containing 0% to 5% with an interval of 0.5% by wt. of cement. 'crimped' steel fibers were tested to determine the enhancement of mechanical properties of concrete. The workability of concrete significantly reduced as the fiber dosage rate increases.

- **G. Murali, A. S. Santhi and G. Mohan Ganesh [2014**], It is well known that concrete is characterized by its high compressive strength, yet its brittle mode of failure is considered as a drawback of high strength concrete when it is subjected to impact and dynamic loads. This study aims to investigate the impact resistance of fiber reinforced concrete (FRC), incorporated with steel fibers at various dosages. For this, a drop weight test was performed on the 28 days cured plain and fiber reinforced concrete samples as per the testing procedure recommended by ACI committee 544. Crimped and hooked end steel fiber of length 30 mm and an aspect ratio equal to 60 was added to concrete in different proportions i.e., 0%, 0.5%, 1.0% and 1.5% with water cement ratio of 0.42. From the test results, it was proved that the (FRC) was effective under the impact loads thus improving the impact resistance. Also, the reduction of strength under impact load in each specimen for every three blows was determined by ultrasonic pulse velocity (UPV) test. Further, a statistical correlation between (UPV) and number of blows under impact load was developed using regression analysis. The developed regression model predicts the reduction in strength of concrete under impact load accurately.

- **Elson John (2014):** In this study it was observed that the "physical properties of the concrete after adding the different volume fractions of fibers" are used in the concrete. In the mix design is carried out as per 10262:2009 and finally the test result of compressive strength split tensile strength and flexural strength in the presence of steel fiber there is an increase in compressive strength split tensile strength and flexural strength the small in fiber specimen.

- **Vikrant Vairagade (2012):** in this "experimental investigation on mechanical properties of steel fiber reinforced concrete" were analyzed and finally he was concluded that the result of compressive strength for M30 grade of concrete on cube and cylinder specimens with 0% and 0.75% steel fibers for aspect ratio 55 is it observed that for addition of 0.75% fibers shows slightly more compressive strength than normal concrete.

- **R.S. Olivito and F.A. Zuccarello (2010):** Increment of tensile strength for short fiber specimen and ultimate strength was shown higher in long fibers.

- **Ganesan and Murthy (1990)** ascertained the stress – strain behavior of short, confined, reinforced concrete column with and without steel fibers. The volume fraction of 1.5% and aspect ratio- 60 of steel fibers was used. The strain at peak loads was increased to certain extent in this study.

Scope of Present Study

- The study is limited to concrete of grade M35.
- Mix Design is done as per IS Standards.
- Super-plasticizer (SP-430 Conplast) is used.
- Steel fibre was used in this study.
- This study is carried out to determine the mechanical properties of normal concrete and steel fibre reinforced concrete, and the results are analyses using destructive and non-destructive tests.

EXPERIMENTAL INVESTIGATION

Cement

Ordinary Portland Cement 53 grade which confirms to IS: 8112-1987 was used for the present experimental investigation. All the tests are carried out in accordance with procedures described in IS: 4031-1968. Tests were conducted for the determination of the cement's physical properties.

Fine Aggregate

Locally accessible river sand that fulfilled IS 383-1970 standards was used the fine aggregate in the concrete. Beach sands usually have smooth, spherical to ovaloid particles from the abrasive action of waves and tides and are free of organic matter.

Coarse Aggregate

Coarse aggregate of nominal size 20 mm, obtained from the local quarry confirming to IS 383-1970 specifications were used. Proportion of coarse aggregate were used 20mm (60%) and 12.5mm (40%).

Water

Water available in the structural laboratory has been used for preparation of concrete in the entire experimental program. The quality of water has been tested in the environmental laboratory as per IS standards and it is found suitable for the use. The test results obtained are confirms the permissible values stipulated in the IS 456-2000.

Admixture

Conplast SP430 is a brown liquid that is instantly dispersible in water and is based on Sulphonated Naphthalene Polymers. Conplast SP430 has been precisely developed to provide significant water reduction of up to 25% without losing workability or producing high quality concrete with decreased permeability.

