"EFFECT OF STEEL FIBRES ON PROPERTIES OF CONCRETE"

A Thesis

Submitted in partial fulfilment of the requirements for the award of the degree

of

BACHELOR'S OF TECHNOLOGY

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CERTIFICATE

This is to certify that the work which is being presented in the project title "**EFFECT OF STEEL FIBRE ON PROPERTIES OF CONCRETE**" in partial fulfilment of the requirements or the award of the degree of Bachelor of technology in civil engineering and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Shubham Nadda and Shubham Mehta during a period from July 2016 to December 2016 under supervision of **Mr.Chandra Pal Gautam** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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Without their valuable guidance this project wouldn’t have been completed.

LIST OF ABBREVATIONS

FRC	**Fibre reinforced concrete**
l,b,w,d	**Length,Breadth,Width,Depth**
SFRC	**Steel fibre reinforced concrete**
OPC	**Ordinary Portland cement**
CA	**Coarse aggregate**
CTM	**Compression testing machine**
P	**Load applied**
f_{ck}	**Characteristic mean strength**
MPa	**Mega pascal**
w/c	**Water Cement ratio**
Avg	**Average**
mm	**Millimeters**

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ABSTRACT

A Fiber Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with an ordered or random distribution of fiber. Plain concrete fails suddenly once the deflection corresponding to ultimate flexural strength is exceeded, on the other hand, fiber reinforced concrete continue to sustain considerable loads ever at deflection considerably in excess of the fracture deflection of plain concrete.

The present work is related to the utilization of fiber material and its various effects on compressive strength, split tensile strength, flexural strength and workability of concrete.

In this report effect of fibres on strength of concrete for M30 grade have been studied by varying the aspect ratio of fibres in concrete. Fibre aspect ratio was varied by 50 and 80. Cubes of size 150x150x150mm to check the compressive strength, beams of size 500x100x100mm for checking flexural strength and cylinder of size 150x200mm for checking the split tensile strength were casted. All specimens were cured for 7 and 28 days before crushing. The results of fibre reinforced concrete for 7 days and 28 days curing with varied aspect ratio of fibre were studied and it has been found that there is significant strength improvement in steel fibre reinforced concrete. Also, it has been observed that with the increase in fibre aspect ratio increases the strength of concrete.

Keywords: **Stainless Steel Fibres, Compressive Strength, Flexural Strength and Split Tensile Strength**

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Fibre reinforced concrete is a composite material made of Cement, aggregate, and fibres.

Now, why would we wish to add such fibres to concrete?

Plain concrete mix is a brittle material, having less tensile strength and less strain capacity. The role of randomly distributes discontinuous fibres is to bridge the cracks. That develop provides some post cracking.

If the fibres are sufficiently strong, bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post cracking stage.

The actual contribution of the fibres is to raise the toughness of the concrete (defined as some function of the area under the load vs. deflection curve}. That is, the fibers often are likely to improve or raise the strain at peak load, and provide a great level of energy absorption in post-peak percentage of the load compared to deflection curve.

In the event fibre reinforcement is in the form of short discrete fibres, they act effectively as stiff inclusions in the concrete matrix. They might have the same order of magnitude as aggregate inclusions; steel fibre strengthening cannot therefore be considered to be an immediate alternative of longitudinal strengthening in reinforced and pre stressed structural members. Yet due to inherent material properties of fibre concrete, the existence of fibres within the body of the concrete or maybe the accessibility of a tensile skin of fibre concrete should be expected to increase the resistance of conventionally reinforced structural members to damage (cracking), deflection and other serviceableness conditions.

Apart from other mix additives , there are some other important parameters which are found to change the properties of concrete

1) Type of fibers

2) Shape of fibers

3) Dosage of fibers

4) Aspect ratio

5) Orientation of fibers in the matrix.

In addition to other mix constituents, there are four important guidelines found to affect the properties of, namely, type and shape of material (fibre), dosage, aspect ratio, and orientation of fibres in the matrix.

The majority of construction material which mostly used is concrete. It has the ability to get in cast in any form and shape. It also supersedes old construction materials such as brick and natural stone masonry. The strength and toughness of concrete can be changed by making appropriate within its materials like cementetious material, combination of aggregates and water and by adding some special substances. Hence concrete is very well suited for a variety of applications. On the other hand concrete has some insufficiencies as listed below:

1) Low tensile strength

2) Low post cracking capacity

3) Brittleness and low ductility

4) Limited fatigue life

5) Incapable of accommodating large deformations

6) Low impact strength

The occurrence of micro splits in the mortar-aggregate user interface is responsible for the weakening of plain concrete. The weakness can be removed by inclusion of fibres in the mix. Different types of materialistic fibres, such as those, utilized in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or potential to resist crack expansion. The fibres help to transfer loads at the internal micro cracks. Many of these a concrete is called fibre-reinforced concrete (FRC).

(Fig.1.1) Fiber Reinforced concrete

1.2 HISTORY

The idea of utilizing fibers is not a new technology. Filaments have been utilized as support for reinforcement since years in concrete. Truly, horsehair was utilized as a part of mortar and straw in mud blocks. In the 1900s, asbestos strands were utilized as a part of cement. In the 1950s, the idea of composite materials appeared and fiber-reinforcement cement was one of the points of discussion. Once the wellbeing dangers related with asbestos were found, there was a need to discover a substitution for the substance in concrete and other building materials. By the 1960s, steel, glass (GFRC), and synthetic fibers, for example, polypropylene filaments were utilized as a part of cement. Inquire about into new fiber-fortified cements proceeds with today. Dynamic research is still in advance on this essential innovation. Fiber Reinforced Concrete is thought to be one of the best headways in the development building amid at the twentieth century.

The idea of utilizing fibres so as to reinforce matrices in strain is over 4500 years of age. Old developments utilized straw strands in sun-dried mud blocks keeping in mind the end goal to make a composite with expanded strength, i.e. a network with a superior imperviousness to breaking and an enhanced post splitting response. Since Portland bond concrete began to be utilized broadly as a development material attempts were made to utilize fibers for capturing breaks. Engineers needed to conquer the significant inadequacies of solid, which were the low elasticity and the high weakness. A French specialist, named Joseph Lambot, in 1847 turned out with including nonstop strands into the solid, as wires or wire meshes[i]. This prompted the advancement of ferrocement and strengthened concrete as known today. The utilization of nonstop steel fortifying bars in the malleable zone of cement undoubtfully overcomed the issue of the low elasticity of cement. Nonetheless, utilizing spasmodic strands in the solid was dependably a test.

The improvement of fiber reinforcement for cement was moderate before 1960's. Until then there were a few papers portraying the essential idea of utilizing strands for support in cement blends yet there was no application. By the by, research on glass filaments had been directed in USA, UK and Russia in mid 1950's. Really, in Russia glass strands were under research as well as utilized as a part of the development business. Be that as it may, this sort of filaments was observed to be inclined to basic assaults. In late 1950's Portland Cement Association began exploring fiber reinforcement[ii].

Since mid 1960's there has been an expanded enthusiasm for fiber fortified cement (FRC). This period is the defining moment for the improvement of FRC. More quick present day advances are paralleled by expanding applications. While all the more new applications were recognized an extensive variety of strands was presented. These include:

· Steel Fibres.

