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AN EXPERIMENTAL STUDY ON BEHAVIOR OF STEEL FIBER REINFORCED CONCRETE AFTER EXPOSED TO HIGH TEMPERATURE

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Abstract: An investigation on compressive strength of M25 grade concrete exposed to high temperature in absence of mixing of fiber. In some cases the steel fiber were added to concrete and then open to high temperature. The steel fiber used in study are 6mm long to a dosage of 0.3%, 0.6%, and 0.9% with the weight of concrete. When concrete open to fire it will be undergoes into spalling which leads expose metallic reinforcement, this motives anguish in concrete shape, in overall performance of concrete is expanded with the addition of steel fiber.

Keywords: Steel fiber, compressive strength, fiber bolstered concrete, fibers volume dosage, accelerated temperature.

I. INTRODUCTION

Concrete is a material it was used in construction of buildings and structural components. It is more over pinnacle fire resistance to compare with other materials. The concrete is exposed to high temperature up to some point it will be helps to durability. When fire resistance is above the point the body will undergo deformation. A concrete shape is subjected to moderate temperature it will deteriorate in many cases. One-of-a-kind approaches such for colour, compressive strength, elasticity and density of concrete will be changed by using high temperature. The engineer getting up must graph for form can face to a high temperature and moreover well known for exposure, in the part of exposure temperature like as fire the mechanical properties of concrete also changed, i.e strength, modulus of elasticity, volume is gradually reduced that's the reason concrete is exposed to fire in moderate temperature.
Fibers are commonly used in concrete to manipulate plasting shrinkage and drying shrinkage cracking. They additionally limit the permeability of concrete and hence lessen the bleeding of water. The addition of fibers was once placed to beautify the behaviour of concrete at multiplied temperature, it also decorates the pre and publishes cracking behaviour.
Steel fibers also furnished cost-effective advantage as they are without difficulty on hand as a waste product from aerospace business enterprise and offers 2 tp5 situations greater pressure than the exceptional fibers, steel fibers possess many doable advantages over different fibers such as a increased strength, larger modulus and elevated durability. Steel fibers make better the furnace resistance, impact, compression, spoil up tensile & amp, flexural strength.

Steel fibers are used in aerospace, civil engineering, military and noticeably pricey when distinction to related fibers.

I. Effects of temperature on concrete

The results of temperature on various belongings of concrete is appreciable. Grow in temperature creates grow opening strength and bring down strength. Fire recognition is one of the wide critical danger to buildings and structures. Display to fire is doubtless the majority disastrous operation that a concrete structure can be opened to throughout its utility. Below excessive temperatures results, chemical mixture, physical structure and moisture content changes. These changes are primarily observed at the cement paste and then at the aggregates as comfortable. Warm to peak temperature result in the dehydration of stiffed cement mortor and changes of calcium hydroxide into calcium oxide in which chemically jump water is slowly opened to become flatter me free water. As a conclusion, the association flatter sick and instant fissure formed and influence affects the concrete to breakdown.

II. Characteristics of steel fiber

Fibers are mixed with to concrete in order to develop the properties in coalifying or the solid condition. The major cause for encompassing fibers bugged to a cement grid is to grow the solidness and tensile strength and improve the develop fissure distortion properties of the consequent complex. When concrete exposed to peak temperature. Steel fibers are fluent in bring down shrinkage fissure and decrease the fragment.

Literature review

1. **Anraj. G,senthil Kumar, S.manivel(2018)** Studied on effect of high temperature on high performance steel fiber reinforced concrete. After being subjected to different elevated heating temperature ranges between 105^0 C and 1200^0 C the compressive strength, flexural strength, elastic modulus and porosity of concrete reinforced with 1% steel fiber increases.
2. **Biswajit jena, Asha Patel (2016)**Studied the effect of elevated temperature on bond between steel reinforcement and fiber reinforced concrete. Steel fiber like hooked steel fiber attained the highest bond resistance against elevated temperature ranging 400^0 C to 600^0 C.
3. **Navya HA, Dr.V.D.Nayana patel(2015)** Studied effect of thermal shock due to rapid cooling on residential mechanical properties of fiber concrete exposed to high temperature. The results prove that the rapid cooling regimes such as quenching in water, or water spraying for 30 min or more caused an action of 'thermal shock' to concrete under elevated temperature. It results a sudden decreased in compressive strength. Cooling by by quenching in water.
4. **T.Ch. madhavi(2015)**Investigated on effect of fiber type and geometry on maximum pore pressure in fiber reinforced high strength concrete at elevated temperature. Fiber type and geometry significantly contributes towards pore pressure reduction while heating. It is found addition of steel fiber in high strength concrete also contributes to pore pressure reduction when exposed to elevated temperature and spalling.

