COMPARATIVE STUDY OF GLASS FIBRE AND STEEL FIBRE IN REINFORCED CONCRETE

A Project Submitted
in Partial Fulfillment of the Requirements
for the Degree of

BACHELOR OF TECHNOLOGY

In

Civil Engineering

By

SHRI RAM PATEL	**(1170431033)**
TUSHAR YADAV	**(1170431038)**
ARUN CHAUHAN	**(1170431012)**
ABHIK SINGH	**(1170431002)**
ADARSH PANDEY	**(1170431004)**

Under Guidance

of

Mr. ANKIT VERMA

(Assistant Professor)

(School of Engineering)

BABU BANARASI DAS UNIVERSITY

LUCKNOW

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CERTIFICATE

Certified that **Shri Ram Patel(1170431033), Tushar Yadav(1170431038), Arun Chauhan(1170431012), Abhik Singh(1170431002), Adarsh Pandey(1170431004)** ha**s** carried out the research work presented in this Project entitled **"COMPARATIVE STUDY OF STEEL FIBRE AND GLASS FIBRE IN REINFORCED CONCRETE"** for the award of **Bachelor of Technology in Civil Engineering** from BabuBanarasi Das University, Lucknow under our supervision. The Project embodies results of original work, and studies are carried out by the student himself and the contents of the Project do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

Signature

Mr. Ankit Verma
(Assistant prof.)
Department ofCivil Engineering
Babu Banarasi Das University,
Lucknow

Signature

Prof. Omprakash Netula
(Head of Department)
Department , Civil Engineering
Babu Banarasi Das University,
Lucknow

DECLARATION

We hereby declare that the project entitled "**COMPARATIVE STUDY OF STEEL FIBRE AND GLASS FIBRE IN REINFORCED CONCRETE"** submitted by us in the fulfillment of the requirements for the award of the Degree of **Bachelor of Technology in Civil Engineering,** to the **Babu Banarasi Das University, Lucknow,** is record of our own work carried under our supervision and guidance of **Mr. Ankit Verma**(Assistant Professor) of Department of Civil Engineering, Babu Banarasi Das University, Lucknow. We further declare that the work reported in this project has not been submitted either in part or in full, for the award of any other degree or diploma in this university or any other institute or university.

Shri Ram Patel
(1170431033)

TusharYadav
(1170431038)

Arun Chauhan
(1170431012)

Abhik Singh
(1170431002)

Adarsh Pandey
(1170431004)

ABSTRACT

Presently, a number of laboratory experiments on mechanical properties of SFRC have been done. Shah Surendra and Rangan], in their investigations conducted uniaxial compression test on fiber reinforced concrete specimens. The results shown the increase in strength of 6% to 17% compressive strength, 18% to 47% split tensile strength, 22% to 63% flexural strength and 8% to 25% modulus of elasticity respectively. Byung Hwan Oh in their investigations, the mechanical properties of concrete have been studied, these results shown the increase in strength of 6% to 17% compressive strength, 14% to 49% split tensile strength, 25% to 55% flexural strength and 13% to 27% modulus of elasticity respectively. Barrows and Figueiras in their investigations the mechanical properties of concrete have been studied. These results shown the increase in strength of 7% to 19% compressive strength, 19% to 48% split tensile strength, 25% to 65% flexural strength and 7% to 25% modulus of elasticity respectively. Chen S. investigated the strength of 15 steel fiber reinforced and plain concrete ground slabs. The slabs were 2x2x0.12m, Paper ID: NOV163300 690International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391 Volume 5 Issue 5, May 2016 www.ijsr.net Licensed Under Creative Commons Attribution CC BY reinforced with hooked end steel fibers and mill cut steel fibers. Dwaraknath and Nagaraj predicted flexural strength of steel fiber concrete by these parameters such as direct tensile strength, split cylinder strength and cube strength. James and Beaudoin stated that the minimum fiber volume dosage rate for steel, glass and polypropylene fibers in the concrete matrix was calculated approximately 0.31%, 0.40% and 0.75%. Patton and Whittaker investigated on steel fiber concrete for dependence of modulus of elasticity and correlation changes on damage due to load. Rossi et. al , analyzed that the effects of steel fibers on the cracking at both local level (behavior of steel fibers) and global level (behavior of the fiber/cement composite) were dependent to each other. Seneret. alcalibrated the size effect of the 18 concrete beams under four-point loading. Swami and Saad], had done an investigation on deformation and ultimate strength of flexural in the reinforced concrete beams under 4 point loading with the usage of steel fibers, where consists of 15 beams (dimensions of 130x203x2500mm) with same steel reinforcement (2Y-10 top bar and 2Y-12 bottom bar) and variables of fibers volume fraction (0%, 0.5% and 1.0%). Tan et. al [9] concluded some investigation on the shear behavior of steel fiber reinforced concrete. Six simply supported beams were tested under two- point loading with hooked steel fibers of 30mm long and

0.5mm diameter, as the fiber volume fraction increased every 0.25% from 0% to 1.0%.

Vandewalle had done a similar crack behavior investigation, which based on combination of five full scale reinforced concrete beams (350x200x3600mm) with steel fibers (volume fraction of 0.38% and 0.56%).In his investigation, the experimental results and theoretical prediction on the crack width was compared

Concrete is most generally utilized development material on the planet. Fibre strengthened cement (FRC) is a solid where little and intermittent filaments are scattered consistently. The fibers used

in FRC capacity be of many materials similar steel, G.I., carbon, glass, aramid, asbestos, polypropylene, jute and so on. The expansion of these filaments into solid mass can drastically expand the compressive quality, rigidity, flexural quality and effect quality of cement. FRC has open numerous applications in structural building field. In view of the research center examination on fibre strengthened cement (FRC), solid shape and chambers examples have been structured with steel fibre fortified cement (SFRC) containing strands of 0% and 0.5% volume division of snare end Steel filaments of 53.85, 50 angle proportion and antacid safe glass strands containing 0% and 0.25% by weight of concrete of 12mm cut length were utilized without admixture. Contrasting the consequence of FRC and plain M20 grade solid, this paper approved the constructive outcome of various filaments with rate increment in pressure and parting improvement of example at 7 and 28 days, broke down the affectability of expansion of strands to concrete with various quality.

Keywords— Compressive Strength, Fiber Reinforced Concrete, Steel Fiber Glass Fibers, TensileStrength

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We wish to convey our sincere gratitude to all the faculties of Civil Engineering Department who have enlightened us during our studies. The facilities and co- operation received from the technical staff of Civil Engineering Department is thankfully acknowledged.

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TABLE OF CONTENTS

CHAPTER -1

INTRODUCTION

GENERAL :

Cement concrete is characterized by brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc

The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cemetitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suited for a wide range of applications. However concrete has some deficiencies as low tensile strength, low post cracking capacity, brittleness and low ductility, limited fatigue life, not capable of accommodating large deformations, low impact strength.

The presence of micro cracks at the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibers in the mix Different types of fibers, such as those used in traditional composite materials have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibers help to transfer loads at the internal micro cracks. Such a concrete is called fiberreinforced concrete (FRC). Thus fiber-reinforced concrete is a composite material essentially consisting of conventional concrete or mortar reinforced by fine fibers.

The fibers can be imagined as an aggregate with an extreme deviation in shape from the rounded smooth aggregate. The fibers interlock and entangle around aggregate particles and considerably reduce the workability, while the mix becomes more cohesive and less prone to segregation. The fibers are dispersed and distributed randomly in the concrete during mixing and thus improve concrete properties in all directions. Fibers help toimprove the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks.

Essentially, fibers act as crack arrester restricting the development of cracks and thus transforming an inherently brittle matrix, i.e. cement concrete with its low tensile and impact resistances, into a strong composite with superior crack resistance, improved ductility and distinctive postcracking behavior prior to failure Hence, this study explores the feasibility of used of metallic and synthetic fibers; aim to do parametric study on compressive strength, tensile strength study etc. for a given grade of concrete, aspect ratio and various percentages of fibers

a. Need and Objective of the Project

- It increases the tensile strength of the concrete.
- It reduce the air voids and water voids the inherent porosity of gel.
- It increases the durability of the concrete.
- Fibres such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibres have a significant influence on the creep performance of rebars/tendons**.**
- Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fibre and the concrete as the matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized.
- It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties.

Objective:

Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete.

The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the fiber's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increasing the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. Longer length results in better matrix inside the concrete and finer diameter increases the count of fibers. To ensure that each fiber strand is effective, it is recommended to use fibers longer than maximum size of aggregate. Normal concrete

contains 19 mm equivalent diameter aggregate which is 35-45% of concrete, fibers longer than 20mm are more effective. However, fibers that are too long and not properly treated at time of processing tend to "ball" in the mix and create work-ability problems.
Fibers are added for long term durability of concrete. Glass and polyester decompose in alkaline condition of concrete and various additives and surface treatment of concrete.

