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Review on the Reinforcement of Steel Fibres in Conventional Concrete to Increase its Strength

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ABTRACT

A ubiquitous substance utilised in the construction of any industry or structure is called concrete. Additionally, concrete is employed in the building and industrial sectors in enormous quantities. Numerous characteristics of concrete, such as its brittleness, can lead to brittle failure when they are unable to withstand tensile loads. Given that the fibres have the ability to make the concrete more durable. Steel fibre reinforced concrete is being used more often to boost its toughness and lessen its crack deformation features because it has been found in numerous trials to have a high resistance to cracking. For a theoretical discussion on the topic of steel fibre reinforced concrete, I thus present this work. Here, we talk about behavioural models and terminology that aim to explain material performance without going into specific mathematical specifics.

Here, it is demonstrated that the flexural strength of concrete reinforced with steel fibres is directly correlated with the steel fibre content and inversely correlated with the water cement ratio. Why the various allusions from classic and early writers are incorporated to connect the topic chronologically. Currently, the historical study serves to establish the context for the contemporary understanding of steel fibre reinforced concrete.

Keywords: SFRC (Steel Fibre Reinforcement Concrete), Optimum replacement, Flexural Strength, Compressive Strength, Fatigue, Workability.

I. INTRODUCTION

Fibres are utilised in cement-based composites and are composed of steel, glass, and polymers for natural materials. Because they tend to be more closely spaced and behave stronger than typical reinforcing steel bars, the fibres are better able to control cracking. Steel fibres are also utilised in plastic and to prevent or control drying shrinkage in concrete. This research examines the impact of steel fibre binding in concrete, examining its chemical and mechanical characteristics as well as the uses of steel fibre reinforced concrete. Another point to note is that the flexural strength of the composite increased from 26% to 100% when steel fibres were added to Portland cement concrete aura factory concrete, depending on the amount of fibres added and the mix design. With the use of steel fibre technology, brittle material is transformed into more ductile material. Because the fibre keeps up with the weight even after cracking, there is almost little chance of catastrophic concrete failure. Steel fibres can be found in a variety of lengths, ranging from 31 mm to 60 mm, with an aspect ratio of 21 to 100. They can be produced in a deformed or hook form. Steel fibre concrete is a castable or sprayable substance consisting of hydraulic cement, fine and coarse aggregates, and discontinuous steel that is randomly distributed throughout the matrix in the shape of a rectangular cross section. The steel fiber's primary function is to fortify the concrete in tensile tracking to detect cracks of this kind. The fibre reinforcement concrete has a higher flexural strength when compared to "concrete with reinforcement" made of welded wire fabric and concrete without reinforcement. However, steel fibre reinforced isotropically strengthens concrete in an isotropic manner, improving resilience to fatigue, cracking, spalling, and fragmentation, in contrast to traditional reinforcement, which strengthens in one or two directions.

Any bheem on a rainforest experiences stress from bending; as the load increases, the deflection increases as well, eventually leading to failure and the beam breaking apart. The term "first crack strength" refers to the beam where the first crack occurs. The initial crack strength is directly correlated with the amount of fibre in the mix and is determined by the design of the concrete mix as well as the amount of fibre in the mix.

II. LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

Throughout history, fibers have been utilized to reinforce brittle materials, with examples such as the use of straws in sun-baked bricks, horse hair in plaster, and asbestos fibers in Portland cement. The inherent low tensile strength and brittleness of concrete led to the introduction of reinforcing rods in the tensile zone of concrete structures since the middle of the nineteenth century. The first patent for Steel Fiber Reinforced Concrete (SFRC) was filed in California by A. Bernard in 1874. Subsequently, patents by H. Alfen in France (1918) and G. C. Martin in California (1972) were granted for SFRC pipes. In 1931, H. Etheridge explored the use of steel rings to address the anchorage of steel fibers.

The period during and after World War II witnessed further developments, with G. Constantineso obtaining patents in England (1943) and the U.S.A. (1954). Although numerous patents followed, the widespread adoption of SFRC faced challenges due to high costs, inadequate testing facilities, and the simultaneous rapid progress of concrete reinforced with steel bar and wire systems. It wasn't until 1962, when James Romualdi at the Carnegie Institute of Technology provided a clearer understanding of the properties of SFRC. An extension of this understanding came with the application of steel fiber-reinforced shotcrete, with the first instance being the stabilization of the rock slope at a tunnel portal in Idaho in 1972.

2.2. INDIAN SCENARIO

In the Indian context, there are extensive opportunities as well as significant challenges for scientists, engineers, and concrete technologists involved in the utilization of fiber-cement composites in the construction industry. Research and development initiatives on Fiber Reinforced Concrete (FRC) composites began in India in the early 1970s. Numerous studies have been documented on the flexural behavior of Steel Fiber Reinforced Concrete (SFRC) beams and Slurry Infiltrated Fiber Reinforced Concrete (SIFCON) elements, focusing on enhancements in cracking resistance, stiffness, and ductility. The establishment of a specific Indian standard code for steel fiber-reinforced concrete would have a positive impact on the development of infrastructure in India. The construction and maintenance sectors offer vast opportunities for a wide range of applications where the distinctive properties of FRC materials can be leveraged to benefit society and contribute to an improved quality of living.