Crimped Steel Fibre

It is a tiny piece of reinforcing material that has characteristics. Fibre reinforced concrete is made up of cement, aggregate, and discontinuous, discrete, uniformly dispersed proper fibres. The length dimensions range from 6.4 mm to 76 mm while the diameter range 0.25 mm to 0.75 mm. The steel fibers are described by a convenient parameter" aspect ratio". The aspect ratio is determined by length to diameter ratio. It varies from 20 to 100.

METHODOLOGY

1. To prepare M35 grade conventional concrete mix and to tests the specimens for mechanical properties.
2. Optimal dose should be determined and preparing FRC with steel fibre at 0.50%, 1%, 1.5%, 2.0%, and 2.5% of volume concrete.
3. To investigate and compare the compressive, flexural, and split tensile strengths of M35 grade normal concrete and fibre reinforced concrete.

4. compare the results of the destructive and non-destructive tests for the optimum fibre mix with conventional concrete mix.
5. The test results can be compared to normal concrete.
6. To investigate the durability of steel fibre reinforced concrete and compare it to normal concrete.

Mix Design

Designed according to IS: 10262 - 2009 and IS 456 - 2000.
The Designed concrete grade - M35
Maximum water-to-cement ratio - 0.45

Table 2: Quantities of Mixture

Mixture	Trail 1	Mix Ratio
Cement	380	1
Fine aggregate(Kg/m^3)	656	1.73
Coarse aggregate(Kg/m^3)	1239	3.26
Water	160	0.42
super plasticizer	0.38	0.001

EXPERIMENTAL METHODS

Compressive Strength Test

A material's compressive strength is assessed by its capacity to withstand failure in the form of cracks and fissures. Concrete compressive strength is defined as the characteristic strength of 150mm concrete cubes @28 days. The compression test is performed on cubical or cylindrical specimens. The compression test is performed in accordance with IS: 516-1959. All concrete specimens are evaluated in a compression-testing machine capacity. Compressive Strength was determined using concrete cubes 150mmx150mm x150mm. The test is performed using 150mm concrete cubes on a Universal testing machine or compressive testing machine. Cubes were tested at the specified age using a compression testing machine.

Figure 2. Test for Compressive Strength.

Split Tensile Strength

The split tensile strength of concrete has to be determined in order to determine the maximum load at which the concrete members may crack. The split tensile strength of concrete test is simple to carry out, and the most essential aspect is that it produces results that are more reliable than other tension tests such as the ring tension test and double punch test.

The specimens were subjected to a split tensile strength test that complied with IS 5816-1999.Three cylindrical specimens of size 150 mm x 300 mm were cast. Experimental setup for Split Tensile Test is shown in below fig. The load increased gradually until the specimen failed. The maximum applied load was then noted.

Figure 3. Test for Split Tensile Strength.

Flexural Strength Test

The flexural strength can be determined by Standard test method. In this study, three beams of size 100 mm x 100 mm x 500 mm to determine flexural strength. If three points are loaded, the critical crack could form anywhere in the structure

Figure 4. Test for Flexural Strength.

Concrete Core Test

The compressive strength of the hardened concrete can be tested using a very well-known and established procedure called a concrete core test. Concrete core testing makes it possible to visually analyze the interior of the concrete member, which is connected to estimating strength. Diamond-tipped rotary cutting tools are typically used to cut concrete cores. The result is a cylindrical specimen with inserted reinforcement pieces at its uneven, parallel, square ends.

Figure 5. Concrete Core Test

Modulus of Elasticity

Concrete modulus of elasticity is defined as the ratio of stress applied to the concrete to the strain generated. A compression test on a cylindrical concrete specimen can be used to determine the exact value of the modulus of elasticity of concrete. The deformation of the specimen with regard to different load variations will be studied during the test. These observations result in a Stress-Strain graph (load-deflection graph) that is used to calculate the modulus of elasticity of concrete. The modulus of elasticity of concrete is given by the slope of a line drawn by the stress-strain curve from a stress value of zero to a compressive stress value of 0.45fck (working stress).