The High Speed tunnel linings incorporated concrete containing 1 kg/m^3 or more of polypropylene fibers, of diameter 18 & 32 μm, giving the benefits noted below. Adding fine diameter polypropylene fibers, not only provides reinforcement in tunnel lining, but also prevents "spalling" and damage of lining in case of fire due to accident.

Perspective:

The concept of using fibers as reinforcement is not new. Fibers have been used as

reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mudbricks. In the 1900s, asbestos fibers were used in concrete. In the 1950s, the concept of composite materials came into being and fiber-reinforced concrete was one of the topics of interest. Once the health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the 1960s, steel, glass (GFRC), and synthetic (such as polypropylene) fibers were used in concrete. Research into new fiber-reinforced concretes continues today.
Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete. Larger steel or synthetic fibers can replace rebar or steel completely in certain situations. Fiber reinforced concrete has all but completely replaced bar in underground construction industry such as tunnel segments where almost all tunnel linings are fiber reinforced in lieu of using rebar. Indeed, some fibers actually reduce the compressive strength of concrete.

CHAPTER-2

LITERATURE REVIEW

Presently, a number of laboratory experiments on mechanical properties of SFRC have been done. Shah Surendra and Rangan], in their investigations conducted uniaxial compression test on fiber reinforced concrete specimens. The results shown the increase in strength of 6% to 17% compressive strength, 18% to 47% split tensile strength, 22% to 63% flexural strength and 8% to 25% modulus of elasticity respectively.

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CHAPTURE 3

METHODOLOGY

FIBRE REINFORCED CONCRETE

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fiber reinforced concrete are of different types and properties with many advantages. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers.

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Fibre-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fibre-reinforced normal concrete are mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations etc) either alone or with hand-tied rebars

Concrete reinforced with fibres (which are usually steel, glass or “plastic” fibres) is less expensive than hand-tied rebar, while still increasing the tensile strength many times. Shape, dimension and length of fibre is important. A thin and short fibre, for example short hair-shaped glass fibre, will only be effective the first hours after pouring the concrete (reduces cracking while the concrete is stiffening) but will not increase the concrete tensile strength.

Effect of Fibers in Concrete

Fibres are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement. Some fibres reduce the strength of concrete.

The amount of fibres added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed volume fraction (V_f). V_f typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibres with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio.

If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres which are too long tend to "ball" in the mix and create workability problems.

Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of concrete materials.This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibres. The results also pointed out that the micro fibres is better in impact resistance compared with the longer fibres.

Factors Affecting Properties of Fiber Reinforced Concrete

Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties would obviously, depends upon the efficient transfer of stress between matrix and the fibers. The factors are briefly discuss below:

1. Relative Fiber Matrix Stiffness

The modulus of elasticity of matrix must be much lower than that of fiber for efficient stress transfer. Low modulus of fiber such as nylons and polypropylene are, therefore, unlikely to give strength improvement, but the help in the absorption of large energy and therefore, impart greater degree of toughness and resistance to impart. High modulus fibers such as steel, glass and carbon impart strength and stiffness to the composite.
Interfacial bond between the matrix and the fiber also determine the effectiveness of stress transfer, from the matrix to the fiber. A good bond is essential for improving tensile strength of the composite.

2. Volume of Fibers

The strength of the composite largely depends on the quantity of fibers used in it. Fig 1 and 2 show the effect of volume on the toughness and strength. It can see from Fig 1 that the increase in the volume of fibers, increase approximately linearly, the tensile strength and toughness of the composite. Use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.

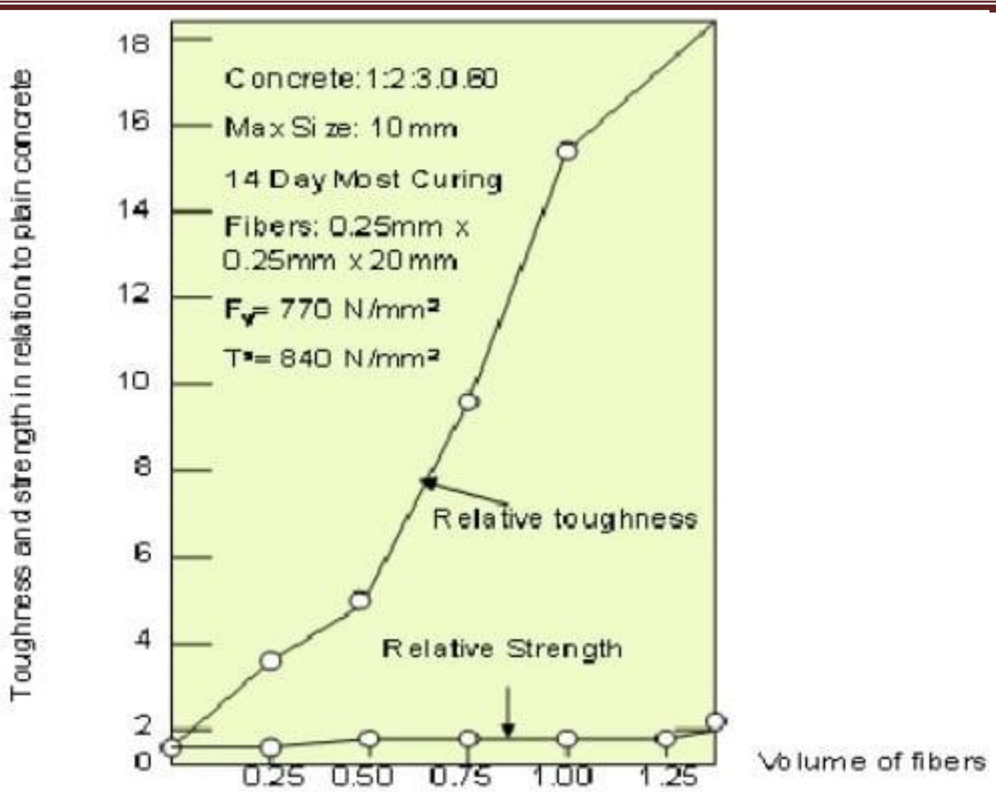


Fig.1: Effect of volume of fibers in flexure

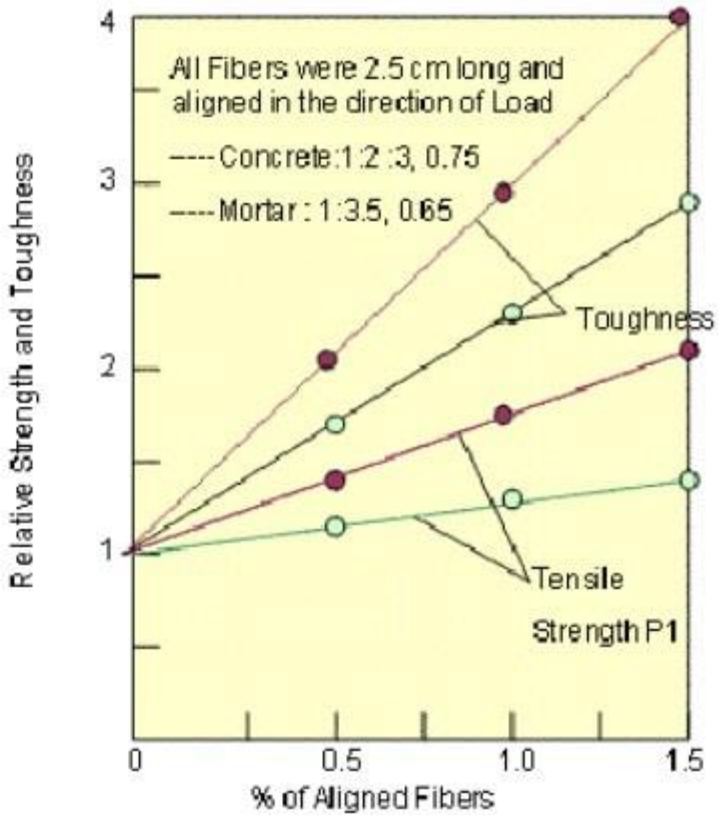


Fig.2: Effect of volume of fibers in tension

3. Aspect Ratio of the Fiber

Another important factor which influences the properties and behavior of the composite is the aspect ratio of the fiber. It has been reported that up to aspect ratio of 75, increase on the aspect ratio increases the ultimate concrete linearly. Beyond 75, relative strength and toughness is reduced. Table-1 shows the effect of aspect ratio on strength and toughness.

Table-1: Aspect ratio of the fiber

Type of concrete	Aspect ratio	Relative strength	Relative toughness
Plain concrete	0	1	1
With	25	1.5	2.0
Randomly	50	1.6	8.0
Dispersed fibers	75	1.7	10.5
	100	1.5	8.5

4. Orientation of Fibers

One of the differences between conventional reinforcement and fiber reinforcement is that in conventional reinforcement, bars are oriented in the direction desired while fibers are randomly oriented. To see the effect of randomness, mortar specimens reinforced with 0.5% volume of fibers were tested. In one set specimens, fibers were aligned in the direction of the load, in another in the direction perpendicular to that of the load, and in the third randomly distributed.