*Study the effect of steel fiber on compressive strength of concrete.

*To predict the performance characteristics of steel fiber with different percentages

(0%, 0.5%, 1%) on concrete with temperatures (200^0 C ,400^0 C)

*To minimize the experimental procedure according to Box-Banker design.

RESEARCH METHODOLOGY

Production of concrete requires use of a number materials, here we are discussing about the a wide variety of substances that are used in the manufacturing of concrete for this experimental locate out about purpose alongside with their properties**.**

Materials used

1. Aggregates
   a. Coarse aggregate
   b. Fine aggregate
2. Cement
3. Steel fiber
4. Water

Aggregates

Aggregates are the sizeable parts in concrete. They supply physique to the concrete, minimize shrinkage and affect economy. They are acquire from sedimentary, igneous and metamorphic rocks. The aggregates exists 70 % to 80 % of whole extent of concrete. It is consequently significant to obtain applicable exceptional of combination for any concrete mix. They should be clean, strong, and durable and grade downsize to acquire the major financial system from the mortar. Recently aggregates had been viewed chemically mix cloth but now it has been represents that few aggregates are chemically energetic and also that definite types consists chemical relationship at the affiliate of aggregates and the mortar. Aggregates of different sizes are used to attain greater bulk density namely, coarse aggregates and fine aggregates.

a) Coarse aggregate

These are crushed, unhurried or partly squashed gravel or stone major of which is maintain on 4.75mm sieve. They are hard, sturdy dense, long lasting and free from adherent coatings and additionally without damages amount of separated fragments, alkali separated fragments and other harmful materials nutty and extended aggregates need to be keep away from as along way as possible.

b) Fine aggregate

Fine combination or fine aggregate is an collection of pieces of minerals be counted attain from the separation of rocks. It is wonderful from coarse aggregates entirely via the usage of the measurement of grain of particles, however it is gorgeous from clay which consists of natural materials. Sands that have been selected out and divided from the natural count by mean soft motion of water present days are similar in dimension of grinds. Basically enterprise fine aggregate identification collect from river bank or from the sand heaps at first fashioned by method of the motion of blow sand (>0.07mm) is utilized as gorgeous aggregate in past and concrete. It is a powder shape of silica. Sand used for mix design is regarded as popular sand (IS:650). The fashionable fine aggregate need to be acquired from Nellore, AP. It should be quartz, light grey or whitish variant and be free from silt.

Cement

Cement is a ingredient, typically in granular shape form, that can be build bugged mortar by way of inclusion of liquid and, when molded, will settle into a strong core. A lot of natural composites are used for sticking substances of substances are referred to as cement, however these are labeled as adhesives, and the time period cement by myself stands for improvement material. The most considerably used sort of cement is (OPC). Two Portland cement is a blue-grey granular gather with aid way of granular grading the clinker built with the useful resource of strongly heating and intimate mixture of shades and calcium minerals. The major composite is limestone. Blast furnace slag may additionally moreover be used in some cement and the cement is know as Ordinary Portland Cement (OPC) .Forty-three grade was used for the analysis. It used to be examined for its physical qualities in accordance with Indian frequent specification.

Chemical components of cement

Components	Percentage
Lime	63%
Silica	22%
Alumina	06%
Iron oxide	03%
Gypsum	01 to 04%

1. When the cement is blended with water, hydration and hydrolysis reactions of Bogue composites of cement begins, ensuring information of gleaned crystal line products.

