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STRENGTH OF CONCRETE REINFORCED WITH FIBRES

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Abstract: *Fiber reinforced concrete (FRC) is a structural material which is most widely used in construction practices. Adding of fiber reinforcement in discrete form improves properties and parameters of concrete i.e. tensile strength, flexural strength, toughness and ductility etc.*

Fiber reinforced concrete has been successfully used in tunnel, concrete slab, bridge deck, seismic regions, thin and thick repairs, concrete pads, footings, hydraulic structures and precasting of the material etc. The application of FRC is for excellent performance to increase structural integrity of structure.

It is economical, high modulus of elasticity, does not rust nor corrode and requires no minimum cover, ideal aspects ratio, easily placed and sprayed, increased the static and dynamic tensile strength and better fatigue strength.

Keywords: Fibre reinforced concrete (FRC), Compressive strength test and compressive strength.

1. INTRODUCTION

Fiber-reinforced concrete (FRC) is a composite or structural material which consists of mortar, cement paste, or concrete with fibres of asbestos, glass, carbon, plastic, or steel which increases its structural integrity. It include steel fibres, natural fibres, synthetic fibres and glass fibres. It is also used to control cracking due to plastic and drying shrinkage in the concrete. Using FRC there is reduce impermeability, bleeding of water, shrinkage crack, and they are not replace structural steel some fibre have greater impact, shatter resistance, and abrasion in concrete.

Fibres is an ideal ingredient for increase the durability of concrete and mortar. It also increase fire resistance and energy absorption. The addition of small fibre, closely spaced fibre, and uniformly dispersed fibres in concrete plays the role of the cracker, substantially and arrester its static and dynamic properties.

Fig-1: Fibre reinforced concrete

It is better to minimize cavitation damage in structures and it is used to avoid corrosion at the maximum level. It is used in tunnels, bridges to reduce compressive strength of concrete and remove failure of the structure. It is discontinuous, discrete, dispersed fibres, uniform .women fibres, Continuous meshes, long wires or not discrete fibres.

Types of fibres

1. Glass fibres:

Glass fibre is a material consisting of numerous fine fibres of glass. It is sustainable, minimal maintenance, electrical insulation and easy to work with it.

Fig 2: Glass fibre

Benefits of Glass Fibres

1. It Improve concrete strength at low cost and at low weight also.
2. It's tensile strength is in all directions
3. It's decorative look as they are visible in the finished concrete surface
4. It has Great Strength and corrosion free.

2. Steel fibres:

Steel fibres is defined ratio of short length of steel to its length. The range of cross-section 20 to 100mm. It is small and dispersed randomly in fresh concrete mix using conventional mixing procedure. It reduces cracks and minimizes the steel reinforcement.

Fig 3: Steel fibre

Benefits of steel fibre

1. It reduces steel reinforcement requirements.
2. It reduces crack widths and control the crack widths tightly.
3. It Improves freeze-thaw resistance of concrete.
4. Steel fibres are more economical design alternative.

3. Carbon fibres

Carbon fibre is made of strong crystalline filaments of carbon about 5-10 micrometre in diameter. It can be thinner than a strand of human hair. It is composed of carbon atom and it combined with other material to form composite which have very heat tolerance.

Fig 4: Carbon fibre

Benefits of Carbon Fibres

1. It has low density
2. It has high strength
3. It has corrosion resistance
4. It has thermal and electrical and conductivity.
5. It has low weight.

4. Cellulose fibres

Cellulose fibres are fibres made up of the ethers or esters of cellulose. It can obtained from the bark, wood or leaves of plants.

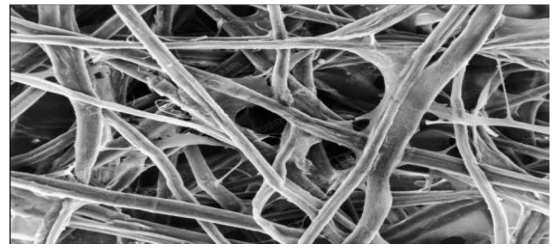

Fig 5: Cellulose fibres

Benefits of Cellulose Fibres

1. It has fire resistance.
2. It reduces the noise.
3. It prevents moisture issues.
4. It is glycogen and starch structure.

5. Synthetic fibres

Those fibres which are made from natural materials (rayon, acetate from cellulose or regenerated protein fibres from zein or casein) are known as synthetic fibre.

These are divided into two parts are given below:

1. Polypropylene Fibres

2. Nylon Fibres

Fig 6: Synthetic fibre

6. Natural Fibres:

Natural fibre is a hairlike raw material directly obtainable from an animal, vegetable, or mineral sources. These are convertible into nonwoven fabrics such as after spinning into yarns and into woven cloth.