It was observed that the fibers aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibers.

5. Workability and Compaction of Concrete

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 consequence of poor workability is non-uniform distribution of the fibers. Generally, the workability and compaction standard of the mix is improved through increased water/ cement ratio or by the use of some kind of water reducing admixtures.

6. Size of Coarse Aggregate

Maximum size of the coarse aggregate should be restricted to 10mm, to avoid appreciable reduction in strength of the composite. Fibers also in effect, act as aggregate. Although they have a simple geometry, their influence on the properties of fresh concrete is complex. The inter-particle friction between fibers and between fibers and aggregates controls the orientation and distribution of the fibers and consequently the properties of the composite. Friction reducing admixtures and admixtures that improve the cohesiveness of the mix can significantly improve the mix.

7. Mixing

Mixing of fiber reinforced concrete needs careful conditions to avoid balling of fibers, segregation and in general the difficulty of mixing the materials uniformly. 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 important that the fibers are dispersed uniformly throughout the mix; this can be done by the addition of the fibers before the water is added. When mixing in a laboratory mixer, introducing the fibers through a wire mesh basket will help even distribution of fibers. For field use, other suitable methods must be adopted.

Different Types of Fiber Reinforced Concrete

Following are the different type of fibers generally used in the construction industries.

1. Steel Fiber Reinforced Concrete
2. Polypropylene Fiber Reinforced (PFR) cement mortar & concrete
3. GFRC Glass Fiber Reinforced Concrete
4. Asbestos Fibers
5. Carbon Fibers
6. Organic Fibers

1. Steel Fiber Reinforced Concrete

A no of steel fiber types are available as reinforcement. Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having a rectangular c/s are produced by silting the sheets about 0.25mm thick.
Fiber made from mild steel drawn wire. Conforming to IS:280-1976 with the diameter of wire varying from 0.3 to 0.5mm have been practically used in India.
Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets.

Deformed fiber, which are loosely bounded with water-soluble glue in the form of a bundle are also available. Since individual fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fibers bundles, which separate during the mixing process.

2. Polypropylene Fiber Reinforced (PFR) cement mortar and concrete

Polypropylene is one of the cheapest & abundantly available polymers polypropylene fibers are resistant to most chemical & it would be cementitious matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degree centigrade) may be sustained for short periods without detriment to fiber properties.
Polypropylene fibers being hydrophobic can be easily mixed as they do not need lengthy contact during mixing and only need to be evenly distressed in the mix.
Polypropylene short fibers in small volume fractions between 0.5 to 15 commercially used in concrete.

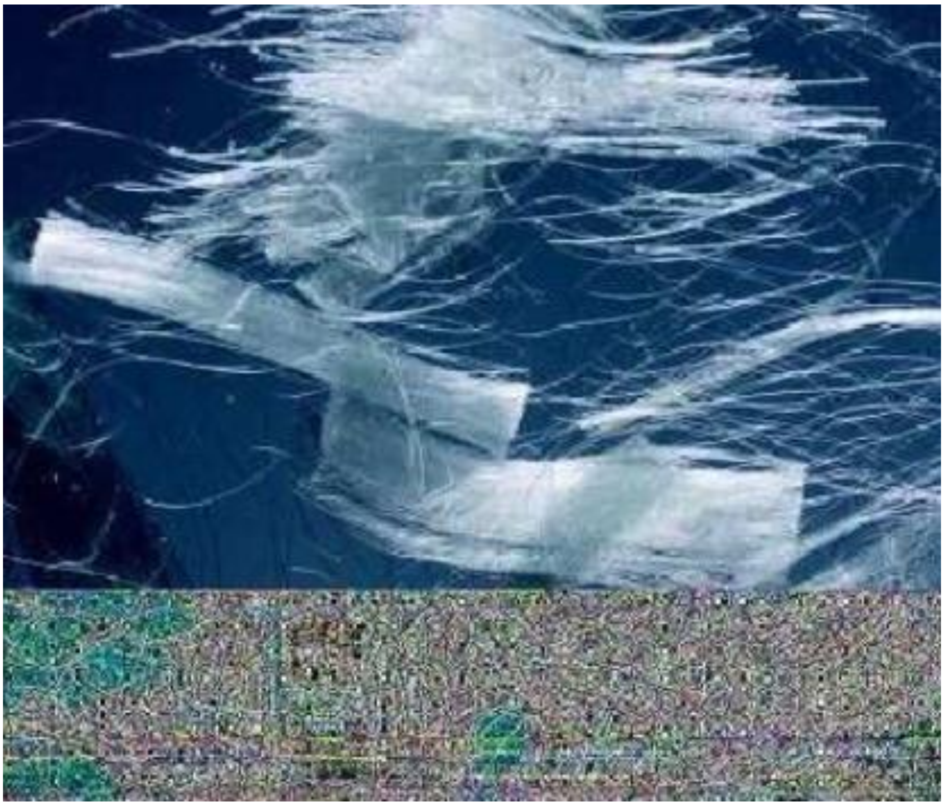


Fig.3: Polypropylene fiber reinforced cement-mortar and concrete

3. GFRC – Glass Fiber Reinforced Concrete

Glass fiber is made up from 200-400 individual filaments which are lightly bonded to make

up a stand. These stands can be chopped into various lengths, or combined to make cloth mat or tape. Using the conventional mixing techniques for normal concrete it is not possible to mix more than about 2% (by volume) of fibers of a length of 25mm.
The major appliance of glass fiber has been in reinforcing the cement or mortar matrices used in the production of thin-sheet products. The commonly used verities of glass fibers are e-glass used. In the reinforced of plastics & AR glass E-glass has inadequate resistance to alkalis present in Portland cement where AR-glass has improved alkali resistant characteristics. Sometimes polymers are also added in the mixes to improve some physical properties such as moisture movement.

Fig.4: Glass-fiber reinforced concrete

4. Asbestos Fibers

The naturally available inexpensive mineral fiber, asbestos, has been successfully combined with Portland cement paste to form a widely used product called asbestos cement. Asbestos fibers herethermal mechanical & chemical resistance making them suitable for sheet product pipes, tiles andcorrugated roofing elements. Asbestos cement board is approximately two or four times that ofunreinforced matrix. However, due to relatively short length (10mm) the fiber have low impact
strength

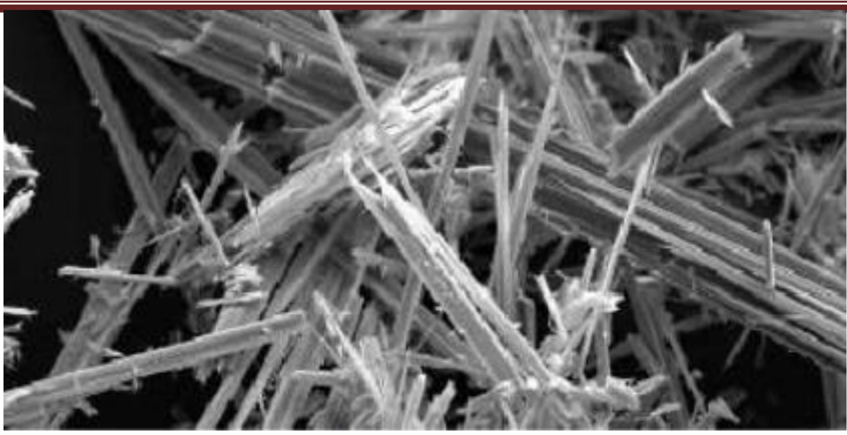


Fig.5: Asbestos fiber

5. Carbon Fibers

Carbon fibers from the most recent & probability the most spectacular addition to the range of fiber available for commercial use. Carbon fiber comes under the very high modulus of elasticity and flexural strength. These are expansive. Their strength & stiffness characteristics have been found to be superior even to those of steel. But they are more vulnerable to damage than even glass fiber, and hence are generally treated with resign coating.

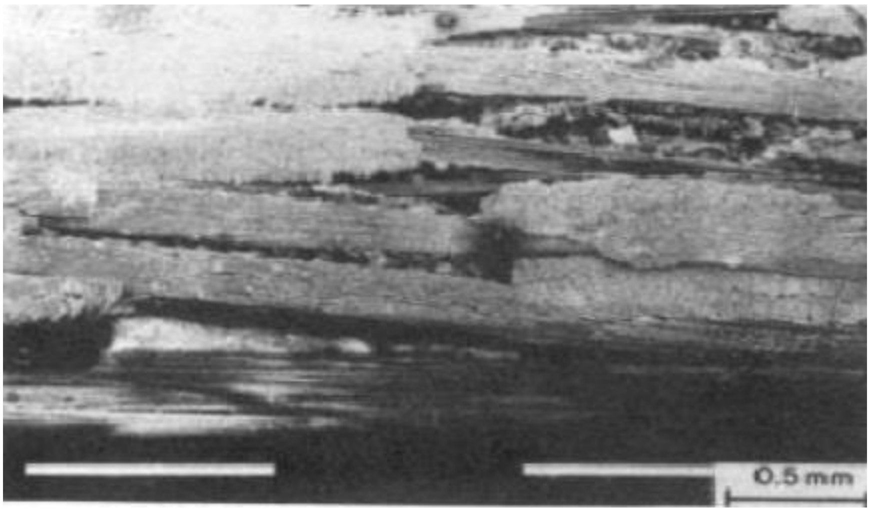


Fig.6: Carbon fibers

6. Organic Fibers

Organic fiber such as polypropylene or natural fiber may be chemically more inert than either steel or glass fibers. They are also cheaper, especially if natural. A large volume of vegetable fiber may be used to obtain a multiple cracking composite. The problem of mixing and uniform dispersion may be solved by adding a superplasticizer.