2. These merchandises have the functionality to embody inert components like sand, bricks and overwhelmed stones, etc. Setting is the stiffening of unique plastic mass due to the technological know-how of torbernite gel. It can be divided into 2 tiers,

a) Initial set

b) Final set

Initial set is when paste being to stiffen.

Final set is when the paste establishing to harden and, in a position to sustain some loads—Hardening is the enhancement of power due to technology of crystals.

Water

Water suit for ingesting is normally considered in shape for making concrete. Water wants to be free from acids, oils, alkalis, veggies or other herbal impurities. Soft waters additionally developed weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to shape a cement paste in which the inert aggregates are held in suspension till the cement paste has toughened. Secondly, it serves as a lubricant in the mixture of excellent aggregates and cement.

Steel Fiber Reinforced Concrete

Steel Fiber Concrete is a type of reinforced concrete. Steel fiber reinforced concrete (SFRC) as the name suggests that is made up of composite materials such as cement, sand, aggregate, water, gravel, steel fiber and admixture. In this concrete fiber, steel fiber is an additional ingredient.

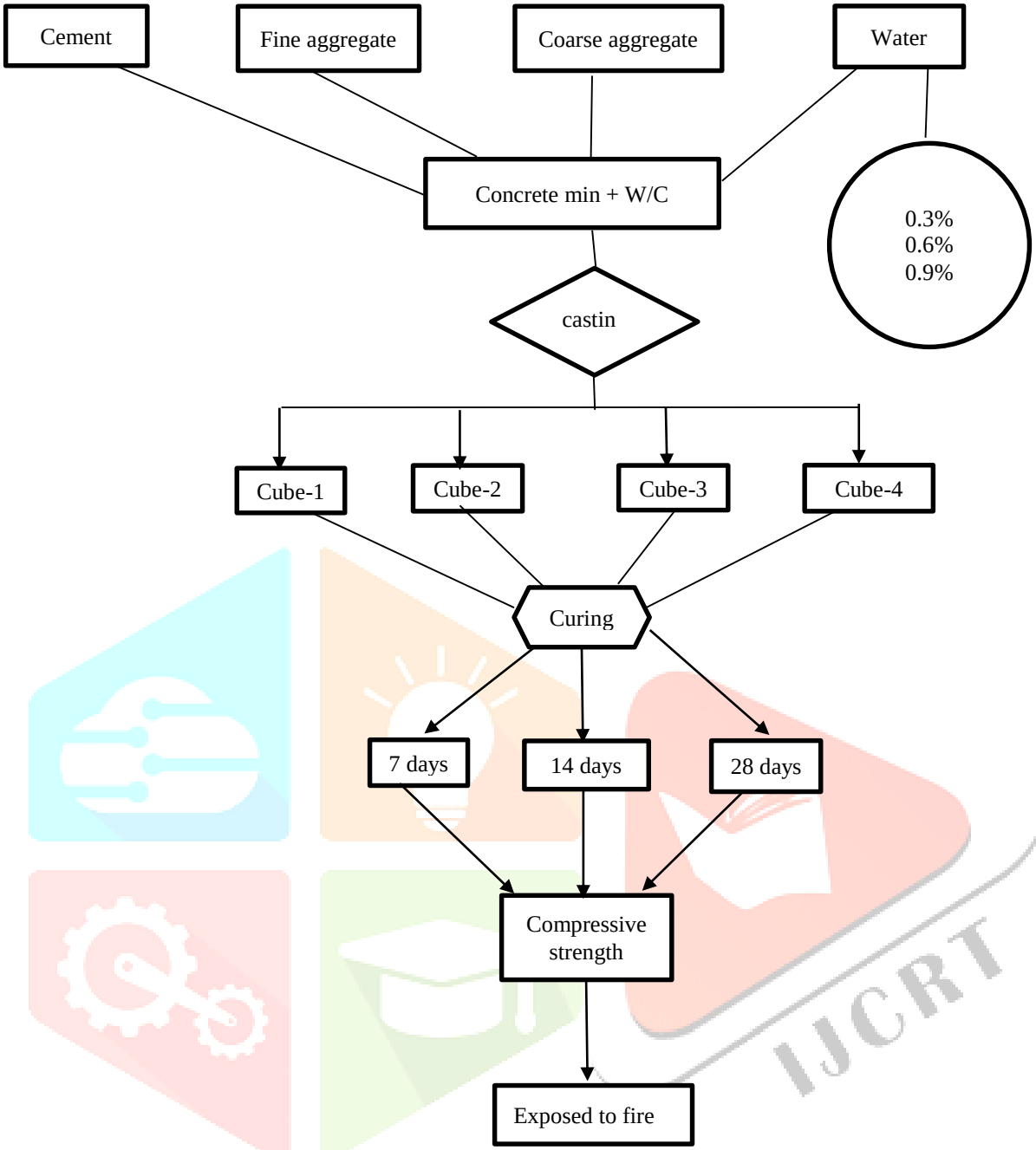
Fiber is added into the concrete is 0.3% to 2.5% by its volume of plain cement concrete. The diameter of steel fiber is used in concrete is 0.25mm to 0.75mm. Commonly round shape of steel fiber is used. In steel fiber reinforced concrete adding steel fibers in the concrete mixer and transfer green concrete into the molds or cubes and then after compacting the concrete, lastly cure the cubes by any conventional method of curing.