2.3. TOUGHNESS

The primary purpose of incorporating steel fibers in concrete and shotcrete is to introduce ductility to an inherently brittle material. Steel fiber reinforcement enhances the energy absorption, impact resistance, and crack resistance of concrete. It allows concrete to carry loads continuously after cracking, a behavior known as post-crack behavior. Various tests have been developed to measure and quantify the improvements achievable in steel fiber-reinforced concrete.

Countries such as the U.S.A, Japan, and European countries like France, Germany, Belgium, Austria, Spain, and the Netherlands have specific standards in this regard. To measure the influence of fibers on toughness, standards like ASTM C-1018 (American Society for Testing and Materials) in the U.S.A and JCI SF4 (Japan Concrete Institute) in Japan prescribe similar bending tests where the load is recorded based on an applied deflection of the specimen.

Studies conducted by Gopala Krishnan et al. (2003) at the Structural Engineering Research Centre (SERC), Chennai, focused on the properties of steel fiber-reinforced shotcrete, including toughness, flexural strength, impact resistance, shear strength, ductility factor, and fatigue endurance limits. The study revealed that the thickness of Steel Fiber-Reinforced Shotcrete (SFRS) panels can be significantly reduced compared to weld mesh concrete. The energy absorption capacity of SFRS panels increased with higher proportions of steel fibers, as shown by the results of static load testing.

In a study by Taylor et al. (1996), strength and toughness measurements were reported for a range of normal and high-strength concrete mixes with and without fiber reinforcement. The rheology of these concretes allows them to be reinforced with sufficient volumes of polypropylene and steel fibers to significantly increase their toughness while maintaining relatively constant strengths in compression and tension.

Durability considerations for Steel Fiber-Reinforced Shotcrete (SFRS) are influenced by factors similar to those affecting conventionally reinforced concrete. As long as the matrix retains inherent alkalinity and remains uncracked, deterioration of SFRC is unlikely. Good-quality SFRC exposed to atmospheric pollution, chemicals, or a marine environment tends to carbonate only to a depth of a few millimeters over many years. While the immediate layer of corroded surface fibers may exhibit rust-colored staining, the interior fibers beneath the carbonated surface layer remain protected as long as the SFRC remains uncracked.

Investigations by Krishnamoorthy et al. (2000) at SERC, Chennai, explored the influence of corrosion on the strength of SFRC. Concrete specimens subjected to accelerated corrosion showed no corrosion of steel fibers in SFRC even after 250 cycles. The addition of steel fibers in the concrete matrix resulted in decreased crack width and delayed cracking.

2.5. SEISMIC RESISTANCE

By using SFRC in a beam-column joint, some of the difficulties associated with joint construction can be overcome and a greater seismic strength can be provided. Michael Gebman (2001)[6] of San Diego State University, U.S.A made two half-scale joints, constructed to reflect U.S building code, two SFRC joints were constructed with a hoop spacing increased by 50%, and two SFRC joints were constructed with a hoop increased by 100%. Hooked-end steel fibres with a length of 1.2-in (31-mm), a diameter of 0.020-in (0.50-mm) and an aspect ratio of 60 were used at a volume fraction of 2%.After simulating a quasi-static earthquake loading, the SFRC joints were found to have dissipated more energy than the conventional joints.

A 90%increase in energy absorption was found for SFRC joints with hoop spacing increased by 100%. A 173% increase in energy absorption was found for SFRC joints with hoop spacing increased by 50%.Earthquake loading is best represented by a burst of energy applied to structures. In conventional joints, such energy is dissipated by concrete cracking, steel deformation, steel bending etc. In steel fibrous joints, the goal is to dissipate such energy via progressive fibre pullout from concrete. Henager (1977) [7] was the first to publish a paper on testing of steel fibre reinforced concrete beam-column joints. Two full-scale joints were constructed. One joint was built according to ACI 318-71[8]. The other joint was reduced steel congestion common in seismic resistant joints by replacing hoops with steel fibre concrete. Brass plated steel fibres with a length of 1.5-in (38-mm) and an aspect ratio of 75 were added to the concrete mix at a volume fraction of 1.67%. An earthquake loading was simulated using a quasi-static loading rate utilizing an applied double acting hydraulic actuator.

It was found that the steel fibre reinforced concrete joint had a higher ultimate moment capacity, had better ductility, was stiffer, and was more damage tolerant. Henager concluded that hoops, in the joint, could be replaced with steel fibres. Henager also concluded that SFRC could provide for a more cost effective joint.

Lakshmipathy and Santhakumar (1986)[9] presented results of SFRC frame testing conducted at Anna University. Two frames, representing a 7 level single bay frame, were constructed at 1/4 scale; one frame was made out of reinforced concrete and the other out of SFRC. Fibres with a length of 1.57-in (40-mm) and an aspect ratio of 100 were used at a volume fraction of 1%. An earthquake loading was simulated by applying load via hydraulic jacks at the 7th, 5th and 3rd levels of the frame. It was found that the SFRC frame had a ductility increase of 57% and a130% increase in cumulative energy dissipation in comparison to the conventional joint.

