FIBRE REINFORCED CONCRETE (FRC)

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ABSTRACT

Fibre Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with a known or unknown distribution of fibre which can be steel, nylon, polythene etc. The addition of these fibres enhance the properties of concrete like flexural strength, impact strength, tensile strength, resistance to spitting and excellent permeability and frost resistance. FRC is known to provide good resistance to plastic shrinkage and has a proven record in the building industry particularly with slab-on-grade application development .The addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack resistor and would substantially improve its properties. If more than one type of fibre in concrete is known as Hybrid Fibre Reinforced Concrete. In ordinary concrete, micro-cracks develop before structure is loaded because of drying shrinkage and other causes of volume change. When the structure is loaded, the micro cracks open up and propagate because of development of such micro-cracks, results in inelastic deformation in concrete. By using Fibre Reinforced Concrete durability is improved by reducing the crack widths. Polypropylene and Nylon fibres are more often used to improve the impact resistance. They improve water migration and aid reduction in corrosion of steel reinforcement (FRC) mixes generally can be poured or sprayed.

Keywords*: Fibre Reinforced Concrete, flexural strength, impact strength, tensile strength, micro cracks, permeability, frost resistance, Polypropylene and Nylon*

INTRODUCTION

Fibre reinforced concrete is a type of concrete that includes fibrous substances that increase its structural strength and cohesion. Fibre reinforced concrete has small distinct fibres that are homogeneously dispersed and oriented haphazardly. Fibres used are steel fibres, synthetic fibres, glass fibres, and natural fibres. The characteristics of fibre reinforced concrete are changed by the alteration of certain factors including type and quantity of fibres, geometric configuration, dispersal, direction, and concentration. Concrete in general has a higher brittleness with increase in strength. This is a major drawback since brittleness can cause sudden and catastrophic failure, especially in structures which are subjected to earthquake, blast or suddenly applied loads i.e., impact. This serious disadvantage of concrete can at least partially be overcome by the incorporation of fibres, especially, steel. The incorporation of fibre can cause a change in the failure mode under compressive deformation from brittle to pseudo-ductile, thereby imparting a degree of toughness to concrete. After the reinforcement of concrete by steel, it becomes a composite group in which the steel endures the tensile stresses.

When concrete is reinforced by using fibre in the mixture, it further increases the tensile strength of the composite system. Research has revealed that the strength of concrete can be improved tremendously by the addition of fibre reinforcing. Since the stretching ability under load of reinforcing fibre is greater than concrete, initially the composite system will function as un-reinforced concrete. However, with additional loading the fibre reinforcing will be activated, to hold the concrete mix together. Fibres of different types have been used for concrete reinforcement since long time though technology has improved significantly, as is applicable for other fields. In the early age, straw and mortar were used for producing mud bricks, and horsehair was used for their reinforcement. As the fibre technology developed, cement was reinforced by asbestos fibers in the early twentieth century. During the middle of the twentieth century, extensive research was in progress for the use of composite materials for concrete reinforcement. Later, the use of asbestos for concrete reinforcement was discouraged due to the detection of health risks. New materials like steel, glass, and synthetic fibres replaced asbestos for reinforcement. Active research is still in progress on this important technology. Fibre Reinforced Concrete is considered to be one of the greatest advancements in the construction engineering during the twentieth century.

Types of Fibre Reinforced Concrete

There are generally four fiber reinforced concrete types:

- 1) *Steel Fibre Reinforced Concrete*
- 2) *Synthetic Fibre Reinforced Concrete*
- 3) *Glass Fibre Reinforced Concrete*
- 4) *Natural Fibre Reinforced Concrete*

1). STEEL FIBRE REINFORCED CONCRETE

Steel (welded wire mesh) fiber reinforced concrete is practically, an easier and cheaper alternative to rebar reinforced concrete that use steel bars for reinforcement. These steel bars are laid in the concrete mass when it is still wet. It requires a lot of work but the result is a very strong concrete. Steel fiber reinforced concrete is the result of replacing steel bars with steel wires. These thin steel wires are mixed in the concrete composition in the same time with the Portland cement. Your concrete will have an outstanding structural strength and will be more protected against extreme cold. Steel fibres increase also, the bending of the concrete, its ductility and they have a great impact resistance and crack control. However, steel fiber is very often used mixed with steel rebar in the concrete composition.The applications of steel fibre reinforced concrete have been varied and widespread, due to which it is difficult to categorize. The most common applications are tunnel linings, slabs, and airport pavements. Many types of steel fibres are used for concrete reinforcement. Round fibres are the most common type and their diameter ranges from 0.25 to 0.75 mm. Rectangular steel fibres are usually 0.25 mm thick. Deformed fibres in the form of a bundle are also used. The main advantage of deformed fibres is their ability to distribute uniformly within the matrix. By using steel fibres the Flexural-strength can be increased of up to 3 times more compared to conventional concrete. 1.5 times increase in fatigue strength is also achieved. Impact resistance is also increased.