During the mixing of ingredients and during compacting the cubes are getting a high chance of segregation balling of steel fiber, and bleeding of the concrete.

Segregation is avoided by adding a uniform rate of fiber. Also, it is more permeable. High efficiency is required for mixing the ingredients, placing, compacting, conveying and finishing steel reinforced concrete.

The main objective of adding steel fibers are into the concrete is to improve the mechanical properties and structural properties, particularly flexural strength and tensile strength, ductility, wear and tear, post cracking. Strength of SFRC is higher than any type of concrete.

Methodology



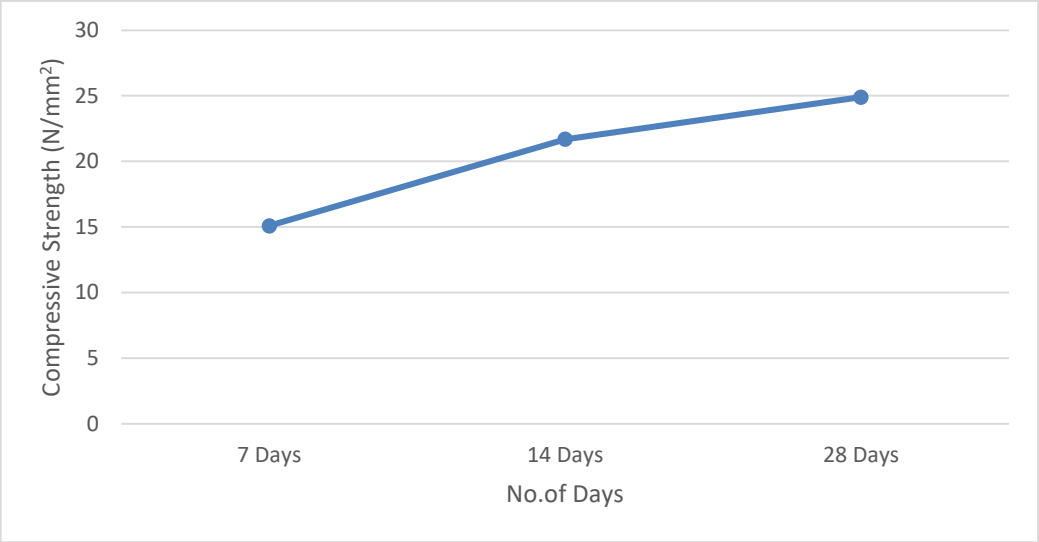
IV. RESULTS AND DISCUSSION

Compressive strength experiment

Cubes of dimensions 150x150mm were casted for various dosage of steel fiber of 0.3%, 0.6%, 0.9%. Results are in the form of tabular and graph as given below.