Fig 7: Natural Fibres

Benefits of Natural fibre

1. It has high tensile strength.
2. It has low thermal expansion.
3. It has high chemical resistance.
4. It has high temperature tolerance

History of fibre reinforced concrete (FRC): In ancient time, horse hair, straw was used in mortar, mud bricks respectively to increase the strength of brick. In the 1900s, asbestos fibres were used in concrete but in 1911, Porter found that fibre could be used in concrete. In the year 1950 this fibre reinforced concrete becoming interesting and health risk association were discovered as a fibre reinforced concrete is a composite material. In 1960 there was a small change by using some substances that were used in concrete that was steel, glass (GFRC), and synthetic (such as polypropylene) fibres.

Fibre are used in reduce permeability, reduce bleeding of water and control cracking due to plastic and drying shrinkage in concrete. In tunnel structures fibre reinforced concrete is used in tunnel linings in form of lieu in rebar, apart from this some fibres are used in reduce the compressive strength of concrete. Concrete and reinforced material have same strain.

Necessity of FRC: In concrete it is used as a structural material to reduce the brittleness, poor tensile strength and resistance to impact strength, fatigue, low ductility, durability and receive dynamic stresses caused due to explosions. The brittleness is set off in structural member by the introduction of reinforcement (or) pre-stressing of steel in the tensile zone. Reinforced concrete improve the low tensile strength, high strength but it never improve the basic properties of concrete. Concrete is deficient in ductility, resistance to fatigue and impact also. The importance of rendering requisite quantities in concrete is increasing with its varied and challenging applications in pre-cast and pre-fabricated elements of buildings. The development characteristics of concrete will solve the problems of structural engineers by the addition of fibres and admixtures to it. The role of fibres are essentially to arrest any advancing cracks by applying punching forces at the rack tips, thus delaying their propagation across matrix. The ultimate cracking strain of the composite is thus increased to many times greater than that of the unreinforced matrix. Admixtures like fly ash, silica fume, blast furnace slag and metakaolin can be used for such purposes. However addition of fibres and mineral admixtures poses certain problems regarding mixing, as fibres tends to form balls and workability tends to decrease during mixing procedure.

3. MATERIALS USED

Materials needed for Fibre Reinforcement cement concrete are cement, fine aggregate, coarse aggregate, Fibres and water.

3.1 Cement: Cement is a binder, a substance that sets and harden and bind other materials together. The cement used in this experimental work is OPC43.

Table -1: Properties of cement

Sl.No.	Property	IS recommendation
01.	**Specific Gravity**	**3.17**
02.	**Consistency**	**57**
03.	**Initial Setting Time**	**30 minutes**
04.	**Final Setting Time**	**10 Hours**

3.2 Sand: Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by the size, being finer than gravel and coarser than the silt.

3.3 Glass fibres: Glass fibre is a material consisting of numerous fine fibres of glass. It is sustainable, minimal maintenance, electrical insulation and easy to work with it.

Benefits of Glass Fibre

- It improves concrete strength at low cost and at low weight also.
- It give tensile strength is in all directions
- It's decorative look as they are visible in the finished concrete surface
- It has Great Strength and it is corrosion free.

3.4 Coarse Aggregate: Aggregates are the most mined materials worldwide. Aggregates are the component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

Table -2: Properties of FA, CA, CS

S.No	Properties	FA	CA	CS
01.	Specific Gravity	2.637	2.713	3.683
02.	Fineness Modulus	3.241	7.428	3.436

3.5 Water: Water is an important ingredient of concrete as it actively participates in chemical reaction with the cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to become very important.

4. METHODOLGY

M25 grade of concrete is designed in accordance with the guidelines of IS code 10262:2009 with replacement of fine aggregate by copper slag.

Praveen Reddy and Dr. Archanaa Dongre had specified that the mixing of fibre reinforced concrete most balling occurs during the fibre addition process. Increase of aspect ratio, volume percentage of fibre, size, quantity of coarse aggregate will intensify the balling tendencies and decrease the workability of concrete. To coat the large surface area of the fibres with paste, minimum cement content of 400 kg/m^3 and water cement ratio between 0.4-0.6 are required.

Fibre reinforced concrete mixes are generally characterized by higher cement factor, higher fine aggregate content and smaller size coarse aggregate. A fibre mix generally requires more vibrations to consolidate the mix. External vibration is preferable to prevent the fibre segregation. Metal trowels, tube floats, and rotating power floats can be used to finish the surface of the concrete.