· Glass Fibres.

· Carbon Fibres.

· Natural Organic Fibres.

· Polypropylene Fibres.

Generally, the fibres used to reinforce concrete can be characterised as discontinuous, discrete fibres with length less than 50mm and diameter no more than 500mm.

The actual purpose of incorporating fibres in the concrete matrix was the development of a composite with improved strength, both compressive and tensile. By analysing the results of the earliest developments in this field it can be observed that neither the compressive nor the tensile strength were increased by any appreciable amount. The actual benefits of fibre reinforcement were difficult to highlight by the researchers at that time.

Later on, during the modern development of FRC in late 1970's and early 1980's, when the testing equipment and analysis procedures became more quantitative and better qualitatively the concept of energy absorption (or fracture toughness) was introduced. This concept enabled the toughness measurement of materials. It was then that the major advantage of FRC was discovered and it was not other than the outstanding property of absorbing large amounts of energy compared to Ordinary Portland Cement Concrete. Even today, after more than three decades of research in this field it can be said that the principal benefit of FRC is the high fracture toughness. However, further research with different types of fibres and admixtures targets the development of a composite with increased tensile and compressive strengths, besides the fracture toughness. These FRC composites are now known as the high performance fibre reinforced concrete (HPFRC).

The production of a cement based material having high tensile and compressive strengths, remarkable energy absorption capacity and which will be homogeneous and isotropic (almost similar to cast iron) is no longer an utopia any more. The incessant research in the field of FRC has led to the production of HPFRC, which shows a combination of amazing properties compared to other cementitious composites.

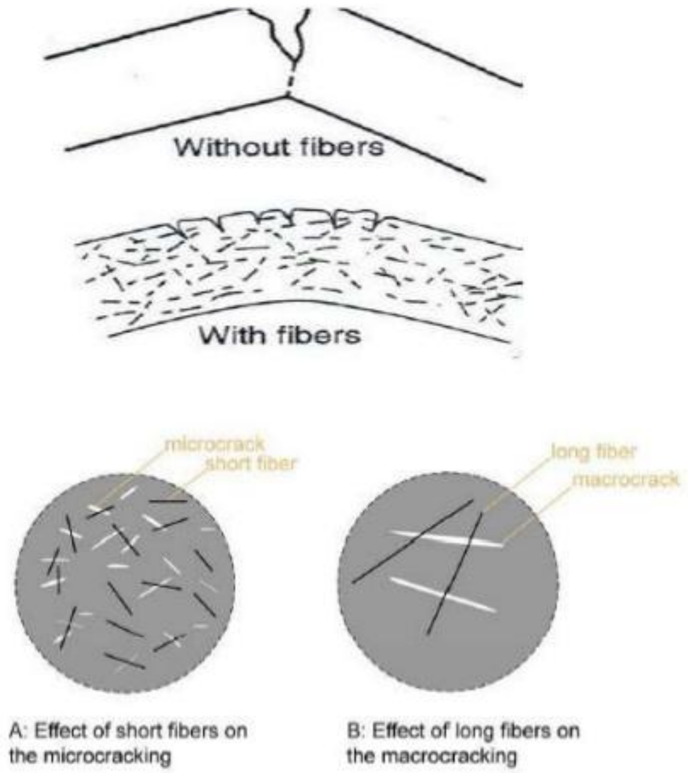
For the most part, the strands used to reinforce cement can be described as discontinuous, discrete filaments with length under 50mm and width close to 500mm.

1.3 MECHANISM OF FIBRES

The bond between steel fibers and portland cement matrices is a critical factor in determining the strength properties of fiber-reinforced concrete structural elements. The influence of the following three major parameters on the pull-out behaviour of fibers was studied: the angle of orientation of the fibers with the loading direction, the number of fibers being simultaneously pulled out from the same area, and the efficiency of random orientation. It is shown that:

- The pull-out load of a randomly oriented fiber is not lower than that of an aligned fiber
- The pull-out capacity of a group of randomly oriented fibers decreases drastically when the number of fibers pulling out from the same area increases.
- The efficiency of fiber orientation after matrix cracking is substantially higher than efficiency factors derived from the theoretical elastic considerations.

These results seem to explain why the addition to a concrete matrix of fibers with highly improved bond properties does not often lead to an equivalent improvement in the composite properties.



Fibre mechanism

1.4 APPLICATION OF FIBER REINFORCED CONCRETE (FRC)…

It is utilized by virtue of the increased expanded tensile strength with better elasticity and better weakness quality.

It has been attempted on overlays of landing strip, road payments, modern footings, connect decks, waterway(canal) lining, explosive safe structures, refractory linings and so on. Utilized for the manufacture of precast items like channels, water crafts, shafts, stair case steps, divider boards, rooftop boards, sewer vent covers and so on.

It is additionally being striven for the produce of pre-assembled formwork moulds of "U" shape for casting lintels and small beams.

Fiber reinforced concrete is used for:

- Industrial flooring
- Sprayed concrete
- Slender structures (usually in precast plants)
- Fire resistant structures
- mortar applications (rehabilitation)

(Fig.1.4) Innovative Use of Fiber Reinforced concrete on The North Strathfield Rail Underpass

1.5 Types of Fiber-Reinforced Concrete

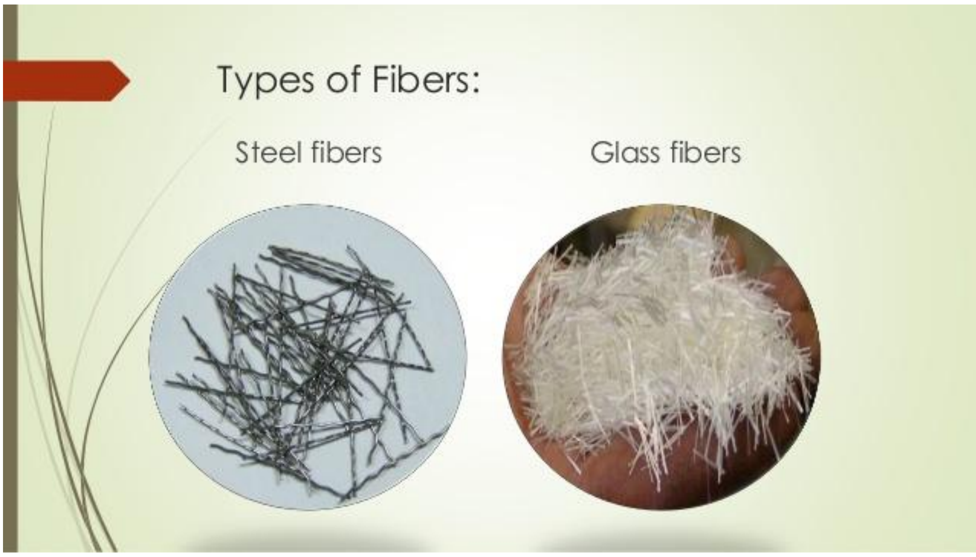
Steel Fiber-Reinforced Concrete

Steel fiber-reinforced cement is essentially a less expensive and less demanding to utilize type of rebar reinforced cement. Rebar reinforced solid uses steel bars that are laid inside the fluid bond, which requires a lot of prep work yet make for a significantly more grounded cement.