MIX PROPORTION	COMPRESSIVE STRENGTH (N/mm^2) in days		
M – 1	7	14	28
	15.09	21.69	24.84

Table 1:- compressive strength of concrete



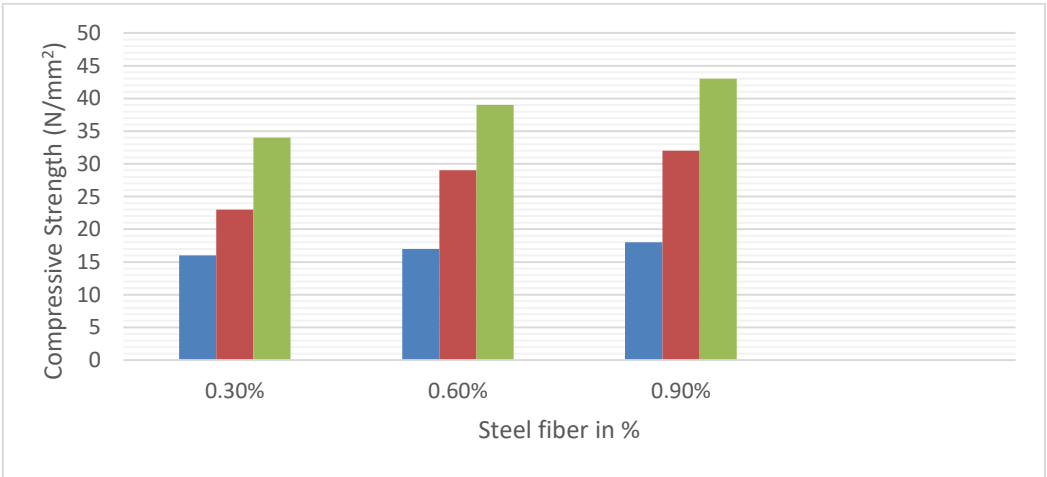
GRAPH-1: Representation of compressive strength of conventional concrete

It has been seen the inertial strength of mix M25 grade has mentioned to be fulfill the basic standards that 7 days strength shall be 1/3rd of the mix percentage (65% of grade of concrete), In the During the period, curing a mild fall in electricity is observed for the mix M25 But when the curing reaches to 28 days, then attain in power is noticed which satisfies the goal strength. Also, it has been seen that M25 grade mix beneath periodical curing stipulations shows successive accelerated in energy.

Compressive strength of steel fiber reinforced concrete

PERCENTAGE OF STEEL FIBER	COMPRESSIVE STRENGTH (N/mm^2) IN DAYS		
	7	14	28
0.3%	15.75	23.69	34.13
0.6%	16.87	29.82	39.17
0.9%	19.06	31.39	42.68

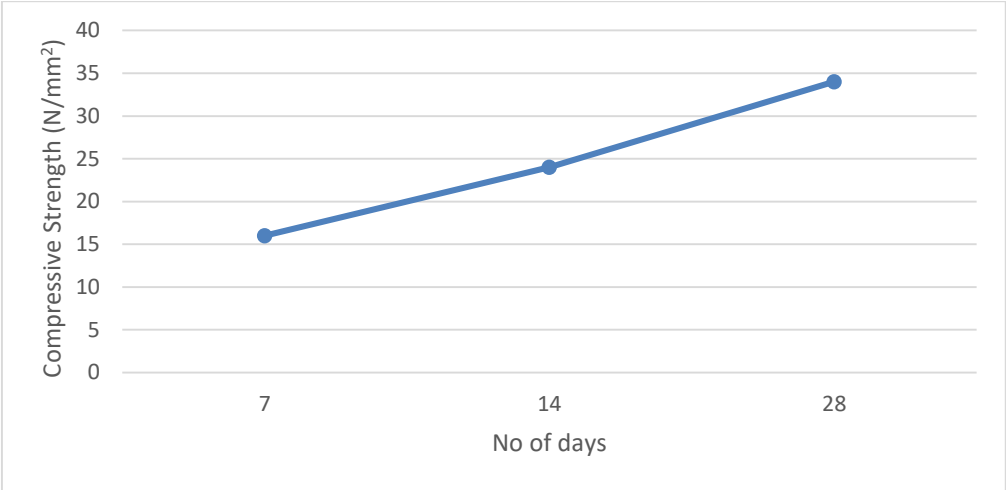
TABLE-2: Compressive strength of steel fiber reinforced concrete