Figure 6. Modulus of Elasticity

Rebound Hammer Test

The rebound hammer test method can be used to distinguish between acceptable and doubtful elements of a construction or to evaluate the strength of two different structures. The best way for determining the relationship between the compressive strength of concrete and the rebound number is to test the concrete cubes simultaneously using compression testing equipment and a rebound hammer.

Figure 7. Rebound Hammer Test.

Ultrasonic Pulse Velocity

A non-destructive test known as the ultrasonic pulse velocity test is performed to assess the quality of the concrete being placed. In this test, an electronic pulse's velocity as it travels through the concrete from a transmitter to a receiver is essentially measured.

The ultrasonic pulse velocity test works on the assumption that the velocity of sound in a solid material is proportional to the square root of the modulus of elasticity E/density P. The material's quality and strength are related to its density and elastic properties, respectively.

Figure 8. Ultrasonic Pulse Velocity

Water Absorption Test

Absorption testing is a typical method for determining the water tightness of concrete. A water absorption test, such as BS 1881-122:2011 Testing Concrete: Method for Determination of Water Absorption, analyses the amount of water that penetrates concrete samples when submerged.

Figure 9: Water Absorption Test

Sorpitivity Test

The capillary rise absorption rate on relatively homogenous material can be used to calculate Sorpitivity. The testing fluid was water. After casting, the cylinders were placed in water for 90 days to cure. After drying in an oven at a temperature of 100 + 10 °C, the specimen was drowned as shown in the figure below, with water level not more than 5 mm above the base of the specimen and flow from the peripheral surface prevented by adequately sealing it with non-absorbent coating.

Figure 10: Sorpitivity Test

RESULTS AND DISCUSSIONS

Optimum Dosage

Table 3: Optimum Dosage of Fibers

various percentages of fiber (%)	Average compressive strength (N/mm^2)for 7 days	Average compressive strength (N/mm^2) for 28 days
0.50	32.6	41.53
1.0	36.51	44.94
1.5	41.93	48.61
2.0	38.13	46.13
2.5	33.47	43.29

From the above results, we clearly observe that fiber addition @1.50% gives max. values. We also refer the standard journals which are published earlier under this study and decided @1.50% is the optimum dosage of fiber.

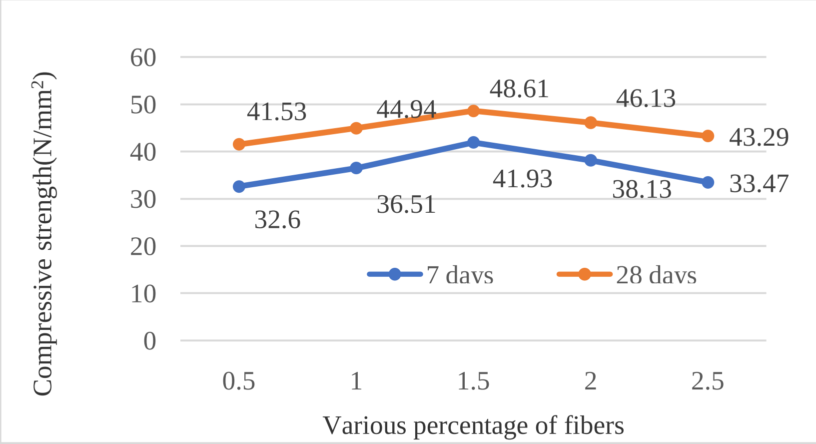


Figure 11.A Graph Showing Compressive Strength for 7 & 28 Days at Various Ages

Compressive Strength Test

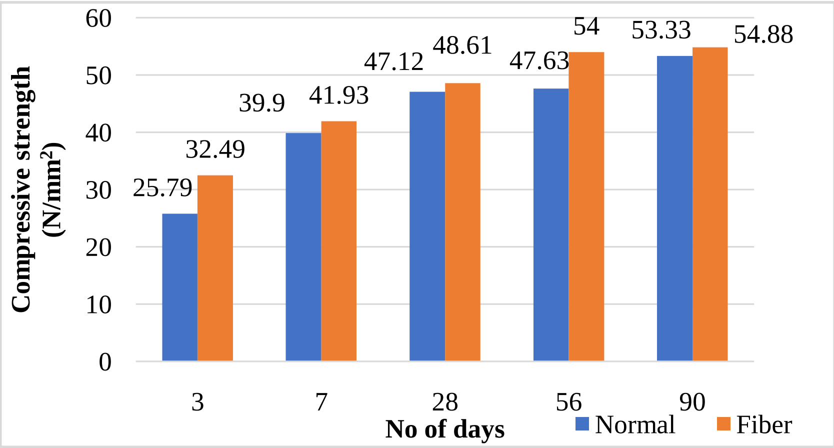


Figure 12. Graph Showing Compressive Strength for Normal & Fiber Reinforced Concrete

