

INFLUENCE OF PROPERTIES OF COMMONLY USED TEXTILE FIBRES IN VARIOUS CIVIL APPLICATIONS – A REVIEW

¹Sr. Prof. Dr. P. A. Khatwani, ²Unnati S. Thakor

¹Senior Professor, ²Ph.D scholar

¹Department of Textile Technology

¹Sarvajani College of Engineering & Technology, Surat, India

Abstract: TRC (Textile reinforced concrete) is like a whiz in the Civil Construction Market. From many years, research and developments are going on for introducing fibres into the various applications to get the best results. People have started using textile fibres successfully in many of the application like fibre reinforced concrete, fibre reinforced plastic, medical textile, geo textile etc. In fibre reinforced concrete, the conventional concrete nature is to shrink as soon as it dries and the product changes its volume and starts generating minor cracks. Since, the water content inside the product had evaporated leaving the pores inside it into a minor crack. So, with the use of textile fibres it will be possible to some extent to reduce crack by evenly distributing fibres in the concrete mixture. The addition of fibres upto some extent will increase the tensile and compressive strength. However, different fibres provide different properties based on their nature. In this paper, we will study how different fibres like Polypropylene, Steel, Nylon, Acrylic, Carbon and Glass along with their properties and will compare them to understand that which fibre suits best for particular application. Also we will discuss about the best performer fibre that can be used for any particular end use for civil application.

IndexTerms: TRC, textile reinforced concrete, fibre reinforced concrete, civil construction application.

I. INTRODUCTION

From many years we have been using concrete structures with their positive properties of strength and stiffness, but their weight is very high and the use of Metal or steel bars have limitation because of their size and shape in concrete products. Also, the reinforcing steel bars are subjected to corrosion which can cause destruction of the concrete by reducing effective cross sectional area of the bar and increasing the stress in the concrete structure. Alternatively, to replace steel reinforcement many of the textile materials are used as reinforcement, which results in increase in their durability and reliability of civil construction application. Textile materials are widely used in various fields of civil construction application including fibre, yarn and fabrics ^[1]. After many research it has been found that the use of particular textile fibres concrete mixture leads to increase in its strength. The textile reinforced concrete (TRC) will help to reduce the drawback of conventional concrete mixture. We also want you to take a note on properties of the fibres which are widely used in the Civil Construction Applications. As suppose some fibres are water absorbent while some doesn't absorb water like Polypropylene, which in turn affects the products of the civil. The end use of all the civil products are different, so obviously using particular fibre is like having limited properties for particular product. So this paper mostly focuses on to the properties of fibres which will help to choose the fibres wisely for particular applications based on their end uses. Before going into the fibre details we also want to focus on drawback of concrete mixture as mentioned below.

II. DRAWBACK OF CONCRETE MIXTURE AND NEED FOR THE USE OF TEXTILE FIBRES IN CIVIL APPLICATION

The concrete mixture though has a very good strength, but due to metal bars inside its structure as stated above causes corrosion. The nature of concrete mixture is to get brittle as soon as it dries resulting into cracking with minimal amount of load and as the load increases it will break very easily. Since, they already had got minor crack inside it they will automatically loses its strength once more load will be applied on it. We can say that the use of textile fibres will help to reduce crack formation and increases their life and their use-ability of the civil products. Again, different types of fibres have different properties, many kinds of fibers including metallic or polymeric is widely used in concrete applications for their advantages of anti-corrosion, light weightiness and to get desired shapes. There are several properties that a good reinforcing fiber must have which influence the mechanical behaviour of fiber-reinforced concrete like its tensile strength, ductility, high elastic modulus, elasticity, and Poisson's ratio. Also fibers must be much stronger than the concrete matrix in tension, since the load bearing area is much less than the matrix^[2]. The fibre's ability as a best performer in cement based composites is proved only when the mechanical behaviour increases, especially when the low modulus and low cost yarns are concerned.