GRAPH-2: Representation of compressive strength of steel fiber reinforced concrete

Compressive strength of steel fiber reinforced concrete for various percentage of fibers:-

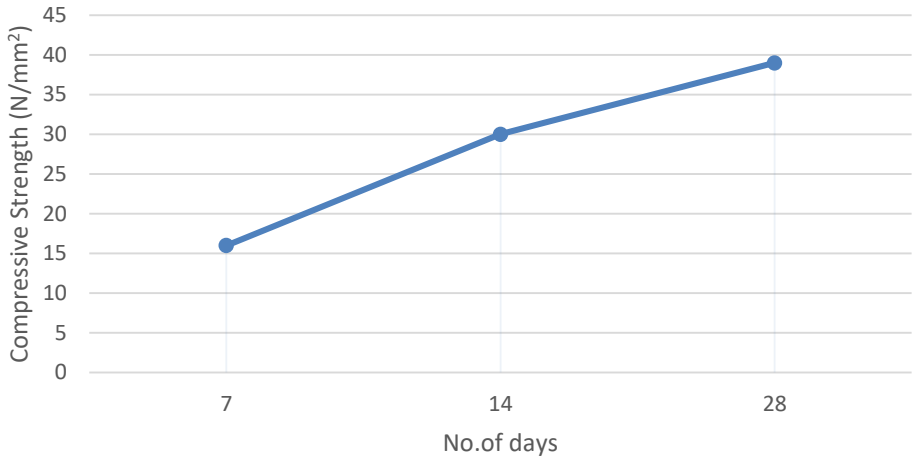
1. **Add 0.3% of steel fiber:-**



GRAPH-3: Representation of compressive strength of 0.3 % of steel fiber reinforced concrete

It is observed that the compressive strength of combine 0.3% is comfortable with basic standards of 7 days electricity 1/3rd of the merge proportion (65% of concrete grade), which is pleasurable for each curing & hardening: irregular curing prerequisites of concrete. During the days of curing proceeds to 14 days a non-stop increase in strength has been noticed. But when the curing approached to 28 days, the range in strength was observed once to satisfy the goal strength.

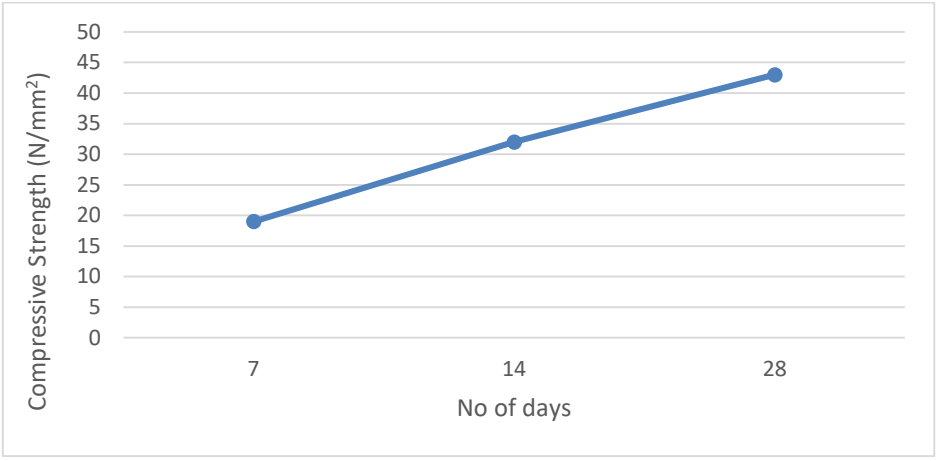
2. **Add 0.6% of steel fiber:-**



GRAPH-4: Representation of compressive strength of 0.6 % of steel fiber reinforced concrete

It is observed that the successive version in energy acquire is noticed in 0.6% steel fiber mix for each and every curing and irregular curing states. The strength constructed up walks hand in hand till the quilt of the curing period. The compressive energy of steel fiber combine 0.6% was not observed to be fulfilling.