2.6. SHEAR RESISTANCE

Large earthquakes result in high shear forces within the beam-column joint. To withstand such forces, hoop spacing is decreased within the joint region. This can sometimes result in congestion problems that can result in construction difficulty. SFRC can be used with increased hoop spacing to provide higher shear resistance. Craig et al (1984) [10] examined the shear behaviour of 21 short columns under double curvature bending. The steel fibres used had a length of 1.18-in (30-mm), an aspect ratio of 60 and were used at volume fractions of 0.75% and 1.5%. It was found that the failure mode changed from explosive to ductile as steel fibre content increased.

Jindal and Hassan (1984)[11] found that the shear resistance of SFRC joints was greater than that of conventional joints. Steel fibres with a length of 1-in (25-mm), and an aspect ratio of 100 were used at a volume fraction of 2%. It was observed that SFRC increased the shear and moment capacities by 19% and 9.9% respectively. It was also observed that the failure mode for SFRC specimens was ductile. Kaushik et al (1987) [12] found that a strength ratio of 1.67 can be achieved with the addition of 1.5% volume fraction of steel fibres with aspect ratio of 100 and the average maximum strain in fibre reinforced concrete beams were of the order of 0.007 as compared to 0.0035 for plain reinforced concrete beams.

2.7. DYNAMIC RESISTANCE

Dynamic strength of concrete reinforced with various types of fibres subjected to explosive charges, dropped weights and dynamic tensile and compressive load has been measured. The dynamic strength of various types of loading was 5 to 10 times greater for fibre reinforced than for plain concrete. The greater energy requirement to strip or pull-out the fibres provides the impact strength and the resistance to spalling and fragmentation.

Steel fibre concrete was found to provide high resistance to the dynamic forces of cavitation under high head, high velocity water flow conditions .Still greater cavitation resistance was reported for steel fibre concrete impregnated with the polymer. An impact test has been devised for fibrous concrete which uses 10-lb hammer dropping on to steel ball resting on test specimen. For fibrous concrete, the number of blows to failure is typically several hundred compared to 30 to 50 for plain concrete. srinivasalu et al (1987) [13] examined that the dynamic behaviour of reinforced concrete beams with equal tension and compression reinforced and varying percentages of steel fibres was studied at SERC. The test beams were subjected to particular static loads those simulated different levels of cracking before they were subjected successively to steady state forced vibration tests. Dynamic flexural rigidity and damping were from the data collected from the test. Tests show that that the dynamic stiffness of SFRC beams in the uncracked state was only marginally high (15% for a fibre volume content of 1%) than for reinforced concrete beams. However large increase in stiffness in the post cracking stage was observed: but this was nearly the same for all the fibre volumes studies (0.5% to 1%).The damping values exhibited by SFRC beams showed significant scatter. Researchers concluded that the average in the uncracked state,

applicable to design of machine foundation is 1% critical. Equation are also formulated from the test results to estimate the dynamic stiffness in the beams in post cracking stage for use in the designs involving SFRC elements in blast and earthquake resistant structures. Tests concluded on SFRC specimens by Jacob et al at Institute of Material and Structure Research,

Yugoslavia also showed that the inclusion of fibres improve the dynamic properties of concrete. It is also found that resistance to blow fatigue are improved by the addition of fibre. Resistance to blow was investigated using the Charpy stricking pendulum an improvement in toughness was reported.

2.8. BAR CONFINEMENT

Confinement of the rebar in a structure is very important for the performance of the joint in an earthquake. The bond between concrete and rebar is affected by the amount of steel congestion in a joint. If there are a lot of hoops overlapping with small spacing in a joint, then the bond between concrete and rebar can be poor. Poor bond results when there is not enough space between the bars to allow the concrete to pass through. A joint with increased hoop spacing will have better bar confinement, as there will be ample room for the concrete to flow around the bars and to properly bond.

However, in a seismic beam-column joint it can be nearly impossible to allow for an increased hoop spacing providing better confinement because the high shearing forces present in a joint require numerous hoops. To remedy this situation, steel fibre concrete can be used in place of some hoops.

2.9. BOND IMPROVEMENT

Soroushian and Bayasi (1991)[14] tested bars embedded in concrete blocks to examine the bond improvement gained by using SFRC. Steel fibres with a length of 2-in (50.8-mm), and an aspect ratio of 57 were added at a 2%volume fraction. It was found that local bond resistance increased by 55%and frictional resistance increased by 140%.

2.10. SOME DEVELOPMENTS IN FIBRE REINFORCED CONCRETE

Engineered Cementitious Composite (ECC), a recently designed fibre reinforced concrete (FRC), is 40% lighter and 500 times more resistant to cracking than conventional concrete. Compared to regular concrete or ordinary fiber-reinforced concrete, ECC can withstand strain-hardening up to several percent strain, resulting in a material ductility that is at least two orders of magnitude higher. Also, ECC has distinct cracking behaviour. Even when distorted to several percent tensile strains, ECC keeps crack width below 100 µm when loaded beyond the elastic limit.

Adding fibres gave the high-performance fiber-reinforced concrete in a bridge deck more residual strength and controlled cracking, according to recent tests. The process of incorporating steel fibres into concrete results in the creation of what is known as homogenous reinforcement. This controls the behaviour after failure but does not significantly improve the mechanical qualities prior to failure. Thus, pseudo-ductile steel fibre reinforced concrete is created from plain concrete, a quasi-brittle substance.