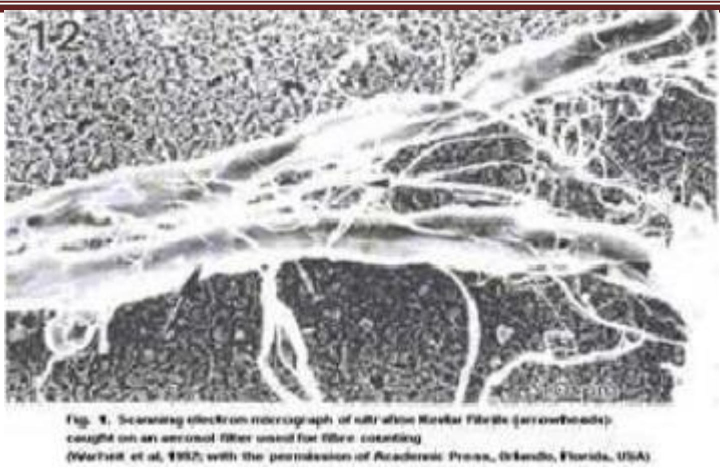


Fig.7: Organic fiber

Factors Affecting Durability of Fiber Reinforced Concrete (FRC)

Following are the factors which affects the durability of fiber reinforced concrete:

- Extreme temperature and fire
- Freezing and thawing
- Degradation and embrittlement due to alkali attack and bundle affect
- Weathering and scaling
- Corrosion resistance

Effect of Extreme Temperature and Fire on Durability of FRC

Generally, concrete has a reasonable resistance to severe temperature because of its low thermal conductivity, great heat capacity, and it is not burn easily while exposed to fire. Concrete constituents for example specific aggregate types and cement clinker are not influenced by high temperature both chemically and physically. However, there are others concrete constituents that affected by temperature changes such as hydration product. It is influenced by loss of water, micro-cracking, and damage by differential expansion.
The addition of steel fiber, synthetic fiber, or combination of both to concrete enhances structural concrete elements resistant against substantial temperature and fire.
The strength of conventional concrete is decreased considerably if it exposed to fire for long time. Cement paste and aggregate bond in concrete is damaged at a temperature of 202^{o}C and about half of the concrete strength is decline at temperature of 427 ^{o}C, and 90% of concrete strength is lost at temperature of larger than 927 ^{o}C.
Fiber provision do not impede concrete failure under this sever condition but it increases fire exposure safe time. The extension of fire exposure safe time provides more time during which evacuations and the fire extinguishment can be proceeded safely.
It is reported that, the application of hybrid combination of steel and polypropylene fibers in precast concrete fireplace hearths produced small or not explosive spalling.
Regarding concrete spalling, when concrete exposed to fire, excess water inside concrete, which used to provide workability during construction, changes to steam pressure. If the pressure inside concrete is not released and surpass concrete tensile strength, explosive spalling will occur.

The concrete spalling depends on the amount of free water and its distribution while concrete element is exposed to fire.
The damage caused by spalling may penetrate concrete to about 6 cm.
Spalling is a serious problem because it may expose steel reinforcement to high temperature. Hence, steel reinforcement is deteriorated quickly which in return ultimate load carrying capacity of concrete member is declined.
It is demonstrated that, when concrete reinforced with polypropylene fiber exposed to high temperature, the polypropylene fiber is melted and fine capillary pores will be emptied and this lead to release the accumulated steam pressure and the concrete maintain its strength.
The provision of steel fiber increases small concrete slab fire resistance to three to nine times that of the slab with no fibers.
Finally, fibers can be added to concrete to bridge cracks and keep structure integrity of the damaged structure.

Effect of Freezing and Thawing on Durability of FRC

In this section durability of three fiber reinforced concrete namely steel, synthetic, and cellulose FRC will be explained.

It is demonstrated that, among factors such as fiber content, air content, cement content,

and water to cement ratio, the air content create significant effect on the steel fiber reinforced concrete resistance against freezing and thawing.

Moreover, the reduction of SFRC modulus of rupture due to freezing and thawing is smaller than that of concrete with zero fiber.
It is recommended by Rider and Heidersbach that, mix design of SFRC that is used in marine environment, need to have water content of no greater than 0.45, cement content should be at least 519 Kg/m^3, and air content ranges from 6-7.5%.
Regarding synthetic fiber reinforced concrete, it is pointed out that, not only does the synthetic fibers improves freezing and thawing resistance of synthetic FRC but also enhances concrete ability to withstand deicer scaling.
Moreover, freezing and thawing cause reduction of flexural strength of concrete reinforced with polyolefin micro-fiber by about 15% whereas plain concrete flexural strength reduced by 30%.
As far as cellulose fiber is concerned, it is found that, fiber reinforced cement board (FRCB) which is laminated material and consist of cellulose fiber, cement, silica, and water, is vulnerable to freezing and thawing deterioration due to its high porosity, hydrophilic and tabular nature of cellulose fibers, and laminated nature of the composite.

FRC Degradation and Embrittlement due to Alkali Attack and Bundle Effect

Strength of various fibers for example glass, polymeric, and natural fibers are decreased in long term because of weathering. It is substantially important to know time-dependent reduction of durability and strength of those fibers in structurally related areas.
That is why deterioration mechanism of various fibers will be explained in this section.

Glass Fiber Concrete

Reinforced concrete commonly contains alkali resistance glass fibers between 3-5% of the whole composite weight. It is reported that, the corrosion of fiber is the major degradation mechanism.
However, it is claimed that, apart from the effect of corrosion, there are other factors that influence the durability of GFRC. Added to that, in most situations, calcium hydroxide, which is a product of cement hydration, is the agent that is to blame for decreasing GFRC durability.
That is why attempts made toward the reduction of calcium hydroxide in order t improve the durability of GFRC. Calcium hydroxide can be reduced by either adding admixtures for example fly ash, ground granulated blast furnace slag, and silica fume or avoid the use of conventional Portland cement especially those types which contain calcium aluminates or sulfo aluminates.
In summary, the glass fiber reinforced concrete damage mechanisms are chemical attack, mechanical attack, delayed fracture.

Cellulose Fiber Concrete

Cycles of wetting and drying lead to degrade cellulose fiber and this degradation occur in different mechanism includes change in degree of fiber cement bonding and fiber mineralization.

In the former mechanism, hydration product transportation specifically lime within the lumen of fibers and around the fibers lead to reduce interface porosity. This could be the cause of the increase of fiber cement bond and the decline of composite ductility.

In the latter mechanism, it is claimed that, the embrittlement of fiber occur as a result of the penetration of cement hydration product into the fiber.
Lastly, the durability of cellulose fiber may be increased by Fiber impregnation with blocking agents, and water repellent Agents Sealing of the matrix pore system; Reduction of $Ca(OH)2$ content in the matrix; and A combination of fiber impregnation and matrix modification.