3. Add 0.9% of steel fiber:-



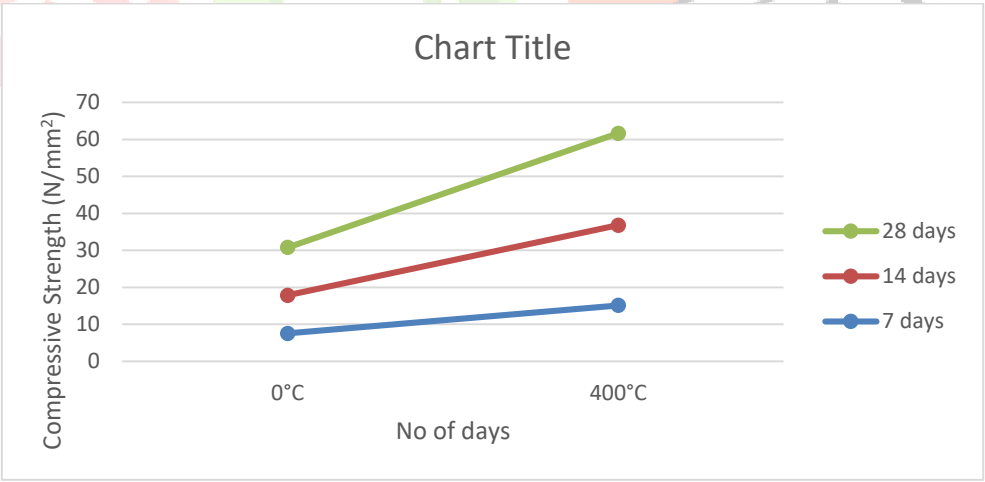
GRAPH-5: Representation of compressive strength of 0.9 % of steel fiber reinforced concrete

Design draw for 0.9% mix proportion, will be seen definitely in 7 days electricity calculated has come out to be lesser as per the1/3rd combine proportion criteria. The 7 days electricity for curing nation is less than irregular curing state. As the days of curing& hardening; publicity states proceeds to 28 days a slight raise in energy is noticed.

Compressive strength of conventional concrete under temperature: -

TEMPERETURE IN DEGREES	COMPRESSIVE STRENGTH (N/mm²) IN DAYS		
	7	14	28
400°C	7.525	10.32	12.945

Table 3- Comparison of compressive strength of conventional concrete under temperature



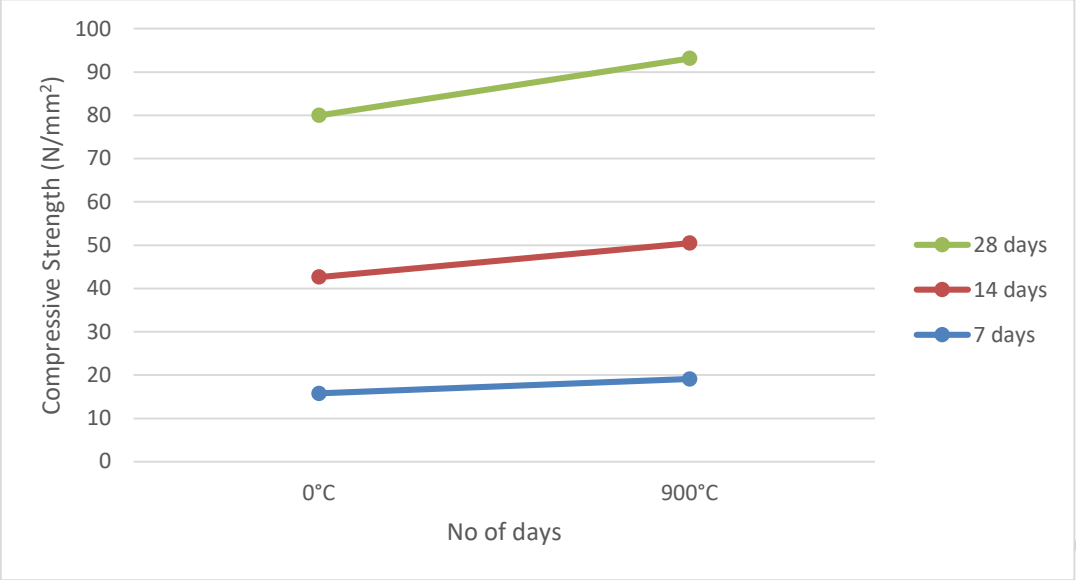
GRAPH-6: Representation of compressive strength of conventional concrete under temperature