Bending moments are shifted and stresses are absorbed by bridge fibres following the beginning of matrix cracks. When the matrix fractures, the concrete element does not break down on its own; instead, the deformation energy is absorbed and the material turns into pseudo-ductile. In addition to increasing concrete's toughness, impact resistance, and fatigue resistance, steel fibre reinforcement also makes the material more resistant to cracking and, consequently, to water and chloride infiltration, greatly extending the life of concrete structures. As a result, using SFRC instead of conventional steel reinforcement in tunnel structures is a desirable technical solution because it lowers construction and labour costs associated with, say, placing conventional steel bars and forming and storing traditional reinforcement frames, as well as the possibility of spalling during transportation and laying. These early SFRC samples showed lessening of the formation of cracks as well as a decreased chance of leaks and concrete flakes breaking off, which is frequently a problem for tunnel roads.

Additionally, it was discovered that under localised force, the steel fibre reinforced details—like the shear teeth of ring joints—exhibited a higher degree of ductility. Because there are currently no design guidelines for Steel Fibre Reinforced Concrete (SFRC) constructions, engineers have typically used the same guidelines that apply to concrete with conventional reinforcement when designing SFRC tunnel lining segments. On the other hand, SFRC constructions behave very differently from traditional RC structures after breaking. Since adding steel fibres to hardened concrete enhances its durability and mechanical properties—most notably its flexural strength, toughness, impact strength, resistance to fatigue, and susceptibility to cracking and spalling—steel fibre reinforced concrete, or SFRC, has been successfully applied in many types of construction. One property of a structural assembly that refers to its ability to resist fire's impacts is fire resistance. A fire-resistant assembly should be able to hold a load in the face of fire exposure or limit the spread of fire outside the compartment in which it is used. In order to quantify the extent of damage, the fire's intensity must be evaluated if the structure is partially damaged or has only sustained significant damage in one area. The fact that actual fires do not always have the same intensity throughout a structure and may have reached various peaks in different locations is one of the primary distinctions between routine fire resistance tests and fires in structural elements. As a result, it is required to create severity assessments for each zone and divide the entire system into them. The fire department often prepares fire reports that list start and end times, the amount of work needed to contain the fire, and any additional issues encountered. It provides information on the length of the fire, its qualitative assessment, its size, degree of damage, and whether certain locations saw higher temperatures than others. Analysing the debris made of various materials can assist determine the maximum temperature reached in various areas, which can provide insight into the intensity of the fire.

The comparison of regular concrete and regular fiber-reinforced concrete exposed to various standard fire temperatures has been handled in accordance with current practice. This process is costly and time-consuming since it requires a substantial experimental research programme to address every important variable in the problem.

The accumulated yearly cost of life and property from fires is comparable to that from earthquakes and cyclones, making the research of concrete behaviour at increased temperatures extremely important nowadays. This calls for the creation of a fire-resistant concrete mixture.

2.11. PUBLISHED LITERATURE ON SFRC:

2.11.1. *A.M. Shende, A.M. Pande and M. Gulfam Pathan*(2012) [30] published a research paper titled "Experimental Study on Steel Fibre Reinforced Concrete for M-40 Grade" in the International Refereed Journal of Engineering and Science (IRJES). The study examined the compressive strength, flexural strength, and split tensile strength of steel fiber-reinforced concrete (SFRC), which contains fibres with 0%, 1%, 2%, and 3% volume fraction of hook tain. The M-40 grade of concrete had a mix proportion of 1:1.43:3.04 with a water cement ratio of 0.35. Steel fibres with aspect ratios of 50, 60, and 67 were employed. The collected result data has been examined and contrasted with a control sample that contains no fibre. A graphic representation of the link between aspect ratio and split tensile strength, flexural strength, and compressive strength. The results clearly demonstrate a % increase in the M-40 Grade of Concrete's 28-day split tensile, flexural, and compressive strengths. The present investigation yielded the following conclusions.

1. It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres.

2. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 60 and 67.

3. It is observed that compressive strength increases from 11 to 24% with addition of steel fibres.

4. It is observed that flexural strength increases from 12 to 49% with addition of steel fibres.

5. It is observed that split tensile strength increases from 3 to 41% with addition of steel fibres.

2.11.2. In 2015, Seong-Cheol Lee, Joung-Hwan Oh, and Jae-Yeol Cho examined the compressive behaviour of fiber-reinforced concrete with steel fibres that were hooked at the end. A uniaxial compression test was used to examine the compressive behaviour of fiber-reinforced concrete with end-hooked steel fibres. The variables were concrete compressive strength, fibre volumetric ratio, and fibre aspect ratio (length to diameter). 48 cylinder specimens, 150 mm in diameter and 300 mm in height, were constructed and subsequently compressed uniaxially to reduce the impact of specimen size on fibre dispersion. Steel fiber-reinforced concrete (SFRC) specimens demonstrated ductile behaviour after achieving their compressive strength, according to test data. Additionally, it was demonstrated that while the elastic modulus reduced, the strain at the compressive strength generally increased as the fibre aspect and volumetric ratios increased. This article proposes a model for the stress-strain relationship of SFRC during compression that takes the influence of steel fibres into account. Additionally, straightforward formulas for predicting the strain at the compressive strength and elastic modulus of SFRC were created. To make accurate predictions about the structural behaviour of SFRC members or structures, the suggested model and formulas would be helpful.