From the above graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 25.97%,5.08%,3.16%,13.37% and 2.90% for 3 days,7days,28 days,56 days and 90 days respectively.

Split Tensile Strength

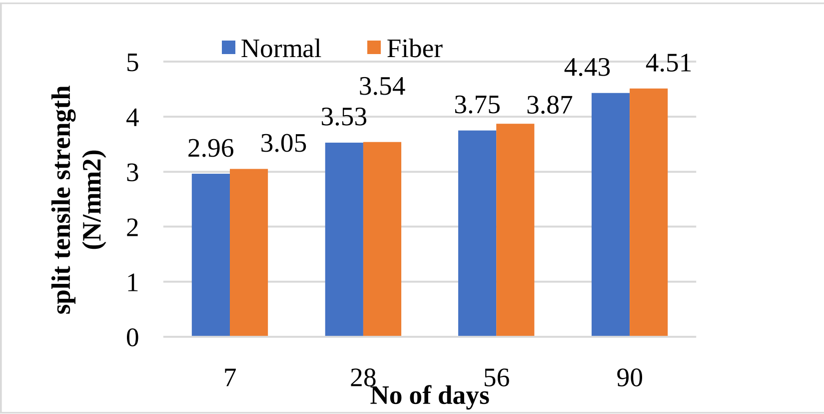


Figure 13. Graph Showing Split Tensile Strength for Normal & Fiber Reinforced Concrete.

From the above graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 3.04%,0.28%,3.2%,1.8% for 7days,28 days,56 days and 90 days respectively.

Flexural Strength

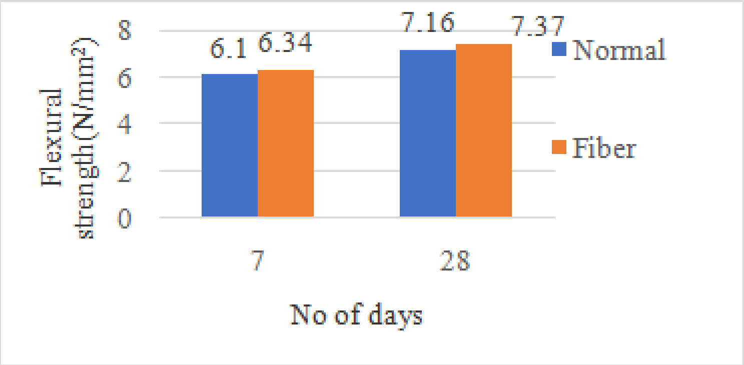


Figure 14. Graph Showing Flexural Strength for Normal & Fiber Reinforced Concrete

From the above graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 3.93%,2.93%, for 7days,28 days respectively.