Steel fiber-reinforced solid uses thin steel wires blended in with the concrete. This bestows the solid with more prominent basic quality, lessens breaking and secures against extreme cold. Steel fiber is regularly utilized as a part of conjunction with rebar or one of the other fiber sorts.

Glass Fiber Reinforced Concrete

Glass fiber-reinforced solid uses fiberglass, much like you would discover in fiberglass protection, to reinforce the concrete. The glass fiber protects the concrete in addition to make it stronger. Glass fiber likewise keeps the concrete from cracking after some time because of mechanical or thermal stress. Furthermore, the glass fiber does not meddle with radio signs like the steel fiber reinforcement does.



(Fig.1.5) Types of Fibers

Synthetic Fibers

Manufactured fiber-reinforced solid uses plastic and nylon filaments to enhance the concrete's quality. What's more, the manufactured filaments i.e. the synthetic fibre have various advantages over alternate fibres. While they are not as strong as steel, they do help enhance the concrete pumpability by shielding it from staying in the channels. The manufactured filaments don't expand in hot temp. or contract in winters which avoids splitting which means that there will be no cracking. At long last synthetic filaments help shield the concrete from spalling amid to minimize the effects of flames.

Natural Fiber Reinforced Concrete

Fiber-reinforced concrete have utilized common strands or the natural fibers, for example, hay or hair. While these fibres help the concrete's quality but they can likewise make it weaker if a lot of is utilized. What's more if the natural fibers are decaying when they are blended in then the spoil can proceed while in the concrte. This in the long run prompts the concrete's disintegrating from within, which is the reason natural fibers are no longer utilized as a part of development in constuction.

1.6 FACTOR'S AFFECTING THE PROPERTIES OF FIBRE REINFORCED CONCRETE

FIBRE QUANTITY

Generally quantity of fibre is measured as percentage of volume of concrete used. As the volume of fibre increases there should be increase in strength in toughness of concrete. Regarding our fibre we hope that there will be increase in strength with increase in fibre content. We are going to test for different percentages at different aspect ratio.

ASPECT RATIO OF THE FIBRE

Aspect ratio is defined as the ratio of length of fibre to width of fibre. The value of aspect ratio varies from 20 to 150.Generally the increase in aspect ratio increases the strength and toughness till the aspect ratio of 100.above that the strength of concrete decreases, in view of decreased workability and reduced compaction. The aspect ratio of fibre used here are 50,64 and 80.

ORIENTATION OF FIBRES

One of the contrasts between regular reinforcement and fiber reinforcement is that in traditional reinforcement, bars are arranged toward the path craved while fibers are randomly situated. To see the impact of irregularity, mortar examples reinforced with 0.5% volume of fibers were tried. It was watched that the fibers adjusted parallel to the connected load offered more toughness and tensile strength than randomly circulated or opposite strands.

1.7 TECHNOLOGY FOR PRODUCING SFRC

SFRC can, by and large, be delivered utilizing conventional concrete practice, however there are clearly some vital differences. The fundamental issue is to present an adequate volume of consistently dispersed to accomplish the desired changes in mechanical behaviour, while holding adequate workability in the fresh mix to allow proper blending, setting and finishing up. The execution of the hardened concrete is upgraded more by fibers with a higher perspective proportion, since this enhances the fiber-matrix bond. Then again, a high viewpoint proportion unfavorably influences the workability of the new fresh mix. All in all, the issues of both workability and uniform appropriation increment with expanding fiber length and volume. One of the central challenges in acquiring a uniform fiber circulation is the propensity for steel filaments to ball or bunch together. clumping might be created by various elements: i The filaments may as of now be clustered together before they are added to the fresh mix; typical blending activity won't separate these bunches. ii Fibers might be added too rapidly to enable them to scatter in the mixer. iii Too high a volume of fibers might be included. iv The mixer itself might be excessively worn or wasteful, making it impossible to scatter the filaments. v Introducing the fibers to the mixer before the other concerte ingredients will make them cluster together. In perspective of this, care must be taken in the mixing techniques. Most regularly, when utilizing a transit blend truck or spinning drum blender, the fibers ought to be added last to the wet cement. The concrete alone, regularly, ought to have a slump of 50-75 mm more prominent than the desired slump of the SFRC. Obviously, the filaments ought to be included free of clusters, more often than not by first going them through a proper screen. Once the fibers are all in the mixer, around 30-40 revolution at mixing pace ought to appropriately disperse the fibers. On the other hand, the fibers might be included to the fine aggregate to a transport line amid the expansion of total to the 111 solid blend. The utilization of gathered fibers held together by a water-solvent measuring which disintegrates amid mixing to a great extent takes out the issue of bunching. SFRC can be put sufficiently utilizing normal concrete equipment. It gives off an impression of being stiff in light of the fact that the fibers have a tendency to restrain stream; however when vibrated, the material will stream promptly into the structures. It ought to be noticed that water ought to be added to SFRC mixers to enhance the workability just with extraordinary care, since over a w/c proportion of around 0.5, extra water may build the droop of the SFRC without expanding its workability and place capacity under vibration. The completing operations with SFRC are basically the same concerning ordinary concrete, thought maybe more care must be taken in regards to workmanship.

1.8 WORKABILITY

Incorporation of steel fiber decreases the workability considerably. This situation adversely affects the consolidation of fresh mix. Even prolonged external vibration fails to compact the concrete. The fiber volume at which this situation is reached depends on the length and diameter of the fiber.

Another outcome of poor workability is non-uniform circulation of the fibers. By and large, the workability and compaction standard of the blend is enhanced through expanded water/bond proportion or by the utilization or something to that affect of water decreasing admixtures. Expansion of fibers in plastic concrete changes its portability, regardless of the possibility that these substance levels are lower. The loss of versatility happens fundamentally by the fibers obstructing the relative development of the totals which is less extreme when lessening the viewpoint proportion of the fiber, which incite decrease of solidified FRC post-break quality. A superior arrangement could be accomplished lessening the most extreme size of the total or expanding the mortar content in the concrete. Therefore, the utilization of a suitable blend outline strategy, considering the impact of the fibers, is expected to ensure satisfactory workability conditions for FRC.

Joining of steel fiber diminishes the workability extensively. This circumstance unfavorably influences the combination of new blend. Indeed, even drawn out outer vibration neglects to minimal the concrete. The fiber volume at which this circumstance is come to relies on upon the length and breadth of the fiber.

MIXING

Blending of fiber reinforced concrete needs cautious conditions to abstain from balling of fibers, isolation and as a rule the trouble of blending the materials consistently. Increase in the aspect ratio, volume percentage and size and quantity of coarse aggregate intensify the difficulties and balling tendency. Steel fiber content in excess of 2% by volume and aspect ratio of more than 100 are difficult to mix.

It is vital that the strands are scattered consistently all through the blend; this should be possible by the option of the fibers before the water is included. When mixing in a laboratory mixer, introducing the fibers through a wire mesh basket will help even distribution of fibers.. For field utilize, other appropriate techniques must be embraced.