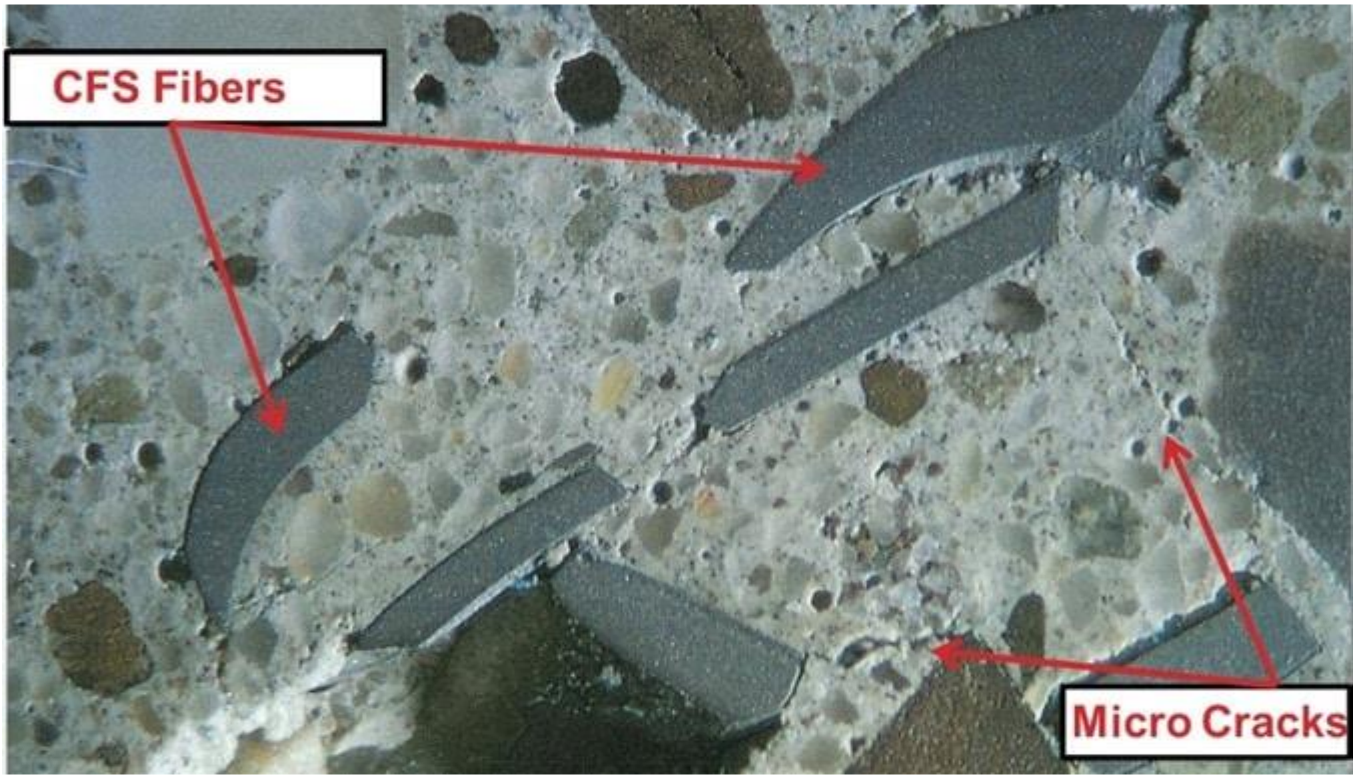
Effect of Weathering and Scaling on Durability of FRC

The deicer salt scaling, which its mechanics is still not clear, is merely affect a thin layer of exposed concrete which not exceed few centimeters. It is reported that, the present fiber and the type of fiber do not influence dicer salt scaling resistance. Moreover, it is pointed out that, steel fibers that in contact with concrete which suffered scaling, rusts.

Corrosion Resistance of Fiber Reinforced Concrete

Unlike ordinary reinforced concrete beam, FRC is distributed in concrete and some of them might be close or at the surface of the concrete. Therefore, those fibers which are not protected by concrete might corrode.

Factor that could lead to corrosion are chloride induced corrosion, corrosion because of PH reduction in the concrete mix.
It is showed that, low carbon steel and galvanized steel fibers do not corrode in chloride concentration that greater than 2 percent by weight. Moreover, at much greater chloride ions, melt extracted fiber does not corrode.



Application of Fiber Reinforced Concrete

There are various applications of fiber reinforced concrete and one of them is in the construction of concrete pavements. Fiber reinforced concrete (FRC) is defined as a composite material consisting of concrete reinforced with discrete randomly but uniformly dispersed short length fibers. The fibers can be made of steel, polymer or natural materials. Woven fabrics, long wires, bars, and continuous wire mesh are not considered discrete fibers.

FRC is considered as a material of improved properties and not as reinforced cement concrete whereas reinforcement is provided for local strengthening of concrete in tension region. Since in FRC, fibers are distributed uniformly in concrete, it has better properties to resist internal stresses due to shrinkage.

As fibers improve specific material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, ductility also improve. Fibers generally used in cement concrete pavements are steel fibers and organic polymer fibers such as polypropylene and polyester.

Steel Fiber Reinforced Concrete

Steel fibers have been used for a long time in construction of roads and also in floorings, particularly where heavy wear and tear is expected. Specifications and nomenclature are important for a material to be used as the tenders are invited based on specifications and nomenclature of the items. Such nomenclature is not available in Delhi Schedule of Rates. In a work where steel fiber reinforced concrete was used for overlays just like flooring, the following nomenclature can be adopted for concreting of small thickness. Providing and laying 40 mm steel fiber reinforced cement concrete in pavement (in panels having area not more than 1.5 sqm) consisting of steel fiber @ 40kg per cubic meter of concrete and cement concrete mix of 1:1.95:1.95 (1 cement: 1.95 coarse sand of fineness modulus 2.42: 1.95 stone aggregate 10 mm and down gauge of fineness modulus 5.99) over existing surface i/c cement slurry, consolidating, tapping, and finishing but excluding the cost of steel fibers which shall be paid separately, complete as per direction of Engineer in Charge (Cement to be used shall be OPC 43 grade and sand and aggregate have to be washed). Second item of fibers was provided separately as "Providing and mixing steel fibers of dia 0.45 mm in cement concrete duly cut into pieces not more than 25 mm in length."

Figure-1: Pavement with steel fiber reinforced concrete

Though the item of steel fiber reinforced concrete has been provided with a design mix of concrete, which is almost of 1:2:2 grading, it can now be used of mix like M30 or M35. Since in the executed item, the thickness was to be restricted, the stone aggregates used were of 10 mm size and below however, in case of the concrete of more than 75 mm thickness, stone aggregates of 20 mm grading can be used. The construction was carried out more than a decade back. It is observed that the performance of the concrete is satisfactory even after many years of construction (Figure 1). Even, no corrosion has been observed in the steel fibers. In fact the concreting has been done just like flooring item in this case over already existing hard surface. In such a case a bonding coat should also be provided like a coat of cement slurry. The fiber reinforced concrete has been provided in small panels considering the workability. Though vacuum dewatered concrete has not been done with steel fiber reinforced concrete but the same is also possible. Vacuum dewatered concrete, though cannot be done in small thickness like 40 or 50 mm but can be used if thickness is 100 mm or more.

Figure-2: A view of PFRC used in parking over lean base concrete

Figure-3: Laying of PFRC in parking over WBM surface

Polymer Fiber Reinforced Concrete

Polymeric fibers are being used now because of their no risk of corrosion and also being cost effective (Sikdar et al, 2005). Polymeric fibers normally used are either of polyester or polypropylene. Polymer fiber reinforced concrete (PFRC) was used on two sites with ready mix concrete and Vacuum dewatering process. The nomenclature can be used in the works as given here. "Providing and laying ready mix fiber reinforced cement concrete of M35 grade (The concrete shall also have minimum works test beam flexural strength of 40 kg per sqm at 28 days) in required slope and camber in panels i/c shaping at drainage points as required using cementitious materials not less than 435 kg per cum of finished concrete from ACC/L&T/AHLCON/ UNITECH or equivalent batching plant for all leads and lifts with Fibercom-CF/Fiber mesh/Recron or equivalent (100 % virgin synthetic fiber size 12 mm long) to be mixed @ 900 grams per cum of concrete i/c finishing with screed vibration, vacuum dewatering process, floating, trowelling, brooming and normal curing etc. complete as per standard manufacturer's specifications and as per direction of Engineer in charge (All related equipment shall be arranged by the contractor. Cost of centering, shuttering, grooving etc. shall be paid separately. Design Mix shall be got approved from the Engineer in Charge). In both the sites, vacuum dewatered concrete was used. Both the sites are to be used for parking. In a site, fiber reinforced concrete was used over a base cement concrete of lean mix of 1:4:8 (Figure 2) while in other site it was laid over water bound macadam (WBM) (Figure 3). When dewatered concrete it has no problem of water being coming out on surface during compaction process but when it is done over WBM, a lot of concrete water is soaked by WBM and thus the concrete loses the water to WBM and the water which comes out during dewatering/compaction process is not in same quantity asin case of lean concrete. It appears that it is better to provide base concrete than WBM as the base. The groove was made in one case before setting of concrete and also panels were cast with expansion joints in one direction. No cracks were observed in the direction in which expansion joints were provided assuming this is longitudinal direction. In lateral direction, no joints were provided and the width of such panel was about 12 m. It was later observed that cracks have developed in this direction (Figure 4). 

Figure-4: A closer view of crack due to no expansion joint provided in PFRC on lean concrete base.