Modulus of Elasticity

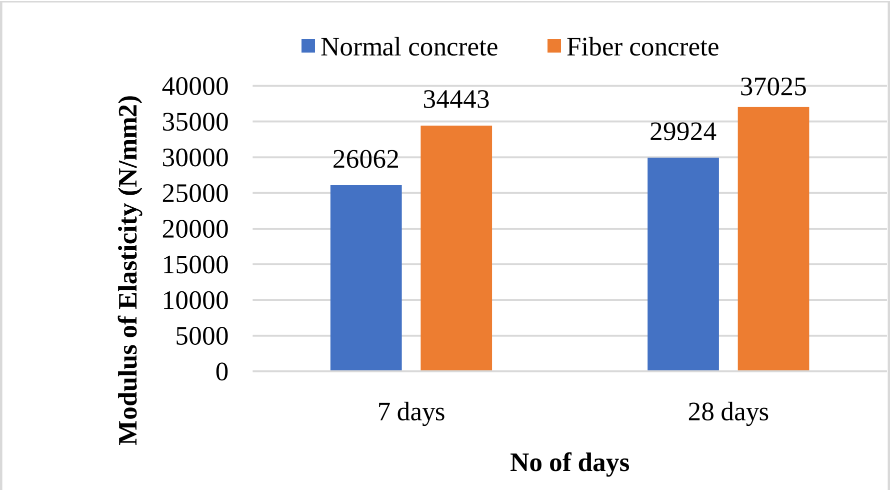


Figure 15. Graph Showing Modulus of Elasticity for Normal & Fiber Concrete

Core Cutter Test

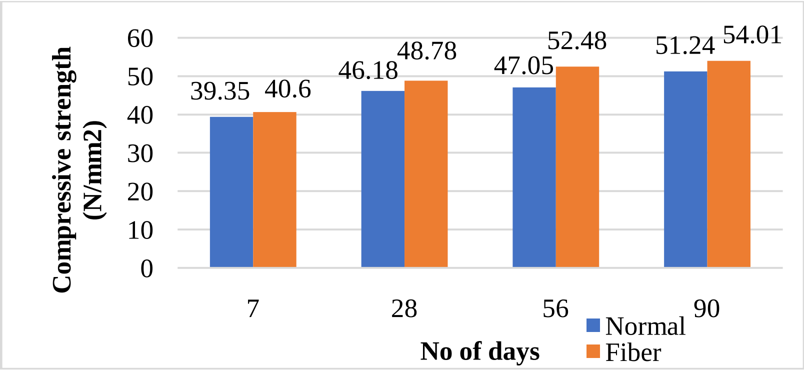


Figure 16. Graph Showing Core Cutter Test for Normal & Fiber Concrete

From the above graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 5.4%,11.54%,5.63%,3.176% for 7days,28 days,56 days and 90 days respectively.

Rebound Hammer Test

From the below graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 3.899%,3.68%,0.22%,26.83% and 33.16% for 3 days,7days,28 days,56 days and 90 days respectively.