1.9 OBJECTIVES OF OUR PROJECT

The aim of our project is to use hooked end steel fibres in concrete for improving its properties

- To compare the properties of SFRC with normal concrete
- Our objective is to add the steel fibres (hooked) to the concrete and to study the strength properties of concrete with the variation in aspect ratio of fibres.
- To study the strength properties of concrete (M30 Grade) for fibre content of 0, 0.6,1.2 and 1.8 with aspect ratio 50,64 and 80 at 7 and 28 days.
- The strength properties being studied in our project are as Compressive strength, Split tensile strength, Flexural strength

CHAPTER 2

REVIEW LITERATURE

2.1 FIBER USED TO PROVIDE STRUCTURAL STRENGTH

Author Amit Rai and Dr.Y.PJoshi

Amit Rai and Dr. Y.P Joshi announced that FRC is a successful approach to expand toughness , shock resistance and imperviousness to plastic shrinkage breaking of the mortar. These fibers have many advantages. Steel fibers can improve the structural strength to reduce the heavy steel reinforcement requirement. Freeze thaw resistance of the concrete is improved. Solidness of the concrete is enhanced to decrease in the break widths. Polypropylene and Nylon filaments are utilized to enhance the effect resistance. Numerous advancements have been made in the fiber reinforced cement and Fiber expansion enhances flexibility of cement and its post-splitting burden conveying limit.

2.2 STUDY OF FLEXURAL AND TENSILE STRENGTH

Author A.M. Shende

Presented Steel fibers of 50, 60 and 67 angle proportion. Result information acquired has been broke down and contrasted and a control example (0% fiber). A connection between viewpoint proportion versus Compressive quality, perspective proportion versus flexural quality, perspective proportion versus Part rigidity spoke to graphically. It is watched that compressive quality, split rigidity and flexural quality are on higher side for 3% fibers when contrasted with that created from 0%, 1% and 2% fibers. All the quality properties are seen to be on higher side for angle proportion of 50 when contrasted with those for perspective proportion 60 and 67. It is watched that compressive quality increments from 11 to 24% with expansion of steel fibers.

2.3 Shear Strengthening Reinforced Concrete Beams with Fiber-Reinforced Polymer

This paper manages the shear fortifying of fortified concrete (RC) pillars with remotely fortified fiber-strengthened polymer (FRP) composite. Its destinations are to blend the discoveries of the examination thinks about completed up to this point, and to look at and break down the parameters that have the best impact on the shear conduct of RC individuals reinforced with remotely fortified FRP. More than a hundred tests were considered in the union. A few conclusions were drawn from this review. It was found that the parameters identified with the properties of the FRP and to those of the shear steel fortification are by all account not the only ones having an impact on the shear conduct of RC individuals reinforced with remotely connected FRP. The shear traverse proportion a/d, the longitudinal steel support proportion, and the geometry of the part likewise have impact on the shear conduct of these individuals and merit promote examination. In perspective of the connection between the parameters, a trial parametric review with close factor control is prescribed. Trial information, specifically, strains experienced by both the FRP and the inside shear steel fortification, are fundamental for understanding the resistance systems included.

2.4 Pull out mechanism in steel fiber reinforced concrete

The bond between steel fibers and portland cement matrices is a critical factor in determining the strength properties of fiber-reinforced concrete structural elements. The influence of the following three major parameters on the pull-out behavior of fibers was studied: the angle of orientation of the fibers with the loading direction, the number of fibers being simultaneously pulled out from the same area, and the efficiency of random orientation. It is shown that: (1)The pull-out load of a randomly oriented fiber is not lower than that of an aligned fiber; (2)the pull-out capacity of a group of randomly oriented fibers decreases drastically when the number of fibers pulling out from the same area increases; and (3)the efficiency of fiber orientation after matrix cracking is substantially higher than efficiency factors derived from the theoretical elastic considerations. These results seem to explain why the addition to a concrete matrix of fibers with highly improved bond properties does not often lead to an equivalent improvement in the composite properties.

CHAPTER 3

3.1 EXPERIMENTAL WORK

In order to achieve the stated objectives, we carried out experiments in few stages. Initially in first stage, the essential equipment and material are taken into account. Then, the concrete mixture is taken in accordance with required design. Concrete samples were tested through concrete tests such as cube test. Finally, the results obtained were analysed to draw out conclusion.

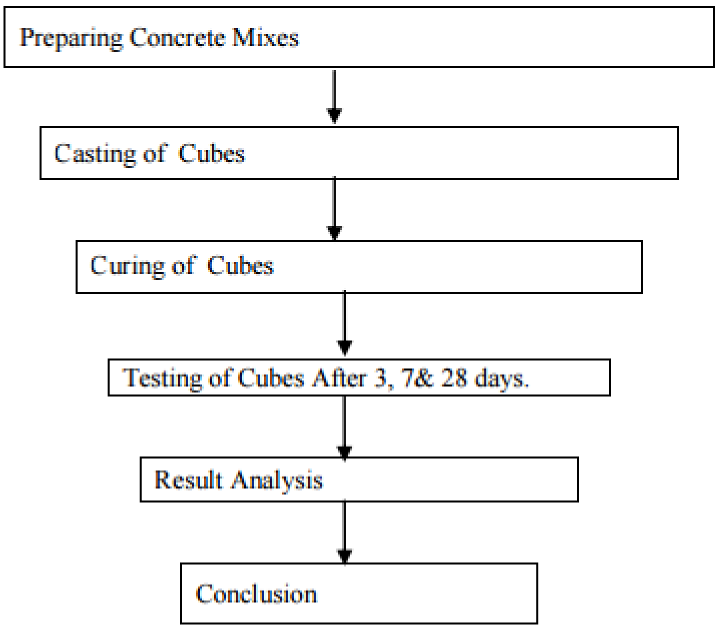


Figure3.1: Flow Chart of Experimental Program

Study the interaction of steel fibres (hooked) with concrete under compression, flexure, split and tension, various cubes, beams and cylinders were casted respectively.

Each group consisted of cubes(15cmx15cmx15cm), cylinder(r=10cm,h=20cm) and beams(15cmx15cmx15cm).

- The first group consisted of plain concrete with 0% fibre.
- The second group consisted of 0.5%, 0.6%,1.2% and 1.8% of steel fibres with aspect ratio 50, by total volume of concrete.
- The third group consisted of 0.5%, 0.6%,1.2% & 1.8%of steel fibres with aspect ratio 64, by total volume of concrete.
- The fourth group consisted of 0.5%, 0.6%, 1.2% and 1.8% of steel fibres with aspect ratio 80, by total volume of concrete.

3.2 MATERIALS

3.2.1 CEMENT

Cement is a construction material which is basically used as a binder in a construction industry that binds other materials.The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. It can be broadly divided into following categories:

- Portland Cement
- Special Cement

The cement used in this experimental investigation is ordinary Portland cement 53 grade. Storage of cement requires extra special care to preserve its quality and fitness for use. To prevent its deterioration it is necessary to protect it from rain, winds and moisture.

3.2.2 FINE AGGREGATE

Initially observation showed the presence of various impurities and moisture. The impurities were removed by sieve analysis. It had cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture, it gave good workability. Sieve analysis was done to find out fineness modulus which comes out to be 3.14% which is under the limit as per IS 383-1970. The specific gravity of fine aggregate was 2.65.