Figure-5: A closer view of crack due to no expansion joint

As it is known that the width of 12 m is too long for expansion/ contraction. It has been observed that almost at about one–third of the panel width, such cracks developed i.e. size of panel from one side is about 4 m and from other side it is about 8m. From the site observation, it is therefore inferred that the panel should have the size of about 4m x 4m in the temperature conditions of Delhi however small variation can also be made as per site conditions. In other case, the contractor delayed the cutting of grooves and thereafter the area was occupied due to some urgent requirements, the cracks in both the directions developed. The cracks were almost in line. Later on the grooves were made through cutters. It has been observed that the distance of cracks in one side was almost near to 4 m and on other side at about 7 to 9 m (Figure 5). Thus from this case study also, inference can be made that grooves if made in panels of 4m x 4m, it would be appropriate. In both the cases, no lateral grooves were made, as working was not a problem due to use of vacuum dewatering process. In both the cases, horizontal line cracks have been observed indicating that the grooves in other direction are also essential. From this, it is imperative that polymer fiber reinforced concrete should be laid in panels or grooves should be provided so that concrete acts like in panels. Cutting grooves is easy as it can be made after casting of the concrete. But it should not be delayed for long and should be made before concrete achieves its desired strength. The size of panels may be kept around 4m x 4m. Thus, fiber reinforced concrete has advantage over normal concrete particularly in case of cement concrete pavements. Polymeric fibers such as polyester or polypropylene are being used due to their cost effective as well as corrosion resistance though steel fibers also work quite satisfactorily for a long time. It appears that fiber reinforced concrete should be laid on base concrete of lean mix such as 1:4:8 cement concrete rather than over WBM and provided with grooves in panels of about 4m x 4m to avoid expansion/ contraction cracks. Grooves can be made after casting of concrete through cutters.

Applications of Steel Fiber Reinforced Concrete

It is known that plain cement concrete does not have good tensile properties to resist flexure in structural members. In case of concrete reinforcement steel, cracks still appear on the tension face due to bending. So, to prevent cracking of concrete, especially in the case of water retaining structures, or water transporting structures, it is advisable to design structural concrete as uncracked section. This results in heavy structural design with resulting in high cost. Steel fiber reinforced concrete is a low cost solution for uncracked section design of concrete members. Use of steel fiber reinforcement in concrete enhances the ability of structural members to carry significant stresses.

The use of fibers increases the toughness of concrete under any type of loads. Fibers in concrete has the ability absorb more energy. As recommended by ACI Committee 544, steel fiber reinforced concrete is used as supplimentary material to prevent cracking, to improve resistance to impact or dynamic loading and to prevent material disintegration. A guide to design of concrete structures with steel fiber reinforcement has also been published by American Concrete Institue. The applications of Steel Fiber reinforced concrete are for so varied and so widespread, that it is difficult to categories them. Following are the common applications of steel fiber reinforced concrete constructions:

- Tunnel linings
- Manholes,
- Risers,
- Burial Vaults,
- Septic Tanks,
- Curbs,
- Pipes,
- Covers,
- Sleepers
- Roller compacted concrete with steel fibers

Steel Fiber Reinforced Concrete Mix Preparation and Uses

Steel fiber reinforced concrete is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e. between 0.3% and 2.5% by volume in plain concrete. SFRC products are manufactured by adding steel fibers to the ingredients of concrete in the mixer and by transferring the green concrete into moulds. The product is then compacted and cured by the conventional methods. Segregation or balling is one of the problems encountered during mixing and compacting SFRC. This should be avoided for uniform distribution of fibers. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher. Use of pan mixer and fiber dispenser to assist in better mixing and to reduce the formation of fiber balls is essential. Additional fines and limiting maximum size of aggregates to 20mm
occasionally, cement contents of 350 kg to 550 kg per cubic meter are normally needed.

Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC

over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers. Plain, straight and round fibers were found to develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to increase with aspect ratio (ratio of length to equivalent diameter). Even though higher ratios of fibers gave increased flexural strength, workability of green SFRC was found to be adversely affected with increasing aspect ratios. Hence aspect ratio is generally limited to an optimum value to achieve good workability and strength. Grey suggested that aspect ratio of less than 60 are best from the point of handling and mixing of fibers, but an aspect ratio of about 100 is desirable from strength point of view. Schwarz however suggested aspect ratio between 50 and 70 is more practicable value for ready mix concrete. In most of the field applications tried out to date, the size of the fibers varies between 0.25 mm and 1.00mm in diameter and from 12mm to 60mm in length, and the fiber content ranged from 0.3 to 2.5 percent by volume. Higher contests of fiber up to 10% have also been experimented. Addition of steel fibers up to 5% by volume increased the flexural strength to about 2.5 times that of plain concrete. As explained above, mixing steel fibers considerably improves the structural properties of concrete, particularly tensile and flexural strength. Ductility and post cracking strength, resistance to fatigue, spalling and wear and tear of SFRC are higher than in the case of conventional reinforced concrete. SFRC is therefore found to be a versatile material for the manufacture of wide varieties of precast products such as manhole covers, slab elements for bridge decks, highways, runways, and tunnel linings, machine foundation blocks, door and window frames, piles, coal storage bunkers, grain storage bins, stair cases and break waters. Technology for this manufacture of SFRC light, medium and heavy duty manholes covers has been developed in India by Structural Engineering Research Centre, Chennai. Field experiments with two percent of fiber content indicated that SFRC runway slabs could be about one half the thickness of plain concrete slabs for the same wheel load coverage. Cement Research Institute of India (CRI) also demonstrated the use of SFRC in one of the jet bays at Delhi airport.

Preparation of Glass Fiber Reinforced Concrete (GFRC)

Glass fibers of 10mm to 50mm in length and a few microns in diameter can be added up to 5% by weight and premixed with cement and water in a pan or a paddle mixer. Small quantities of lubricating admixtures, such as polyethylene oxide or methyl cellulose may be added into the mix. The resulting mix may be sprayed or cast into the moulds. The products can also be produced either by extrusion or by injection-moulded process. In some of the processes, rovings can be chopped in-situ and sprayed simultaneously with a slurry of suitable consistency on a mould of production. This is very effective and convenient for casting shell roofs and sheets.

Properties of Glass Fiber Reinforced Concrete

Addition of glass fibres of about 10% by volume increased the tensile strength by roughly two times, and the impact resistance by about 10 times. The cyclic loading tests conducted on glass fibre cement laminates showed fatigue resistance of Glass fiber reinforced concrete (GFRC) roughly comparable with that of Steel fiber reinforced concrete (SFRC).

Uses of Glass Fiber Reinforced Concrete

Uses of glass fibers in concrete is very limited because they suffer severe damage and loss of strength due to abrasion and impact forces generated during movement of aggregates in mixer. Considerable attention has been paid for thorough understanding of the mechanical properties and performance characteristics of GFRC in the design of GFRC components. Several projects were reported for building wall panels made of GFRC in UK and USA. GFRC has also been used for repair works and for industrial floors in USA.

Applications of Glass Fiber Reinforced Concrete

The glass fiber reinforced concrete usually finds applications in following construction works:

- Building renovation works
- Water and drainage works
- Bridge and tunnel lining panels
- Permanent formwork method of construction
- Architectural cladding
- Acoustic barriers and screens

CHAPTER 4

EXPERIMENTAL WORK

Materials and Properties

Materials used for experimental study and their properties are given below.

Cement

Cement used for preparation of test specimen is OPC. They are used for producing high sterngth concrete. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. . Many tests were conducted on cement, some of them are consistency tests, setting tests, etc.as per Indian standard specifications.

PROPERTIES OF CEMENT

Properties Values ,Grade- 53 ,Specific gravity- 3.126, Fineness of cement -2% ,Standard consistency- 38%, Initial setting time- More than 52.38 mins

Sand

Good excellence river sand was used as a fine aggregate. Locally existing sand, authorizing to zone II with specific gravity- 2.45, water absorption- 2% and fineness modulus- 3.18, conforming to I.S. – 383-1970

Fine aggregate

The sand particles should pack to give minimum void ratio, higher voids content leads to the requirement of more water while mixing. In our present study the sand conforms to zone II as per the Indian standards.

PROPERTIES OF FINE AGGREGATE

Properties Values ,Specific gravity -2.73 ,Bulk density- 1.56kg/l ,Void ratio- 0.7492

Coarse aggregate

It should be hard, strong, dense, durable and clean. It must be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces are avoided as it increase the voids. Size of coarse aggregate used is 20mm

.

PROPERTIES OF COARSE AGGREGATE

Properties Value ,Specific gravity- 2.68, Bulk density- 1.46kg/l, Void ratio- 0.8146

Water

Water should be free from acids, oils, alkalies, vegetable matters or other organic impurities. Soft water also should be avoided as it produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement pastes are hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement. Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2000 is used.

Superplasticizer

Super plasticizers belong to a relatively new category and improved version of plasticizers. The use of super plasticizers allows the reduction of water to an extent of 20% without reducing workability. To obtain additional workability, a super plasticizer (CERAPLAST 400) was used. It is a high performance,

low dosage super plasticizer based on Melamine Formaldehyde Sulphonate (MFS). Ceraplast 400 disperses cement particles more rapidly in the concrete mix. When incorporated into the concrete, it improves the workability of the concrete without entraining air due to its excellent dispersion characteristics.

PROPERTIES OF SUPERPLASTICIZER

Properties Values ,Supply form- liquid ,Colour- transparent, Specific gravity- 1.3

- **The Properties of Glass Fibre**

Glass fibre is a material made up of several **fine fibres of glass**. The product is one of the most versatile industrial materials known today. It has comparable

mechanical properties to other fibres such as carbon fibre and polymers. Glass fibre is used as a **reinforcing agent** for many polymer products in order to form a very durable and lightweight material, known as **fibreglass**.