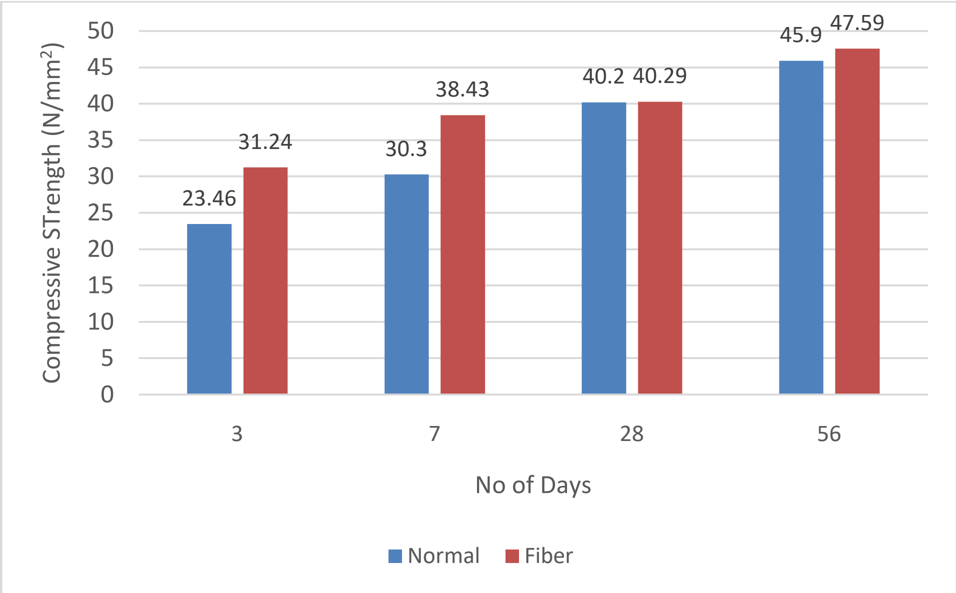


Figure 17. Graph Showing Rebound Hammer Test for Normal & Fiber concrete

Ultrasonic Pulse Velocity

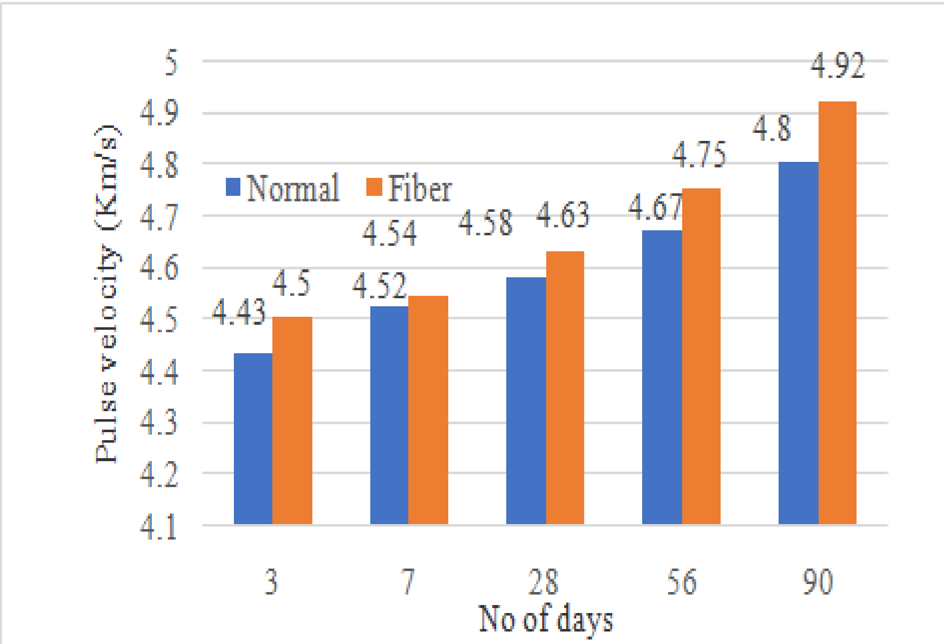


Figure 18. Graph Showing Ultrasonic Pulse Velocity for Normal & Fiber Concrete

From the above graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is 1.58%,0.44%,1.09%,1.71% and 2.5% for 3 days,7days,28 days,56 days and 90 days respectively.

Water Absorption Test

From the below graph, we clearly observe that the compressive strength is increased for fiber reinforced concrete than control concrete, and the percentage increase is -31.66%,7.08%,21.42% for 28 days,56 days and 90 days respectively.