3.2.3 COARSE AGGREGATE

Initial observations showed the presence of dust particles, leaves. The material whose particles are of size that are retained on IS sieve No. 480 (4.75mm) is termed as coarse aggregate.The coarse aggregates used is dependent on the work of construction. The coarse aggregate used in this experimental investigation are of 20mm and below sizes, crushed angular in shape.

3.2.4 WATER

w/c cement ratio =0.42

3.2.5 FIBRE

The hooked end steel fibre used in the experiment is taken from Komatko, Pune Maharashtra. Hooked end fibre has been in the market for over 25 years.The shape and size of fiber is a very important prospective in its properties.So all the manufacturers have taken hooked end fibres to their manufactured product mostly.Hooked end fibres can be used with any concrete mix and high concrete density is less mandatory then for undulated or for flat-end fibres. Load transfer in the crack is very good with this fibre shape.So,after the first crack propagates load bearing capacity loss occurs but it gets stabilizes due to fibre and also increases in some cases.

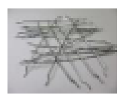
Item Nos.	Length (mm)	Diameter (mm)	Aspect Ratio	Type	Formation	UTS (N/mm2)	Additiona Info	Price exclusive of tax	Brand	Appx. Look
1	60	0.75	80	Single hooked end	Glued	1225	Bright wire	145.0	Bekaert	
2	50	1	50	Single hooked end	Loose	1050	Bright wire	105.0	Beakert	
3	35	0.55	64	Single hooked end	Glued	1345	Bright wire	210.0	Local	

Fig.3.2(Steel Fibres)

3.3 SPECIMEN CASTING

For casting the cubes, beam and cylinder specimen, standard cast iron metal moulds of size 150x150x150mm cubes, 100x100x500mm beams and 100x200mm cylinder moulds were used. The moulds had been cleaned for dust particles and applied with oil on all sides, before the concrete is poured into the moulds.Mixed concrete is filled into the mould followed by tamping. Mould is placed on the table vibrator for compaction. Excess concrete is removed and the top surface is cleaned.

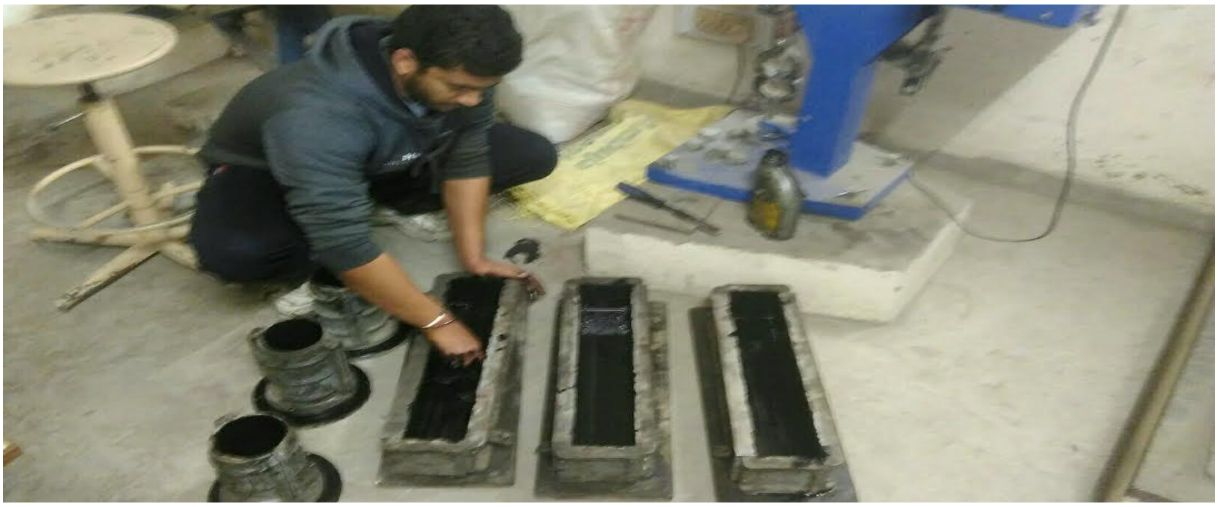


Fig.3.3(Casting process)

3.4 MIX DESIGN

Mix proportions

Mix ratio: 1:1.87:3.37

Table 2.5: Mix Proportions for (M30) Grade for steel fiber

S N	S F (%)	W/C Ratio	Mix Proportion (Kg/M^3)			
			Cement	Sand	Agg.	Water
1	0	0.42	380	711	1283	160
2	0.5	0.42	378.10	711	1283	160
3	1.0	0.42	376.20	711	1283	160
4	1.5	0.42	374.30	711	1283	160
5	2.0	0.42	372.40	711	1283	160

3.5 TESTS PERFORMED DURING THE PROJECT

A number of tests were carried out to ascertain the design mix properties of concrete in the laboratory. These tests are based on strength as well as durability concern. The overall performance of any concrete is measured on the basis of mainly two criteria's viz strength and durability of hardened concrete. In case of HPC, strength is major governing attribute whereas durability is a measure of performance. In the present work, the strength of the hardened concrete is ascertained. The strength criterion includes measurement of following parameters:

- Compressive Strength on cubes
- Flexural Strength
- Split Tensile Strength on Cylinders

3.5.1 COMPRESSION TEST

To examine the compressive strength of SFRC, cube of 150mmX150mmX150mm has been used in this experimental work cubes has been casted to determine the compressive strength. firstly cement and sand are mixed uniformly in dry condition . Secondly coarse aggregates are added in this mixture . Now steel fibres also added according to mix proportion to get the resultant mixture of M30 grade. Required dosage of water was added in the course of mixing. Through mixing was done until concrete appeared to be homogeneous and of desired consistency. Now cube moulds were filled with concrete in three layers and after each layer, concrete was compacted with temping rod . The mould‟s surface level should be plane with trowel . The cube moulds were demoulded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM) as per IS 516-1959

The cubes of standard size 150x150x150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of CTM and load was applied till the failure of cube..

Compressive strength (f_{ck}) in MPa = P/A

Where,

P= Cube compression load

A= Area of cube

Fig.3.4(Compression test)

3.5.2 SPLIT TENSILE STRENGTH

Fibers adjusted toward the pliable anxiety may realize expansive increments in direct elasticity. In any case, for pretty much haphazardly dispersed fibers, the expansion in quality is considerably littler, going from as meager as no increment in a few cases to maybe 60%, with numerous examinations demonstrating middle of the road values. In this way, adding fibers only to expand the direct rigidity is most likely not advantageous. Be that as it may, as in pressure, steel fibers do prompt real increments in the post-splitting conduct or sturdiness of the composites.

Fig.3.5(Split Tensile Failure)

3.5.3 FLEXURAL TEST

Steel fibers are for the most part found to have total significantly more noteworthy impact on the flexural quality of SFRC than on either the compressive or rigidity, with increments of over 100% having been accounted for. The expansion in flexural quality is especially delicate, to the fiber volume, as well as to the perspective proportion o0f the fibers, with higher angle proportion prompting bigger quality increments.