Fibreglass offers some unique advantages over other materials due to its **thickness, weight and strength**. With such a wide range of properties, the material can satisfy design and project objectives in many industrial applications.

➢ Properties of glass fibre

- **High tensile strength.** Glass has greater tensile strength than steel wire of the same diameter, at a lower weight.
- **Dimensional stability.** Glass fibre is not sensitive to variations in temperature and hygrometry. It has a low coefficient of linear expansion.
- **High heat resistance.** Glass fabrics retain 50% of room temperature tensile strength at 370°C, 25% at 480°C, a softening point of 845°C and a melting point of 1,135°C.

- **Good thermal conductivity.** Glass fibres are great thermal insulators because of their high ratio of surface area to weight. This property makes it highly useful in the building industry.
- **Great fire resistance.** Since glass fibre is a mineral material, it is naturally incombustible. It does not propagate or support a flame. It does not emit smoke or toxic products when exposed to heat.
- **Good chemical resistance.** Glass fibre is highly resistant to the attack by most chemicals.
- **Outstanding electrical properties.** Glass fibre has a high dielectric strength and low dielectric constant. It is a great electrical insulator even at low thickness.
- **Dielectric permeability.** This property of glass fibre makes it suitable for electromagnetic windows.
- **Compatibility with organic matrices.** Glass fibre can vary in sizes and has the ability to combine with many synthetic resins and certain mineral matrices like cement.
- **Great durability.** Glass fibre is not prone to sunlight, fungi or bacteria.
- **Non-rotting.** Glass fibre does not rot and remains unaffected by the action of rodents and insects.
- **Highly economical.** It is a cost-efficient choice compared to similar materials.

PHYSICAL PROPERTIES OF GLASS FIBER

Spesific Gravity	2.4-2.8
Bulk Density	2.53
Moisture Content(%)	Nill
Fine particles less than 0.075mm%	12-15

CHEMICAL PROPERTIES – GLASS FIBER

Conctituents	**Glass Fibre**
Silica(SiO_2)	72.5
Alumina(Al_2O_3)	1.06
Iron Oxide(Fe_2O_3)	0.36
Lime(CaO)	08
Magnesia(MgO)	4.18
Sodium Oxide(Na_2O)	13.1
Potassium Oxide(K_2O)	0.26
Sulphur Trioxide(SO_3)	0.18

The Properties of Steel Fibre

- Improve structural strength
- Reduce steel reinforcement requirements
- Improve ductility

- Reduce crack widths and control the crack widths tightly, thus improving durability
- Improve impact– and abrasion–resistance Improve freeze-thaw resis

MECHANICAL PROPERTIES OF STEEL FIBRES

Diameter	0.75MM
Length	60MM
Tensile Strength	1023MPa
Tolerance for Diameter and Length	(+)10%(As Per ASTM)

CHEMICAL PROPERTIES OF STEEL FIBRES

Chemical Composition of Mild Seel wire	Persentages (%)
C	0.074
Mn	0.36
Si	0.065
P	0.01
S	0.009

The tests have been performed to determine the mechanical properties such as compressive strength and splitting tensilestrength of concrete mix with steel fibers 0%, 0.5% by volume of concrete and alkali resistance glass fibers, 0.25% by weight of cement.

A. Compressive Strength Test

The quality of cement is normally characterized and controlled by the devastating quality of 150mm x

150mmx150mm, at an age of 7 and 28days. It is most regular test led on solidified concrete as it is a
simple test to perform and furthermore the vast majority of the attractive trademark properties of cement are subjectively identified with its compressive quality. Steel form made of cast iron measurement 150mm x 150mmx150mm utilized for throwing of solid 3D shapes loaded up with steel filaments 0%, 0. 5% by volume of cement and antacid opposition glass strands, 0% and 0.24% by weight of concrete. The shape and its base inflexibly damped together in order to decrease spillages during throwing. The sides of the shape and base plates were oiled before throwing to forestall holding between the form and cement. The solid shape was then put away for 24 hours undisturbed at temperature of l8°C to 22°C and an overall dampness of at the very least 90% (IS 516-1959).

It additionally expressed in IS 516-1959 that the heap was applied without stun and expanded consistently at the pace of roughly 140 Kg/sq cm/min until the obstruction of example to the expanding loads separates and no more prominent burden can be continued. The most extreme burden applied to the example was then recorded according to May be: 516-1959. The testing of shape and chambers under pressure were appeared.

The compressive quality was determined my estimating the compressive strength test on samples

Compressive quality (MPa) = Failure load/cross sectional
territory.

$\sigma = P/A$

Where,
P- Applied load
A- Cross-sectional Area.

Figure 1: Compression Test on Cube and Cylinders

B. Split Tensile Strength Test

The test was led according to IS 5816:1999 [23]. For rigidity test, round and hollow examples of measurement 100 mm breadth and 200 mm length were thrown. The examples

weredemoulded following 24 hours of throwing and were moved to restoring tank wherein they were permitted to remedy for 7 and

28 days. In every classification, three chambers were tried and their normal worth was accounted for [10]. The split strain test was led as appeared in figure 2 utilizing advanced pressure machine having 2000 kN limit.

Split rigidity was determined by conducting split tensile strength test.

$S = 2P/\pi DL$

Where,
P = Failure Load (kN)
D = Diameter of Specimen (100 mm)
L = Length of Specimen (200 mm)

Figre2. Cylinder under Split tension

C. Flexural strength Test

For flexural strength test beam specimens of dimension 100x100x500 mm are casted. The specimens are detached from the moulds after 24 hours of casting and are placed in curing tank for 7 and 14 days of curing. The flexural strength specimens are tested under three point loading as per I.S. 516-1959, over a load effective span of 400 mm on flexural strength testing machine. Load and corresponding deflections

are noted up to the failure of specimen. For each percentages of fibre content, three beams are tested and their average value is noted.


Fig.5. Specimen flexural strength test

CHAPTER 5

EXPERIMENTAL RESULTS AND DISCUSSIONS

A. Compressive Strength Test Results –

The compressive quality test is considering the most appropriate technique for assessing the conduct of steel fibre fortified cement for underground development at an early age, on the grounds that much of the time, for example, in burrows, steel fibre strengthened cement is essentially exposed to pressure. Compressive quality of control concrete and cement with different strands was determined by above equation according to I.S. 516:1959 [5]. It is seen that when strands in discrete structure present in the solid, spread of split is limited which is because of the holding of filaments in to the solid and it changes its fragile method of disappointment in to a progressively malleable one and improves the post splitting burden and vitality retention limit.

Consequences of compressive quality for M20 evaluation of cement on 3D shape and chamber examples with steel strands 0%, 0.5% by volume of cement and soluble base opposition glass filaments, 0.25% by weight of concrete was appeared in figure 3 as underneath.

Figure 3: Compressive Strength with Cube Samples

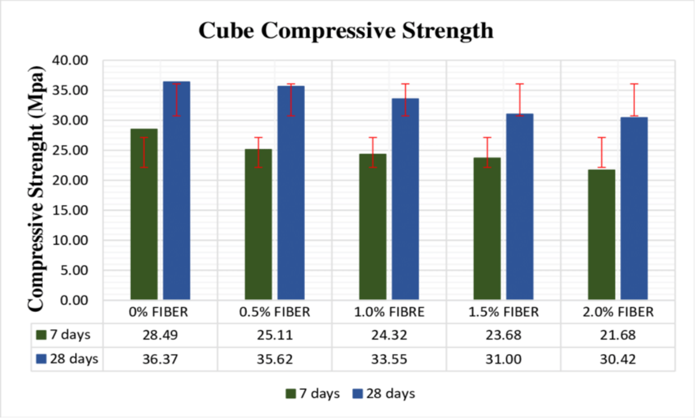


Fig3-shows the results of compression test on cube for M20 grade of concrete with many fibers at dissimilar volume fractions. It was detected that, adding of 0.5%, 50 mm length, steel fiber gives max compressive strength in calculation with all other fibers.

B. SPLIT TENSILE STRENGTH RESULTS

Under hub pressure, control solid specimen split into two sections, yet FRC example shows upgrading of disruptions along its longitudinal axis. This might be credited to the way that filaments choke the control of small-scale disruptions and thus the pure elasticity of the grid increases.

Test Results of parting elasticity for M20 evaluation of cement with steel and glass strands for given volume divisions as appeared in figure 4 bellow.