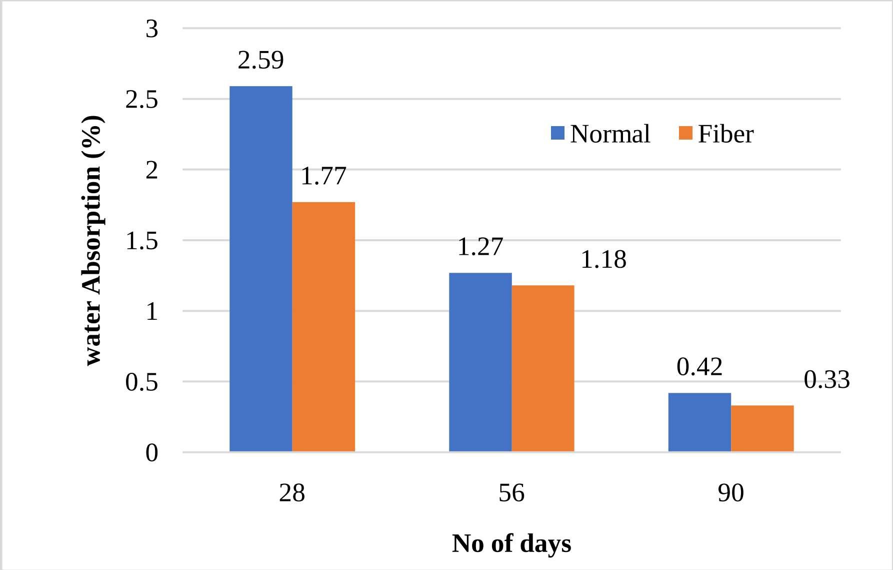
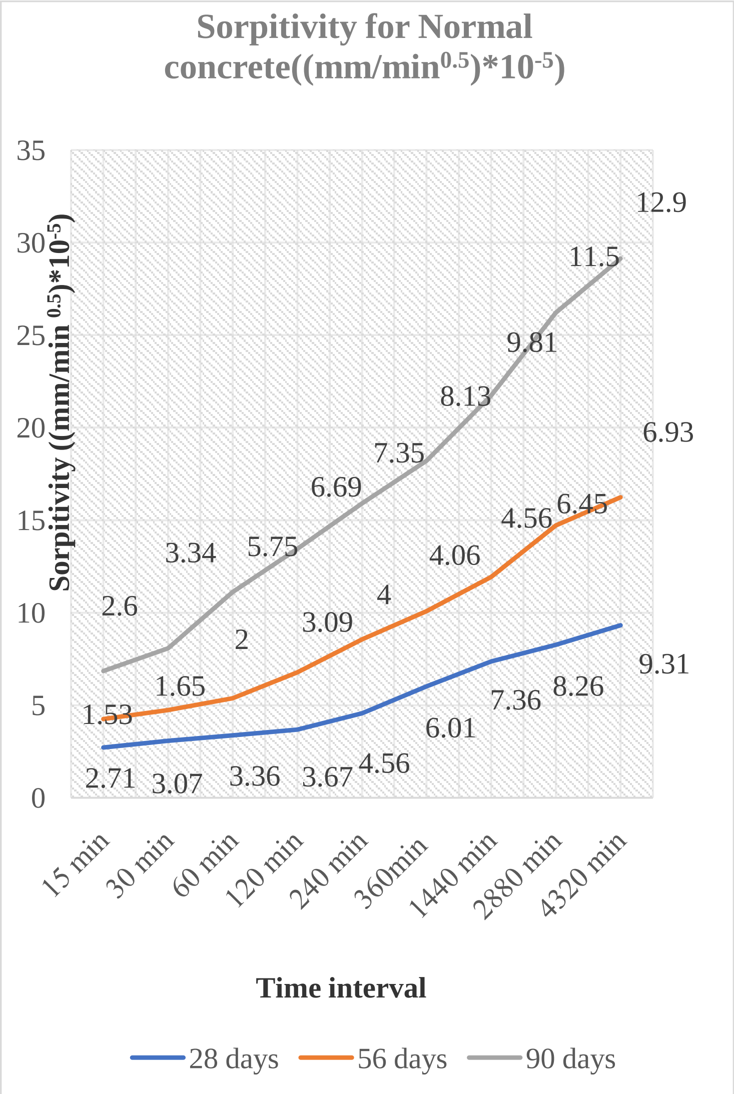