Fig.3.6(flexural strength)

CHAPTER 4

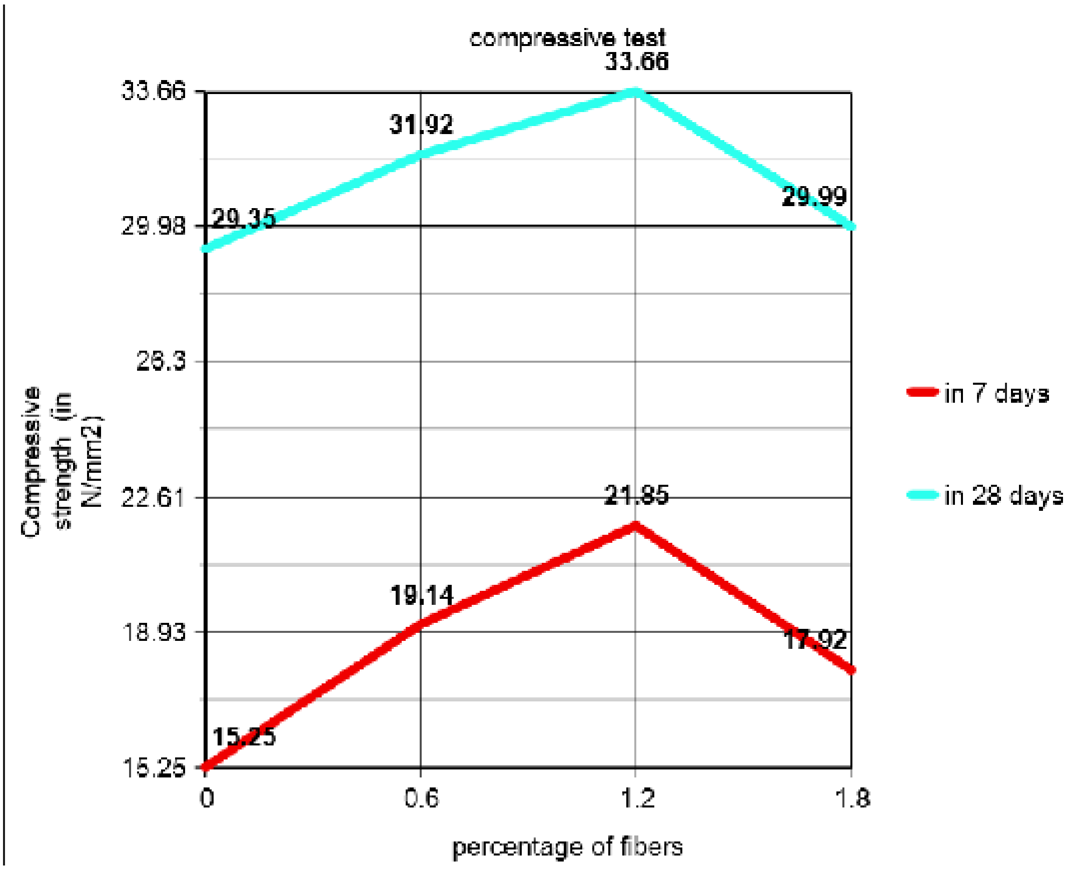
OBSERVATIONS AND RESULTS

4.1.1 Compression test values of M30 grade with aspect ratio 80

Percentage of fibers	Aspect Ratio	1 specimen	Compressive strength (in N/mm^2)
0	0	15.25	15.25
0.6	80	19.14	19.14
1.2	80	21.85	21.85
1.8	80	17.92	17.92

4.1.2 Compression test values of M30 grade with aspect ratio 80

Percentage of fibers	Aspect Ratio	1 specimen	Compressive strength (in N/mm^2)
0	0	29.35	29.35
0.6	80	31.92	31.92
1.2	80	33.66	33.66
1.8	80	29.99	29.99



From the above results, we observe that compressive strength of concrete increases due to incorporation of steel fibres. From the plot we can say that compressive strength of concrete increases upto 33 % with 1.2% steel fibres.

4.2.1 Split tensile test values of M30 grade with aspect ratio 50

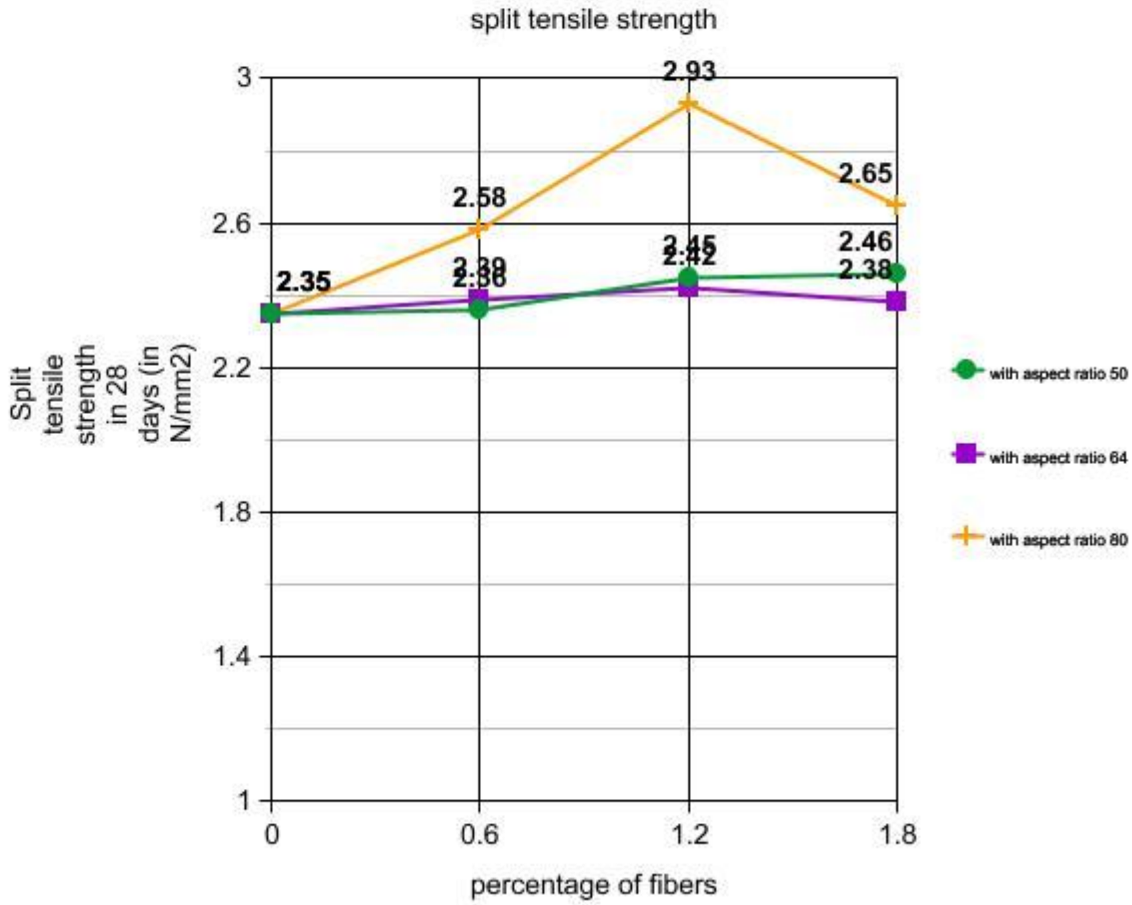
Percentage of fibers	Aspect Ratio	Split tensile strength in 7 days	Split tensile strength in 28 days (in N/mm^2)
0	0	1.45	2.35
0.6	50	1.48	2.36
1.2	50	1.55	2.45
1.8	50	1.57	2.46