4.1 Tests Conducted

A. Compressive Strength Test

One of the most important properties of the concrete is the measurement of its ability to withstand the compressive loads. This load withstand capacity is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is to apply a load at a constant rate on a cube (having dimensions 150×150×150 mm), until the sample fails. The compression tests performed in this were completed in accordance with IS code 516 “Methods of Tests for Strength of Concrete”. For this study samples were tested for compression testing at 28 days of curing.

5. RESULTS AND DISCUSSION

5.1 Compressive Strength:

The improvement of compressive strength values occurred 0 to 15 percent of the fibre.

Normal concrete is a brittle material and there is an adverse relation between strength and ductility. To overcome this problem, fibers are used. This is due to its effect in delaying and controlling the crack propagation. In 1990 there was a test that the mixing of fibers in concrete reduce the probability of explosive spalling in fire. It has been found that when polypropylene fiber high strength concrete is heated up to 170 °C, fibers readly melt and volatillse, creating additional porosity and small channels in the concrete. Mechanical tests showed small changes in compressive strength, modulus of elasticity and splitting tensile strength that could be due to the polypropylene fiber melting. Bing Chen and Juanyu Liu studied the residual strength of hybrid fiber reinforced high strength concrete after exposure to the high temperatures. The results showed that the normal high strength concrete (HSC) is prone to spalling after exposure to high temperatures, and the first spalling occurs when the temperature approaches to 400 °C. For HSC reinforced by high melting point fibers, the first spalling occurs when the temperature reaches to approximately 800 °C, while there is no spalling during exposing to high temperature for HSC reinforced by polypropylene (PP) fiber with a low melting point. Mixing high melting point fiber (i.e. carbon or steel fiber) with low melting point fiber (i.e. PP fiber), HSC greatly improves the properties of HSC after exposure to high temperatures. C. S. Poon, Z. H. Shui and L. Lam studied the compressive strength of fiber reinforced on high-performance concrete is subjected to elevated temperatures. The result that after exposure to 600-800 °C the concrete mixes retained, 23%-45% of their compressive strength, on average, the results also that steel fibers were effective in minimizing the degradation of compressive strength.

5.2 Modulus of elasticity:

A modulus of elasticity is a quantity that measures a material being deformed elastically on application of stress. The elastic modulus of a material is defined as the slope of stress–strain curve in the elastic deformation region.

Modulus of elasticity of Fibre reinforced concrete increases slightly with fibers content. Its range increases from 1%-3% increase in fiber content by volume in fibre content in the modulus of elasticity. In stiffer concrete elastic modulus is higher.

5.3 Flexure Strength:

The flexural strength of fibre reinforced concrete is increased by 2.5 times using 4% fibers at constant aspect ratio 70. It is increasing from 0.5% to 2.5% of fibre content. In this flexural strength is increased from 29.2% to 119.69% as compared to plain concrete. In this there is a increase of tensile strength, ductility, moment capacity, stiffness, fibre improve crack and preserve post cracking intergrity of the member.

5.4 Impact resistance:

Drop weight impact machine is an instrument that was used to carry out compressive impact tests on various Fibre reinforced concrete systems with compressive strengths range 60 MPa -120 MPa.

The impact strength for fibrous concrete depend on volume of fibre and it is generally 5-10 times that of plain concrete. Fibre reinforcement concrete changes under the static compressive loading and the toughness is increases in plain concrete.

5.5 Torsion:

Torsion strength is defined as the use of fibers suddenly failure characteristic of plain concrete beams. In this there is increases in stiffness, torsional strength, ductility, rotational capacity, number of cracks with less crack width of concrete member.

5.6 Shear:

When fibre is added to the reinforced concrete the shear capacity of beams is increases up to 100 % and when we add the fibre randomly fibers increases shear-friction strength, crack strength, and ultimate strength also.

5.7 Cracking and deflection:

Deflection and cracking is controlled by reinforcing the fiber to the concrete. By adding fibre to the concrete the strength and stiffness is improved. The adding of fibre in concrete increases the strength ductility and remove the cracking and reduce deflection.

6. CONCLUSIONS

Fiber reinforced concrete pavements prove to be more efficient than conventional RC pavements, in several aspects. The total energy absorbed for fiber-reinforced concrete measured by the area under the load-deflection curve is at least 10 to 40 times higher than that of plain concrete. Compressive strength for fibre reinforcement concrete can be improved significantly.

Compressive strength for fibre reinforced concrete is seen to be improved. It can be clearly seen that strength at 28 days Compressive strength for fibre reinforced concrete is seen to be improved.

Fibers are usually used in concrete to control cracking due to plastic shrinkage and too drying shrinkage. They also reduce the permeability of concrete and thus reduce the bleeding of water, increases fluxual strength, tensile strength, durability, protective corrosion, and decrease cracking and deflection.

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