Figure 19. Graph Showing Water Absorption for Normal & Fiber Concrete

Sorpitivity Test



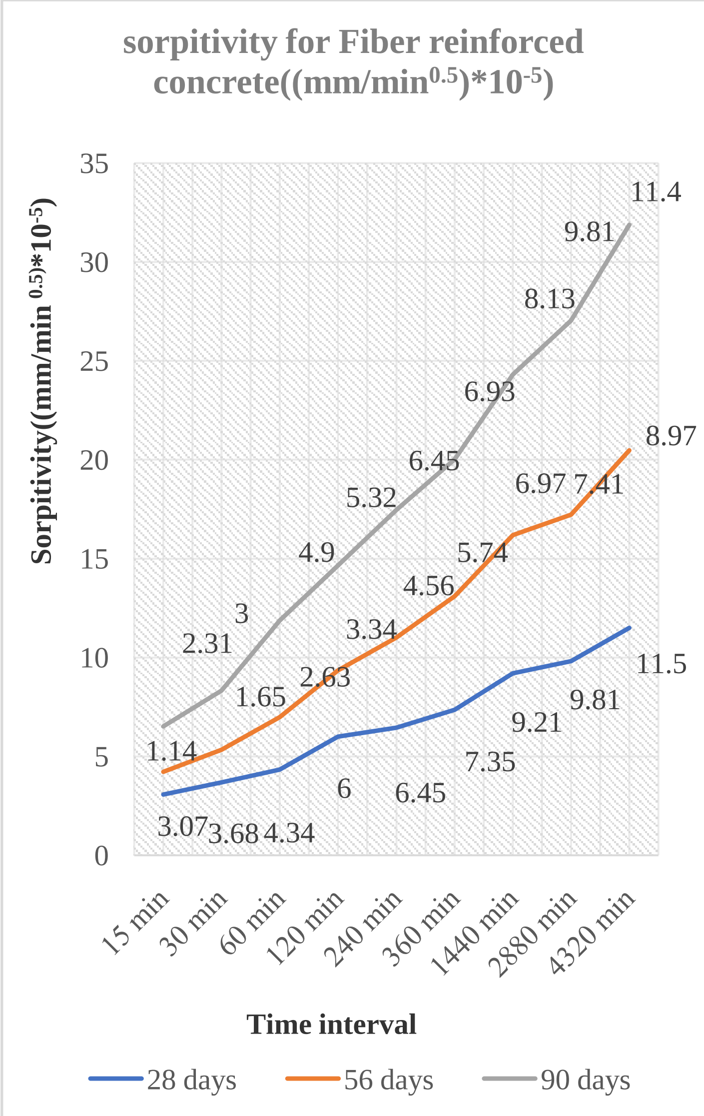


Figure 20. Graph Showing Sorpitivity Test for Normal and Fiber Concrete

CONCLUSIONS

- For M35 Grade the Normal concrete compressive strength obtained is 47.12 N/mm^2.
- 2Compressive strength is found to be highest for 1.5% fibres when compared to 0%, 1%, 1.5%, 2.0%, and 2.5% fibres.
- Compressive strength improves by approximately 25.97%, 5.08%, 3.162%, 13.37%, and 2.92% after 3, 7, 28, 56, and 90 days when 1.5% steel fibres are added to the concrete mix.
- Split tensile strength improves by approximately 3.04%, 0.28%, 3.2%, and 1.8% after 7, 28, 56, and 90 days when 1.5% steel fibres are added to the concrete mix.
- Flexural strength improves by roughly 3.93%, 2.93%, and 3.93% after 7 and 28 days, respectively, when 1.5% steel fibres are added to the concrete mix.
- The compressive strength measured by concrete core tests for normal and 1.5% steel fibres in the concrete mix is not significantly different from the corresponding compressive strengths.
- 7.When 1.5% steel fibres are added to the concrete mix, the modulus of elasticity increases by around 32.15, 23.73% for 7 and 28 days, respectively.
- From the Rebound hammer test results, Quality of concrete is fair to good for Normal concrete and good to very good for Fibre Reinforced Concrete.
- According to the UPV test results, the quality of normal and fibre reinforced concrete is good to exceptional.
- Water absorption decreases with addition of 1.5% steel fibers in concrete mix. From ASTM C 642 classification for water Absorption, the concrete comes under “EXCELLENT” category.
- Sorpitivity increases with respect to time for both Normal and fiber Reinforced concrete.

REFERENCES

[1]. Bayramov et al(2020), Optimisation of steel fibre reinforced concretes by means of statistical response surface method.
[2]. Abdul Ghaffar, Amit S. Chavhan, Dr. R.S. Tatwawadi[2014],A Review on the Study of Strength Properties of High Performance Concrete Using Various Fibers
[3]. G. Murali, A. S. Santhi and G. Mohan Ganesh [2014], Impact Resistance and Strength Reliability of Fiber-Reinforced Concrete in Bending Under Drop Weight Impact Load
[4]. Elson John (2014),The Mechanical Properties of Steel Fibre Reinforced Concrete with Quarry Dust as a Partial Replacement of Fine Aggregate
[5]. Vikrant Vairagade (2012), Experimental Study on Behavior of Steel and Glass Fiber Reinforced Concrete Composites
[6]. R.S. Olivito and F.A. Zuccarello (2010),An experimental study on the tensile strength of steel fiber reinforced concrete
[7]. Ganesan and Murthy (1990), Strength and Behavior of Confined Steel Fiber Reinforced Concrete Columns