4.2.2 Split tensile test values of M30 grade with aspect ratio 64

Percentage of fibers	Aspect Ratio	Split tensile strength in 7 days	Split tensile strength in 28 days (in N/mm^2)
0	0	1.45	2.35
0.6	64	1.49	2.39
1.2	64	1.58	2.42
1.8	64	1.56	2.38

4.2.3 Split tensile test value of M30 grade with aspect ratio 80

Percentage of fibers	Aspect ratio	Split tensile strength for 7 days ($N/mm^{2)}$	Split tensile strength for 28 days ($N/mm^{2)}$
0	0	1.45	2.35
0.6	80	1.69	2.58
1.2	80	1.8	2.93
1.8	80	1.6	2.65



From the above results, we observe that Split Tensile Strength of concrete increases due to incorporation of steel fibres. From the plot we can say that Split Tensile strength of concrete increases upto 29 % with 1.2% steel fibres as compared to plain concrete.

4.3.1Flexural test values of M30 grade SFRC with aspect ratio 50

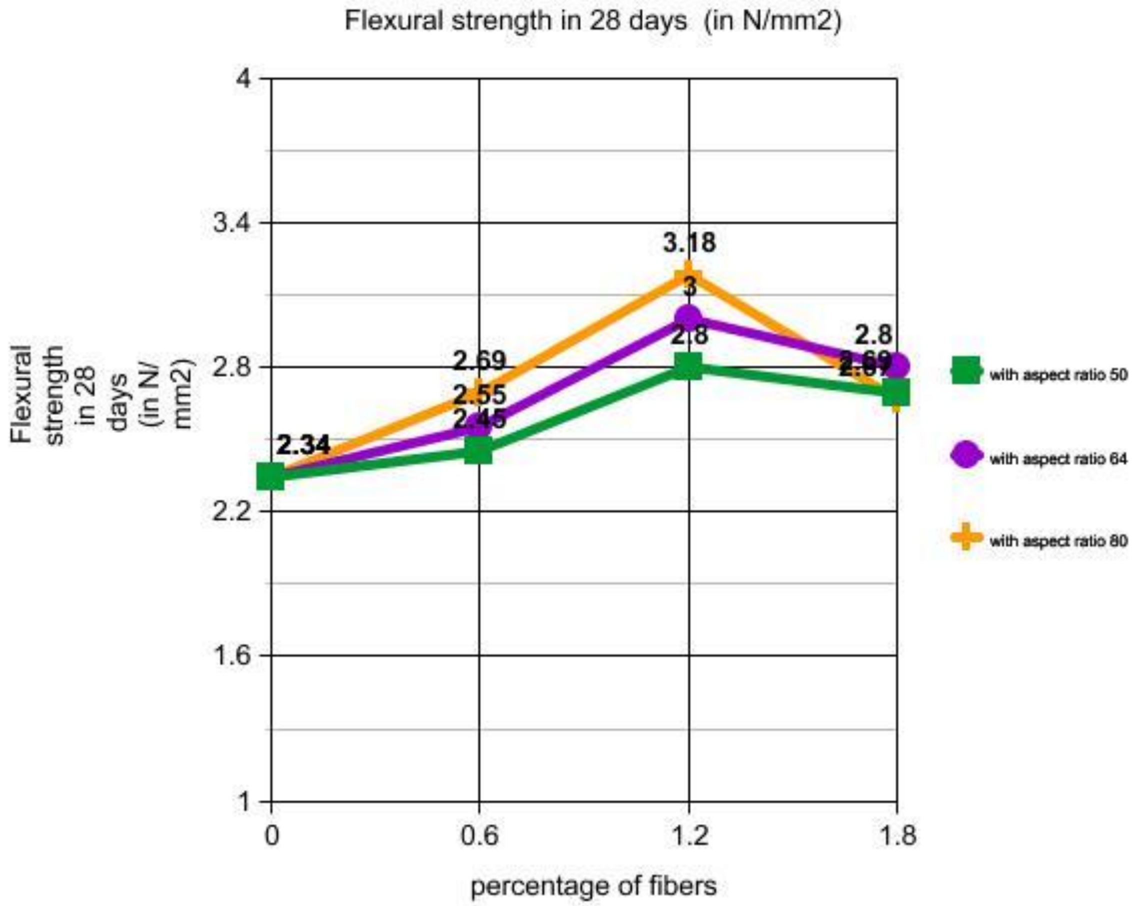
Percentage of fibers	Aspect Ratio	Flexural strength in 7 days (in N/mm^2)	Flexural strength in 28 days (in N/mm^2)
0	**0**	1.44	2.34
0.6	**50**	1.6	2.45
1.2	**50**	2	2.8
1.8	**50**	1.8	2.69

4.3.2Flexural test values of M30 grade SFRC with aspect ratio 64

Percentage of fibers	Aspect Ratio	Flexural strength in 7 days (in N/mm^2)	Flexural strength in 28 days (in N/mm^2)
0	**0**	1.44	2.34
0.6	**64**	1.71	2.55
1.2	**64**	2.1	3
1.8	**64**	1.9	2.8

4.3.3Flexural test values of M30 grade SFRC with aspect ratio 80

Percentage of fibers	Aspect Ratio	Flexural strength in 7 days (in N/mm^2)	Flexural strength in 28 days (in N/mm^2)
0	**0**	1.44	2.34
0.6	**80**	1.77	2.69
1.2	**80**	2.10	3.18
1.8	**80**	1.79	2.67
2.4	**80**	1.86	3.05



The results obtained from the experiment showed that flexural strength of the SFRC increased upto 32 % as compared with plain concrete.

4.4 RESULT

ASPECT RATIO 50:

- Split tensile strength increased 24% with 1.8% steel fibers.
- Flexural strength increased by 28% with 1.2% steel fibers.

ASPECT RATIO 64:

- Split tensile strength increased 28% with 1.8% steel fibers.
- Flexural strength increased by 30% with 1.2% steel fibers.

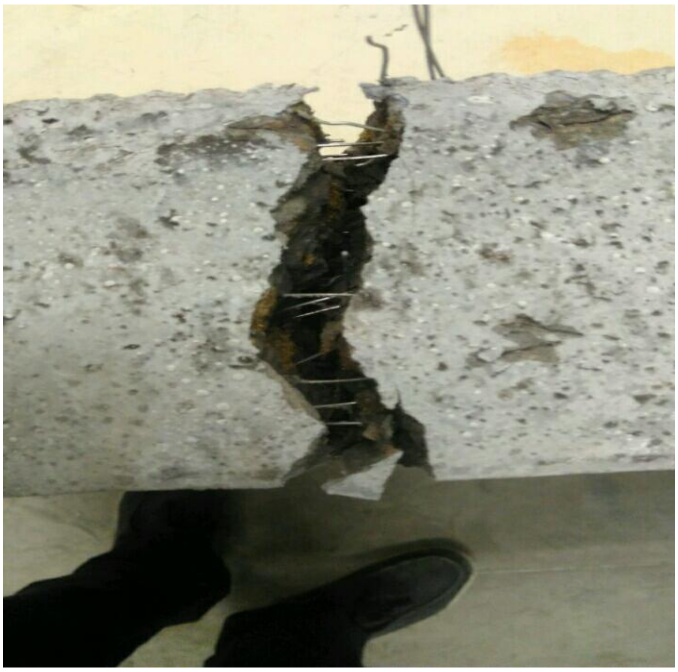
ASPECT RATIO 80:

- compressive strength of concrete increases upto ***33 % with 1.2%*** steel fibres.
- Split tensile strength increased by **29 %** with **1.2%** steel fibres.
- Flexural strength increased by **32%** with 1.2% steel fibers.