The appropriateness of the previous models is still in doubt because the variables were too limited to fully reflect the effect of steel fibres or because the test specimens for the investigation were relatively small in comparison to the fibre length, despite the fact that many researchers proposed several models based on their own test results in order to quantitatively evaluate the compressive behaviour of SFRC. Due to varying fibre distributions, the compressive behaviour may have been different from that of real structures.

In order to study the compressive behaviour of SFRC with end-hooked steel fibres, an experimental programme was put into place. The concrete's compressive strength, fibre aspect ratio, and fibre volumetric ratio were the program's variables. In order to reduce the impact of member size on the dispersion of fibres, big cylindrical specimens were made and put through testing. Upon comparing the test results with the predictions of other researchers' models, it was determined that no prior model was able to accurately capture the impact of end-hooked steel fibres on the compressive behaviour.

Simple formulas to predict the strain at the compressive strength and the elastic modulus were derived from the test data in order to better characterise the pre-peak compressive behaviour of SFRC.Furthermore, a basic model was suggested to forecast the compressive behaviour of SFRC while accounting for the influence of steel fibres by altering the coefficient β. With the help of the suggested formulas and model, the compressive behaviour of SFRC with end-hooked steel fibres may be fairly anticipated. Predicting the structural behaviour of SFRC members or structures with end-hooked steel fibres should benefit from the application of the suggested model. To fully comprehend the impact of other fibre kinds, such as synthetic and straight steel fibres, more research is necessary. Furthermore, the suggested model can be extended to SFRC members of different dimensions by further examining how the size of the member affects the compressive behaviour.

2.11.3. Milind V. Mohod (2012) investigated the steel fibre reinforced concrete's performance. The most often utilised building material worldwide is cement concrete. Its wide application can be attributed to its excellent workability and ability to be moulded into any shape. Ordinary cement concrete has extremely little resistance to cracking, little ductility, and very low tensile strength. internal microcracks that cause the concrete to break easily. Civil engineering buildings in the present era have certain structural and durability criteria. Since each structure has a purpose, typical cement concrete must be modified in order to fulfil it. It has been discovered that adding various types of fibres to concrete at a specified percentage enhances the structure's mechanical qualities, serviceability, and longevity. It is well known that Steel Fibre Reinforced Concrete's (SFRC) exceptional resistance to cracking and crack propagation is one of its key characteristics. By altering the proportion of fibres in the concrete, the impact of fibres on the strength of M 30 grade concrete has been investigated. By cement volume, the fibre content was adjusted by 0.25%, 0.50%, 0.75%, 1%, 1.5%, and 2%. Sizes of 150 x 150 x 150 mm cubes were cast to test the compressive strength, and 500 x 100 x 100 mm beams were cast to test the flexural strength. Before being crushed, each specimen was cured for three, seven, and twenty-eight days. Steel fibre reinforced concrete significantly improves in strength after three, seven, and twenty-eight days of curing with varying percentages of fibre, according to research on the results. When examining the cube's compressive strength, the ideal fibre content is determined to be 1%, and for the beam's flexural strength, it is 0.75%. Additionally, it has been noted that concrete's strength rises as its fibre content reaches its ideal level. The slump cone test was used to gauge how workable concrete was. The results of the Slump cone test showed that workability decreases as fibre content increases.

The following were the study's findings: Cubes and beams were cast and tested to examine the impact of steel fibre reinforcing on SFRC parameters such as cube compressive strength and flexural strength. The impact of increasing the percentage of steel fibre by cement volume was investigated. The slump cone test was used to determine whether the steel fibre reinforced concrete mix was workable. Tables and graphs representing the observations for the 3, 7, and 28-day curing periods were created and submitted.

1) The compressive strength was calculated as follows:

Compressive strength (MPa) = Failure load / cross sectional area.

2) The flexural strength was calculated as follows:

Flexural strength (MPa) = (P x L x 6) / (4 x b x (d*d)) (1)

Where, P= Failure Load,

L= Center to center distance between the supports = 400mm,

b= Width of specimen= 100mm, d= depth of specimen=100 mm.