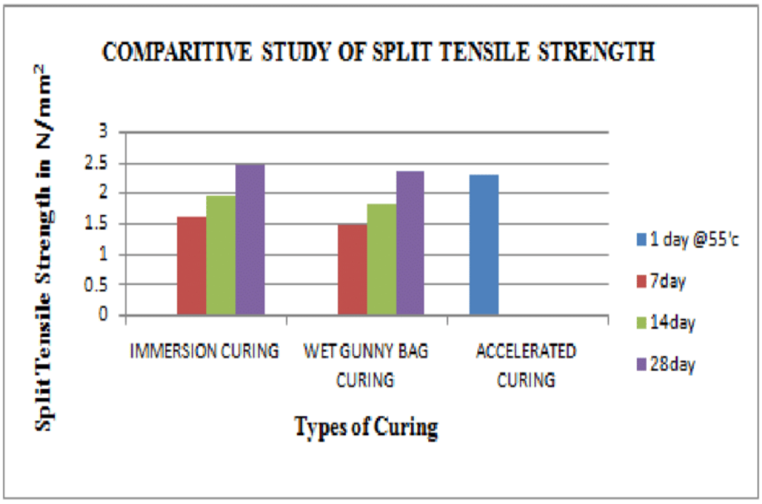
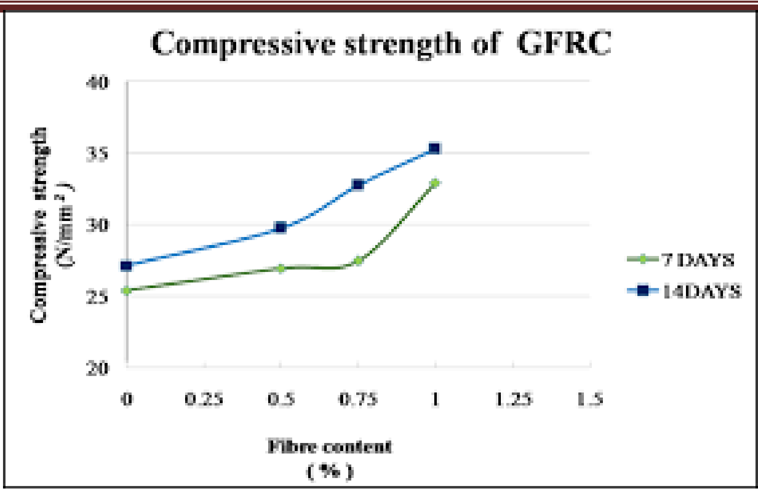
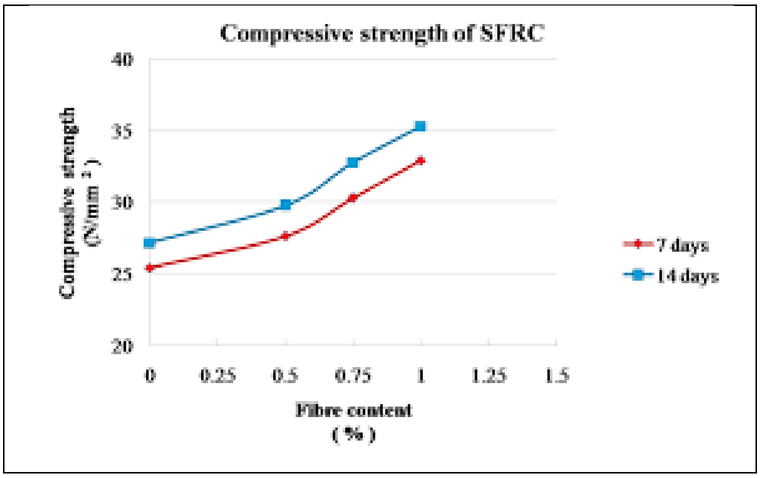
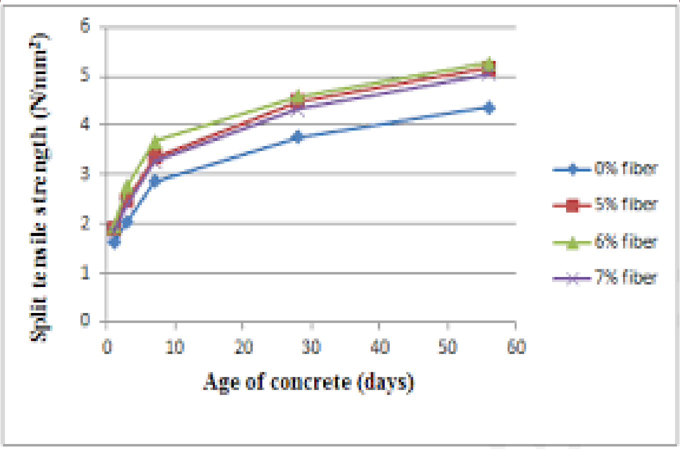


Figure 4 demonstrates the consequences of split elasticity for M20 evaluation of solid utilizing different filaments at various volume divisions.

It was seen that expansion of 0.5%, 50 mm length, snare end steel filaments invigorate max split pliable in examination with every single other fibre.


Compressive strength of GFRC
Compressive strength (N/mm²)
40
35
30
25
20
0
0.25
0.5
0.75
1
1.25
1.5
Fibre content (%)
7 DAYS
14DAYS


Compressive strength of SFRC
Compressive strength (N/mm²)
40
35
30
25
20
0
0.25
0.5
0.75
1
1.25
1.5
Fibre content (%)
7 days
14 days



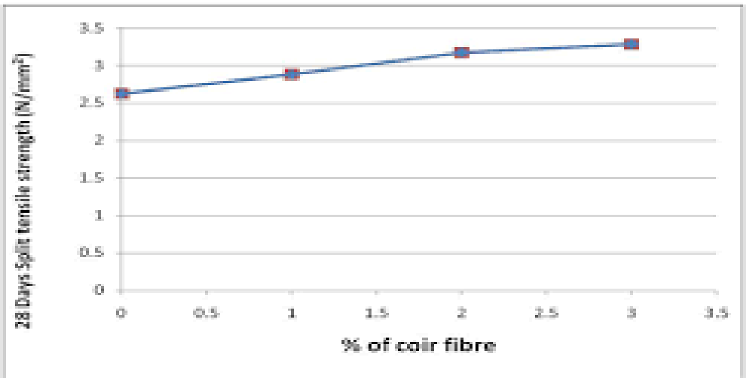
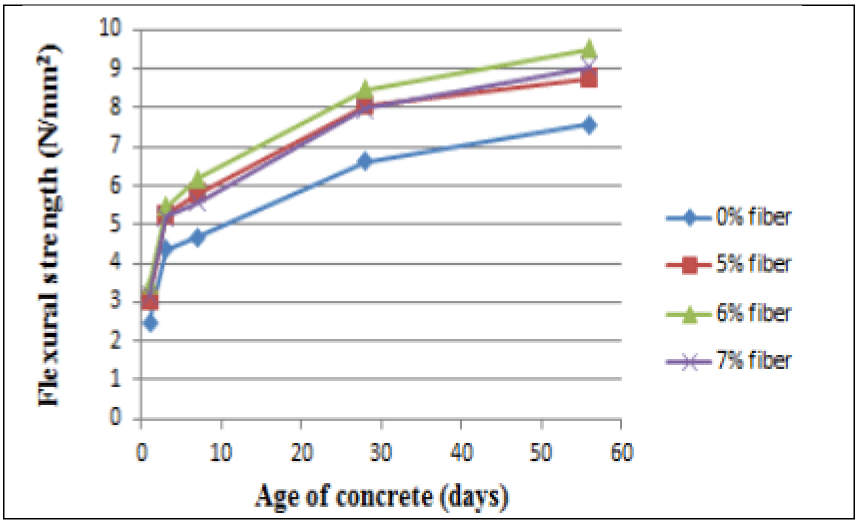


Fig. 6.3 Split Tensile Strength Test on Coir Fiber Reinforced Concrete



BENEFITS OF STEEL AND GLASS FIBER IN REINFORCE CONCRETE

BENEFITS OF FIBER IN REINFORCED CONCRETE

Highly durable and safeDesign freedom since GFRC is able to be molded into almost any shape and color

Requires very low maintenance

Installation is quick and cost effective

Weather and fire resistant

Economical Energy efficient

BENEFITS OF STEEL FIBER IN REINFORCED CONCRETE

Steel Fiber Reinforced Concrete distributes localized stresses.

Reduction in maintenance and repair cost.

Provides tough andurable surfaces.

Reduces surface permeability, dusting and wear.

Cost saving.They act as crack arrestor.Increases tensile strength and toughness.

Resistance to impact.

CHAPTER6

CONCLUSIONS

The study on the effect of fibers with properties can still be a promising work as there is always a need to overcome the badlybehaved of brittleness of concrete. The paper obvious that the adding of steel fibers at 0.5% by volume of concrete decreases the cracks under different loading situations.

The brittleness of concrete can also be better-quality by addition steel fibers than glass fibers. Since concrete is very weak in tension, the steel fibers are helpful in axial-tension to increase tensile strength.

The following decisions could be drawn from the current investigation.

1. Max compressive strength for M20 grade of concrete was got by addition of 0.5%, 50mm length, steel fibres.
2. Max split tensile strength for M20 grade of concrete was obtained by adding of 0.5%, 50 mm length, steelfibres.
3. Ratio of compressive strength of cylinders to the compressive strength of cube was found to be closely 3/4.
4. Workability of concrete pretentious by addition of fibers. Adding of fibre decreases workability of concrete in contrast to other fibers for dissimilar volume fraction

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