DISCUSSION

For studying the effect of fibres on normal concrete various beans and cylinders were casted.The effect of increase in aspect ratio in fiber were studied. The observation for 7 and 28 days curing period were recorded and presented in the form of tables .It is observed that there is noticable increase in both split tensile and flexural strength by the introduction of hooked end steel fibres in concrete.

Increase in strength in both tensile and flexural is more in case of steel fibers with aspect ratio 80 than the steel fibers with aspect ratio 50 and 64.



CONCLUSIONS

- The steel fibres used in this project work led to increase in the mechanical properties of conventional concrete as flexural strength and split tensile strength which significantly improved the behaviour of lean concrete under loading.
- 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.
- Workability of the mix is of concern as it gets tougher to mix the material with fibre inside them.
- Steel fibers can be made into use while construction work.

SCOPE FOR FUTURE WORK

- Further study on the seepage characteristics of steel fibres can be done.
- Deflection and durability of concrete behaviour can be a great study in fibre.
- Effect of sudden cooling, continuous cooling and irregular cooling on the properties of steel fiber fortified ternary mixed concrete when subjected to maintained lifted temperatures.
- Effect of grade of concrete on the properties of steel fibre reinforced ternary blended concrete when subjected to sustained elevated temperatures.
- The impact of various total sorts on the properties of steel fiber fortified ternary mixed concrete when subjected to managed lifted temperatures

ANNEXURE A

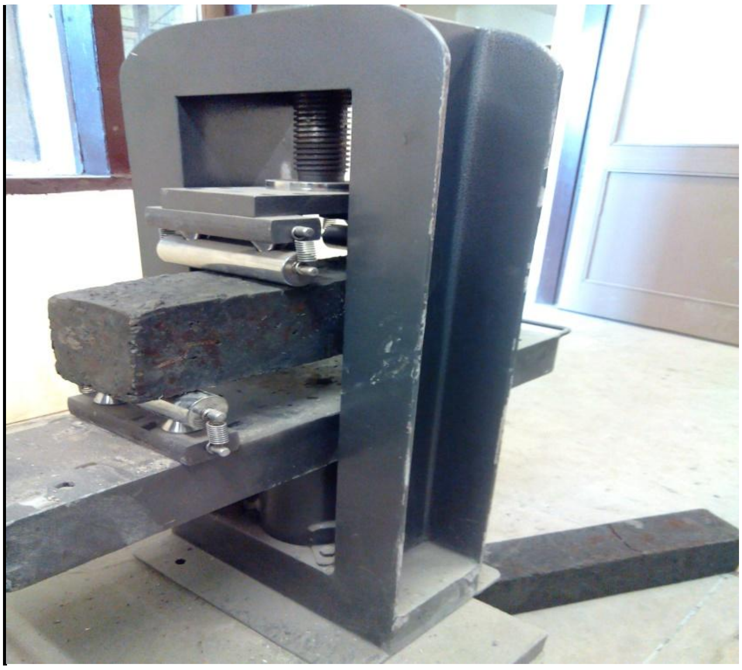
IMAGES TAKEN DURING PROJECT

Mixing of aggregates

Vibrating machine

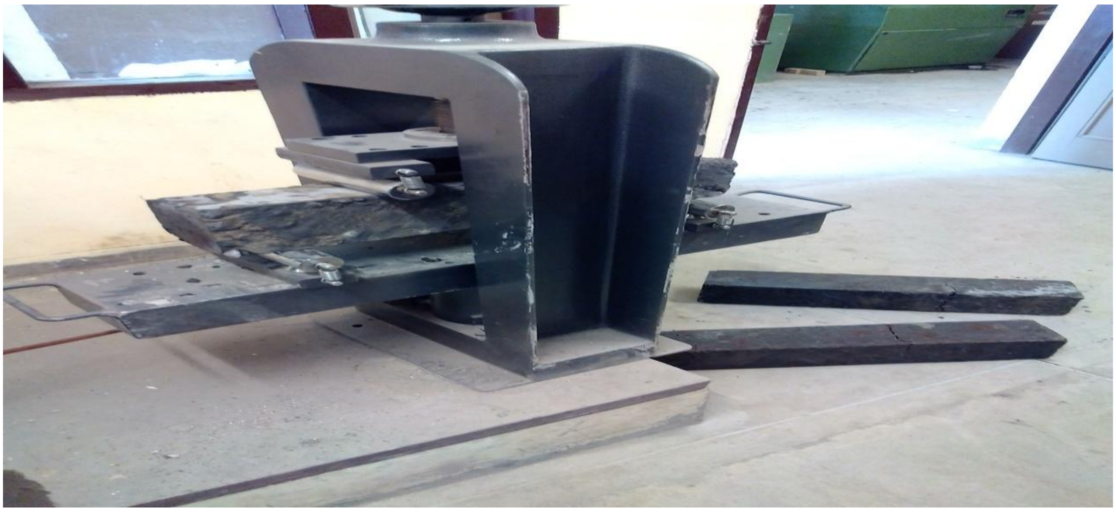
Flexural test

Flexural test

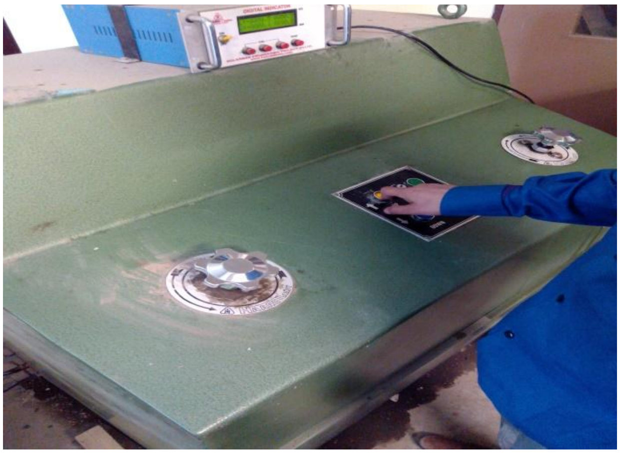


Testing on beams

Cracks propogation



Testing



Compression testing machine

Testing specimen

Casting process (mould)

Beam specimen mould(150mmX150mmX150mm)

Testing of specimen

ANNEXURE B

TABLE 1 IS 10262:2009

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm^2 (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm^2.

TABLE 2 IS 10262:2009

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate

(*Clauses* 4.2, A-5 *and* B-5)

Sl No.	Nominal Maximum Size of Aggregate mm	Maximum Water Content [1)] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1)] Water}content corresponding to saturated surface dry aggregate.

TABLE 3 IS 10262:2009

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate

(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
	mm	Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

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REMARKS