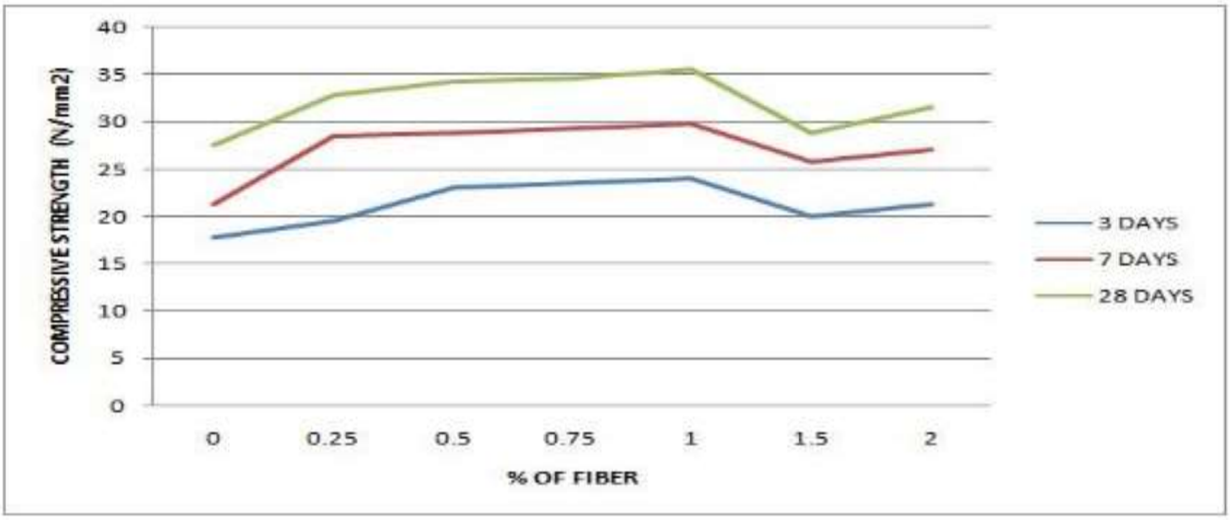

Fig.1. Variation of Compressive strength with respect to % of Fibre content

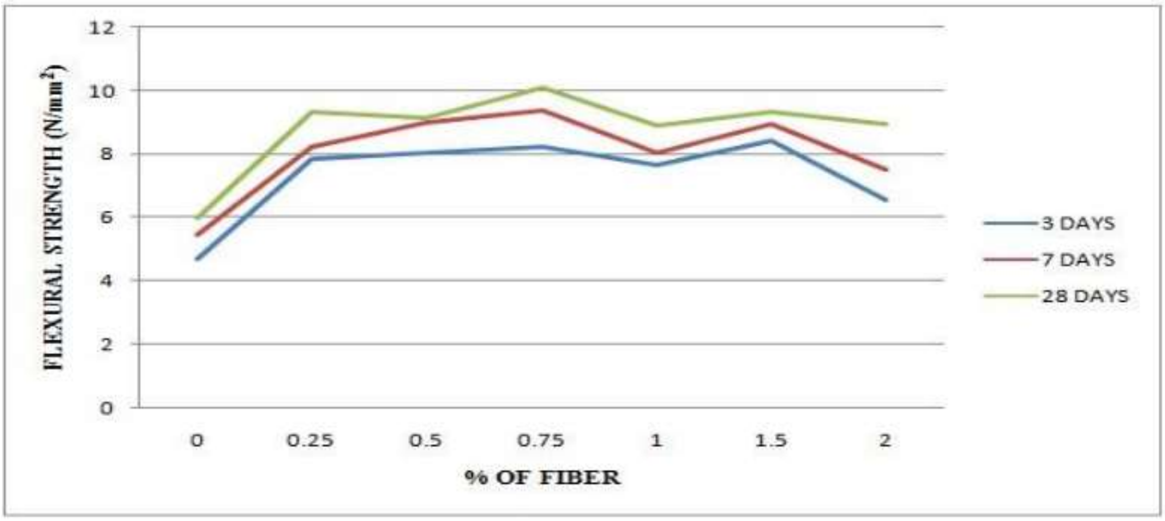

Fig.2. Variation of Flexural strength with respect to % of fibre content

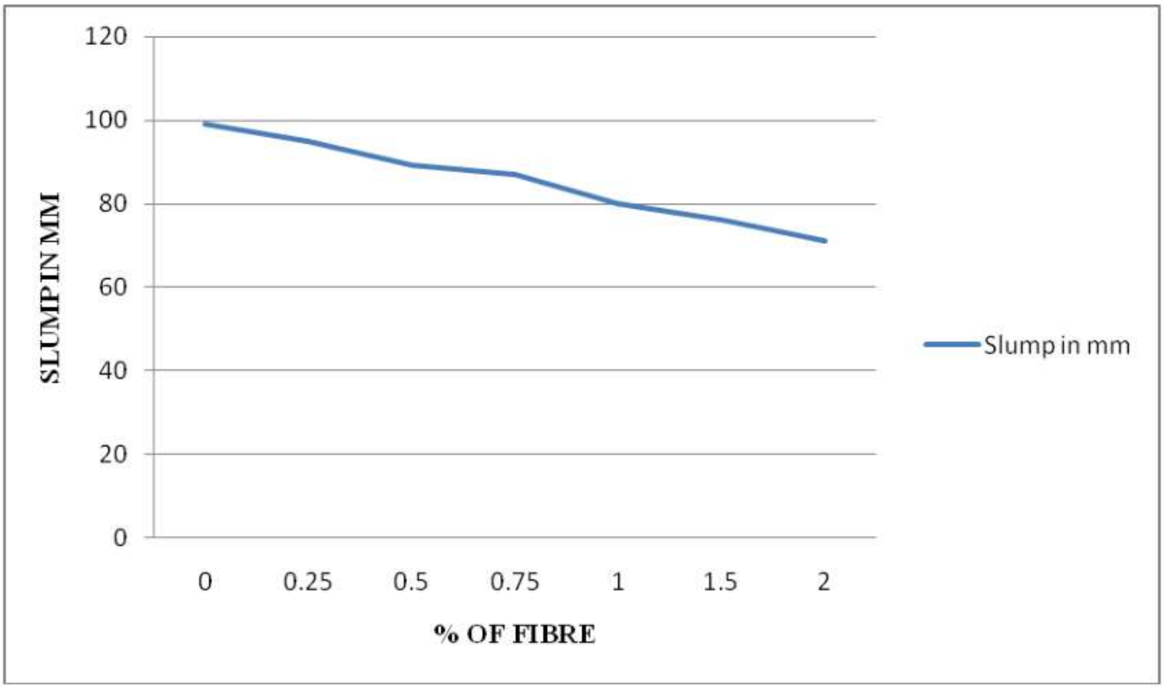

Fig.3. Variation in Slump of concrete with respect to % of Fibre content

Following conclusions were drawn from the work carried out;