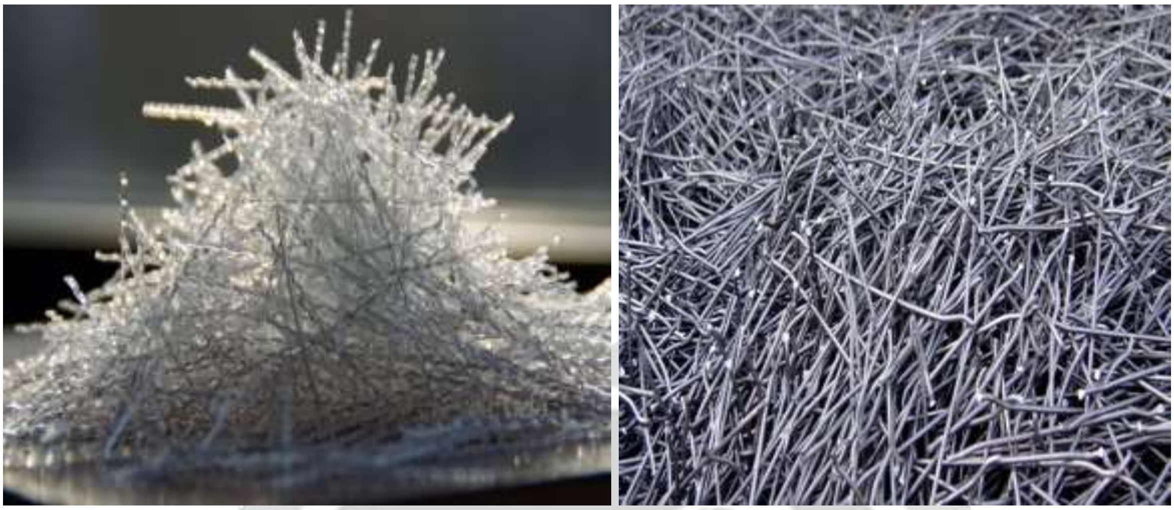

FIG.1. Different types of steel fibres

Though steel fibre reinforced concrete has numerous advantages, it has certain concerns that are yet to be resolved completely.

- There are complications involved in attaining uniform dispersal of fibres and consistent concrete characteristics. In fact uniform composition is rare to have.
- The use of SFRC requires a more precise configuration compared to normal concrete.
- Another problem is that unless steel fibers are added in adequate quantity, the desired improvements cannot be obtained.

However, as the quantity of fibres is increased, the workability of the concrete is affected. Therefore, special techniques and concrete mixtures are used for steel fibres. If proper techniques and proportions are not used, the fibres may also cause a finishing problem, with the fibres coming out of the concrete.

3).GLASS FIBRE REINFORCED CONCRETE

Glass fibre reinforced concrete is another type of reinforced concrete especially used as façade panels for residential and commercial buildings. This type of reinforced concrete is made by adding glass fibres in the concrete mass. These fibres are similar with the fibers from fiberglass insulation, therefore these fibreglass will make the concrete much stronger and plus will insulate it. More than that, steel fiber interferes with radio signals while glass fibre does not. Glass fibre consists of 200-400 individual filaments, lightly bonded in order to form a stand. These stands can then be chopped into various lengths and be used for a variety of applications. The main industrial application of glass fibres is cement or mortar matrices reinforcing, used for thin-sheet products manufacture. The conventional mixing techniques for concrete only allow about 2% (by volume) of fibres of a length of 25mm to be used. The most common type of glass fibres used for general applications is e-glass. Polymers or other materials may also be added in the glass fibre mixes in order to improve physical properties.

FIG.2. Different types of glass fibres

Glass Fibre Reinforced Concrete (GFRC) is likely to function better due to the absence of steel reinforcement that may corrode. GFRC has the characteristics to be cast into almost any shape.

GFRC consists of materials that are unlikely to burn. The concrete takes the role of a thermal regulator while exposed to fire and protects the materials from the flame heat. GFRC is thin and strong, with weight being 75% to 90% less compared to solid concrete. Less weight facilitates easy and rapid installation, and also decreases the load applied on the structure. The light weight and tough material also minimizes the transportation expenditures, permits flexibility in design, and reduces the impact on environment. GFRC is less vulnerable to weather effects and more resistant to freeze thaw than the normal concrete. The elasticity and density of the GFRC is greater than precast concrete.. The glass fibres included to reinforce the concrete produce considerably greater impact strength and lower permeability to water and air than precast concrete. GFRC looks like a natural stone and permits the designer greater flexibility in form, color, and texture.