The compressive strength of ordinary concrete and SFRC (Steel fiber reinforced concrete) specimens exposed to different elevated temperature is expressed as percentage of 28 days compressive strength of ordinary at room temperature. The variation of compressive strength with temperature has been plotted.

Compressive strength with temperature for conventional concrete and steel fiber reinforced concrete:-

% OF ADDITION OF FIBERS	COMPRESSIVE STRENGTH (N/mm²) IN DAYS		
	7	14	28
0.3%	11.2	19.6	29.9
0.6%	12.3	25.7	34.85
0.9%	15.75	26.86	37.35

Table 4- Comparison of compressive strength of conventional concrete under temperature



GRAPH-7: Representation of compressive strength of conventional concrete under temperature

From the graph, it can be seen that the power reduces for lengthen in temperature and ends up almost 40% discounting electricity at 900°C. This suggests that the concrete undergoes drastic power reduction past 900°C. The percentage raise in compressive electricity at exquisite fiber volume fee with admire to manage mix. A successive proportion amplify in strength is over served up to a fiber quantity of 0.6%. The proportion expand in electrical energy is greater when the fiber quantity is elevate from 0.6% to 0.9%.There is an elevate of about 38.5% in compressive electrical energy at 0.6% fiber quantity dosage as in contrast to manipulate mix. The share compressive energy received with admire to the compressive energy gained with the resource of manage mix at28 days. Hence this indicates that concrete with steel fibers at extent of 0.9% can be used economically where faster price of building is needed.

In actual time, all through fire damages, the structure is uncovered to unintended unstoppable fireplace in which the temperature deflects between outer fiber. Such a furnace acts on concrete specimen variant from that of manipulate temperature in a standard furnace. Such an open fireplace is produced on the specimen and the bodily and energy dimensions are examined.

Color: dislike in standard furnace, the coloration of the specimen darken to black shade that when subjected to open fire. But in standard furnace the color advocated two diminished while subjected to evaluated temperature.

Cracks, spalling: In case of this open fire test, the specimen to show off cracks excessive temperature not lots. It can be seen that steel fiber strengthened concrete after evaluated temperature reveals extra compressive electricity than the steel fiber

It can be seen that steel fiber strengthened concrete before evaluated temperature. The deference between compressive electricity of steel fiber bolstered concrete is 0 to 9%.

Conclusions

The present work addresses the synergistic effect of the steel fiber aspect ratio and heating on the mechanical behavior of concrete. The following conclusions were observed from the results and discussions:
1, The addition of steel fiber contributes to the increased tensile strength in diametrical compression.
2, The addition of steel fibers contributes to the increase of the flexural strength.
3,The investigation concluded that concrete reinforced with steel Fibers has a much higher residual mechanical behavior after the fires when compared to non-reinforced concretes.
4, The increase in Fiber length leads to higher residual strength after fire. It was observed that the addition of Fibers did not promote relevant variations in the compressive strength of the analyzed models.
5, The addition of Fibers of different aspect ratios did not significantly change the compressive strength when compared to the variations observed in the literature given by the different mounding processes, curing, and load application speed. Therefore, it can be concluded that the use of steel Fibers in concrete-based materials significantly enhances their fire and hear-resistant characteristics.
6,Evaluation of the chipping inhibition of concretes in fire situations by the addition of steel Fibers. Evaluation of the mechanical properties of steel Fiber reinforced concrete during fires; and Finite element simulation of the mechanical behavior of steel Fiber reinforced concrete.

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