1. It is observed that the workability of steel fibre reinforced concrete gets reduced as the percentage of steel fibres increases.
2. Compressive strength goes on increasing by increase in steel fibre percentage up to the optimum value.
3. The optimum value of fibre content of steel fibre reinforced concrete was found to be 1%.
4. The flexural strength of concrete goes on increasing with the increase in fibre content up to the optimum value. The optimum value for flexural strength of steel fibre reinforced cement concrete was found to be 0.75%.
5. While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which leaded into splitting of beam in two piece geometry. But due to addition of steel fibres in concrete cracks gets ceased which results into the ductile behaviour of SFRC.

2.11.4. In 2013, K. Srinivasa Rao, S. Rakesh Kumar, and A. Laxmi Narayana conducted an experimental investigation to compare the performance of standard concrete with fiber-reinforced standard concrete exposed to elevated temperatures. He summed up his research by saying that temperature gradients caused by fire cause physical changes in concrete, such as spalling, which exposes steel reinforcing. Concrete buildings become distressed as a result. Steel fibres can be added to concrete to enhance its performance, particularly when the concrete is heated. Thus, the purpose of this study is to produce experimental data on grade M45 standard concrete and fiber-reinforced standard concrete that has been exposed to high temperatures.

Six sets of cubes, cylinders, and beams have been cast for each variety of concrete. Every set comprises five specimens. Thirty cubes, thirty cylinders, and thirty beams of standard concrete and fiber-reinforced standard concrete have been cast in total. Five sets of these sets of concrete are subjected to elevated temperatures—500, 1000, 1500, 2000, and 2500 degrees Celsius—for three hours, while the sixth set is tested as control concrete at room temperature.

After being removed from the oven, these specimens underwent tests for flexural strength, split tensile strength, and compressive strength while still hot. After analysing the data, definitive conclusions are made.

The percentage of the 28-day compressive strength of standard concrete (SC) at room temperature is used to compare the compressive strengths of SC (standard concrete) and FRSC (fibre reinforced standard concrete) specimens exposed to various high temperatures. Figure 4 illustrates the plotted fluctuation in compressive strength with temperature.

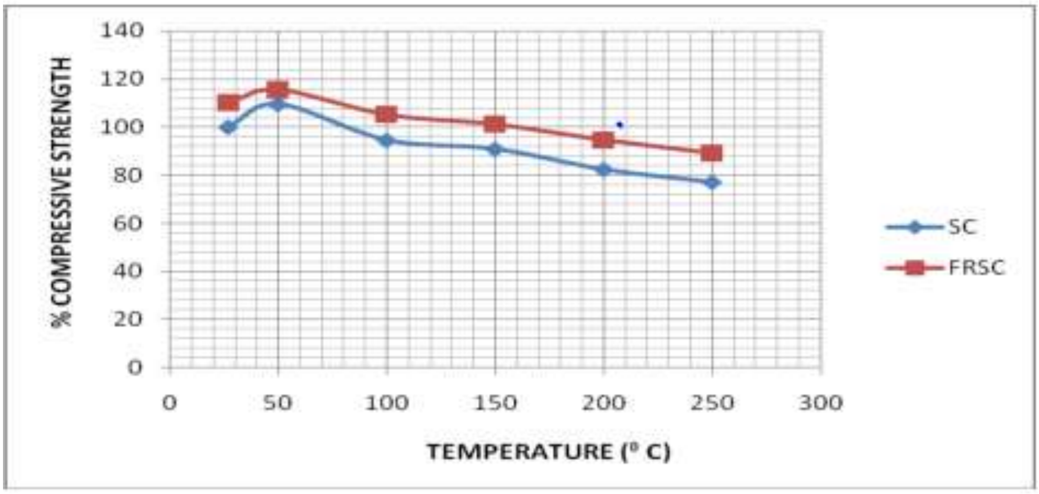

Fig.4. Comparison of variation compressive strength with temperature for SC and FRSC.

From Fig.4, it can be observed that FRSC exhibits more compressive strength than the SC at the all temperatures. As the temperature is increased FRSC maintained low decrement profile than SC resulting in more percentage compressive strengths after 100^0C. The difference between compressive strength of FRSC and SC varies in the range is 6-10 percentage.

The split tensile strength of SC (standard concrete) and FRSC (fibre reinforced standard concrete) specimens exposed to different elevated temperature is expressed as percentage of 28 days compressive strength of SC (standard concrete) at room temperature. The variation of compressive strength with temperature has been plotted as shown in Fig-5.

From Fig-5, it can be observed that FRSC exhibits more split tensile strength than the SC at the all temperatures. As the temperature is increased FRSC maintained low decrement profile than SC resulting in more percentage split tensile strengths after 100^0 C. The difference between split tensile strength of FRSC and SC varies in the range is 0-12 percentage.