2).SYNTHETIC FIBRE REINFORCED CONCRETE

Synthetic fibre reinforced concrete consists of concrete mixed with nylon and plastic fibres. They improve quite significantly the concrete strength. The use of steel fibre reinforced concrete in residential building construction has been on the decline for the last decade. More contractors switch their preferences to synthetic fibre reinforced concrete, which quickly became a substitute for welded wire mesh reinforced concrete in residential building slabs. They do not expand or contract as steel fibre to temperature changes. That prevents synthetic fibre reinforced concrete to crack. Obviously, synthetic fibres are not so strong as steel fibres but they improve a lot the cement pump ability and will keep the concrete to stick in the pump pipes. Synthetic fibres have three-dimensional reinforcing with enhanced flexural, toughness, impact and abrasion resistance and will also help mitigate the formation of plastic shrinkage cracking in concrete.

FIG.3. BENTO-FIBRE(most commonly used synthetic fibre)

Synthetic fibres are man-made fibres resulting from research and development in the petrochemical and textile industries. There are two different physical fibre forms: monofilament fibres, and fibres produced from fibrillated tape. Currently there are two different synthetic fibre volumes used in application, namely low-volume percentage (0.1 to 0.3% by volume) and high-volume percentage (0.4 to 0.8% by volume). Most synthetic fibre applications are at the 0.1% by volume level. At this level, the strength of the concrete is considered unaffected and crack control characteristics are sought. Fibre types that have been tried in concrete matrices include: acrylic, aramid, carbon, nylon, polyester, polyethylene and polypropylene. The characteristics are depending on the types of synthetics used to reinforce with polymer concrete. Different fibres have different properties. Adding carbon fibre decreased the unit weight of polymer concrete. Carbon fibre provides much higher compressive strength, flexure strength and ductility of polymer concrete. PVC and polypropylene fibers did not significantly influence the compressive strength and gave the lowest pulse velocities and modulus.

4).NATURAL FIBRE REINFORCED CONCRETE

Different kinds of natural fibres have been used as reinforcement such as hair, hay, coconut, plantain (banana), sugarcane, sisal, jute, bagasse, palm, etc. , until recently too little scientific effort has been given in the development of a technology capable of using these natural fibres on an industrial scale. However, naturally available fibres that can be used as reinforcement create a low-cost reinforced concrete. Potential use of natural fibre reinforced concrete in the application of natural fibres has long attracted the attention of researchers. Various researches has been conducted in many countries for a variety of mechanical properties, physical performance and durability of materials reinforced by natural fibres. Natural fibre reinforced concrete is essentially a special concrete where it contains fibres with a small diameter, independently and randomly distributed in the cement matrix. Uniform distribution in the cement matrix, contributing to an increase in the tensile and resistance to cracking , impact and improved the ductility values for the good aspects of energy absorption. Although many types of fibres were used as reinforce material in concrete, the use of natural fibres had long been in existence and there is a lot of evidence of the usage of these fibres in the history of civilization. Nature has given human the fibre reinforced material in the form of wood, bamboo and other plants. The use of straw in mud bricks and horse hair in the mortar has the potential of natural fibres.

FIG.3. Natural fibres(coconut hair and jute)

Only in the late 1960s and early 1970s, research began to study the potential use of various types of natural fibres as reinforcement material in the slab concrete and cement-based composite materials. Natural fibre reinforced cement or concrete products that use fibers such as coir, sisal, sugar bagasse, bamboo and so on have been produced and tested in more than 40 countries. For economic reasons in developing countries where natural fibres are so much available, it is demanding for construction industry players to enhance the usefulness of these resources in an effective and economical as to introduce composite materials for residential use and others.Basic needs use of natural fibres as reinforcement material in concrete matrix is tensile strength and high elastic modulus, the bond between the matrix and fibre, good chemical composition, stable geometry and good durability.

CONCLUSION:

Fibre addition improves ductility of concrete and its post-cracking load-carrying capacity. Fibre reinforced concrete requires large quantities of fibres in order to make a difference regarding resistance. Fibre addition improves ductility of concrete and its post-cracking load-carrying capacity. There has been significant interest and development in the use of continuous fibre reinforcement for improving the behavior of concrete. Fibre Reinforced Polymers (FRP) or sometime also referred to as Fibre Reinforced Plastic are increasingly being accepted as an alternative for uncoated and epoxy-coated steel reinforcement for pre-stressed and non-Pre-stressed concrete applications. Plain concrete fails suddenly once the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand, fibre-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete. In FRC crack density is increased, but the crack size is decreased. The addition of any type of fibers to plain concrete reduces the workability. FRC is generally made with a high cement content and low water/cement ratio .Steel fibres reinforced concrete act against impact forces, thereby improving the toughness characteristics of hardened concrete. The largest application for steel fibre reinforced concrete is floor slab construction; although it is used as a replacement or complement to structural reinforcement in other applications is growing fast. Slump tests were carried out to determine the workability and consistency of fresh concrete. The efficiency of all fibres depend upon achievement of a uniform distribution of the fibers in the concrete, their interaction with the cement matrix, and the ability of the concrete to be successfully cast or sprayed.

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