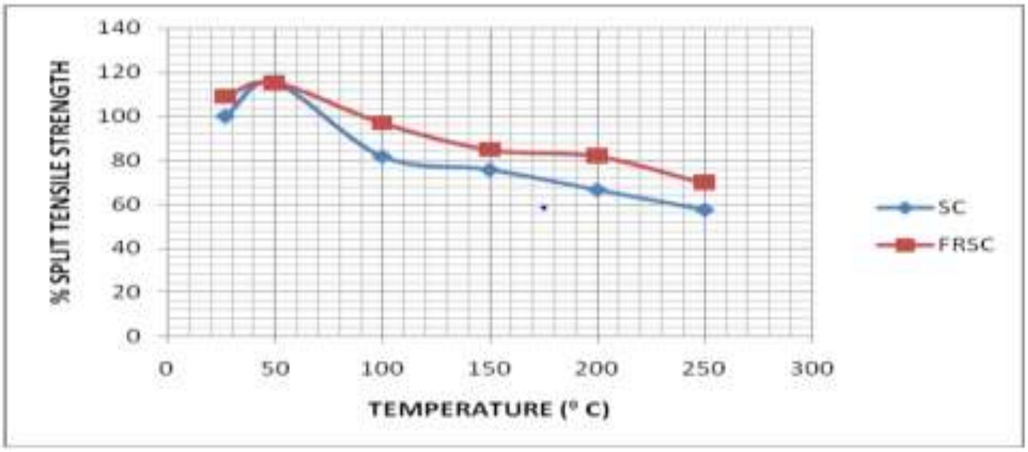

Fig.5.Comparison of variation split tensile strength with temperature for SC and FRSC.

The flexural strength of SC (standard concrete) and FRSC (fibre reinforced standard concrete) specimens exposed to different elevated temperature is expressed as percentage of 28 days compressive strength of SC (standard concrete) at room temperature. The variation of compressive strength with temperature has been plotted as shown in Fig-6.

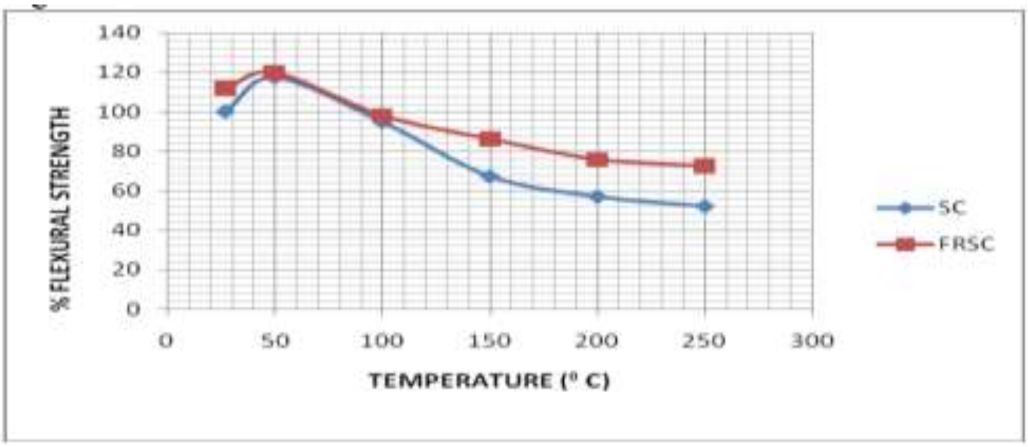

Fig.6.Comparison of variation flexural strength with temperature for SC and FRSC.

From Fig 6, it can be observed that FRSC exhibits more flexural strength than the SC at the all temperatures. As the temperature is increased FRSC maintained low decreament profile than SC resulting in more percentage flexural strengths after 100^0C. The difference between flexural strength of FRSC and SC varies in the range is 0-20 percentage.

Following were the conclusions drawn:

1. An increase in compressive strength and tensile strength has been observed for both standard concrete and fibre reinforced standard concrete when exposed to a temperature of 50^0 C.
2. In the range of 50 to 80^0 C the split tensile strength of both standard concrete and fibre reinforced standard concrete is same.
3. Flexural strength of standard concrete is equal to that of the fibre reinforced standard concrete in range of 50^0 C-80^0 C.
4. Beyond 50^0 C, both standard concrete and fibre reinforced standard concrete are found to loose compressive strength gradually.
5. Fibre reinforced standard concrete is found to exhibit more compressive strength split tensile strength and flexural strength than standard concrete at all temperatures.
6. The difference between compressive strength of fibre reinforced standard concrete and standard concrete varies in the range of 6-10percentage.
7. The difference between split tensile strength of fibre reinforced standard concrete and standard concrete varies in the range of 0-12 percentage.
8. The difference between flexural strength of fibre reinforced standard concrete and standard concrete varies in the range of 0-20 percentage.

IV. CONCLUSION

It has been discovered that adding steel fibre to concrete improves its strength and toughness when compared to untreated concrete.

Improved abrasion, flexural strength, impact resistance, high flexural and fatigue flexural with durability are the outcomes of steel fibre reinforced concrete.

These days, steel fibre reinforced concrete is a relatively affordable architectural option.

The ductility of concrete is increased by the addition of steel fibres.

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