III. TEXTILE FIBRES WITH THEIR PROPERTIES AND THEIR EFFECT IN CIVIL APPLICATIONS

Research and development is still going on with number of the fibres for reinforcing in civil construction application. We will focus on some of the Synthetic fibres with their properties which are mostly used in civil products. Below are the fibre details along with their properties to be used in civil products for better results:

3.1 Polypropylene

PP is a polymeric fibre, however earlier it's uses was limited to Apparel, Household products and Industrial products. The PP fibres are lustrous, white in colour with tenacity at 3.5 to 8.0 gpd, have a lowest density 0.91 g/cc and has good elasticity with excellent abrasion resistance. The PP has 0% moisture regains and has a very good melting point at around 170°C^[3]. It is not affected by insects or mildew, which means fibres will not be affected during wet condition and concrete strength will not be lost while testing as generation of minor cracks will reduces. Also the best property of PP is having good alkaline resistance. Since, its excellent resistance to alkaline will help to give good strength while mixing it into cement mortar. The only drawback is it loses strength under sun light, since we are not going to use it on the surface and it will be inside the mixture, so the sunlight will not affect the fibre strength.

The above properties states that PP can be used in concrete because of its light weight property, elasticity and moisture regain. Since the fibre is lustrous it will be easy to spread evenly in the mixture without much entanglement, because of the good tenacity it gives good strength. Finally we can say that Polypropylene is the best suited fibre for civil construction application.

3.2 Steel

There are various types of steel fibers used in cement based mixture. Steel fibers are classified depending on their types of manufacturing method. Hooked end stainless steel has proven to give the best performance as per studies. Steel fiber length ranges from 1/4 to 3 inches (1.5 to 75 mm) and aspect ratio ranges from 30 to 100. Steel fibres do not significantly increases the compressive strength, but it increases the tensile toughness and ductility. It also increases the ability to withstand stresses after significant cracking (damage tolerance) and shear resistance^[3].

In general, Steel Fibre Reinforced Concrete(SFRC) is very ductile and particularly well suited for structures which requires more strength. The steel fibres have many excellent properties like impact resistance, withstand high amount of load, high flexural strength, shear strength and tensile strength. Also it has good resistance to splitting, excellent abrasion resistance have high thermal temperatures^[4]. Above all characteristics of steel fibres are best suited to be used into the civil applications and finally they have started replacing metal rods in beams where ductility, corrosion resistance and strength are of utmost importance.

3.3 Nylon

Nylon 6 is a polyamide fibre and was earlier used in apparel and automobiles industries. Nylon is having a very good tenacity and the strength. And the life of nylon is much more as compared to other fibres. It is also having a high strength to weight ratio. It is among the fibres which are very lightest as well as strongest fibres. Nylon is very lustrous fibre with excellent elasticity which will help to move the fibres to their original position after stretching^[5,6]. Some of the properties of Nylon are tenacity 6.0 to 8.5 gpd and density is 1.14 g/cc. The tenacity is far better and we can expect the good compressive tensile strength from nylon fibre as compared to other fibres. The moisture regain is also good at around 3.5 to 5% and has excellent melting point at 215° C. The abrasion resistance is also excellent which means it can be used into such civil applications where the end use application require abrasion resistance, also it is a good alkali resistance which helps to maintain its strength while mixing it into the cement mortar.

Since nylon is having good impact resistance it will help to reduce crack by increasing its load carrying capacity. Basically, the main application of nylon fibres is to reduce crack which happens due to plastic shrinkage of concrete as discussed earlier. It is also used in slabs, elevated decks, pavements, sports, roadways, in parking areas etc. Finally, we can say that Nylon is also the best suited fibre for the civil application especially where abrasion resistance is required.

3.4 Acrylic

Acrylic is a synthetic fibre made from a polymer called polyacrylonitrile. The Acrylic fibres are dull in lustre with good tenacity at 5gpd and density is 1.17g/cc. Also, its elasticity is fair enough and melting point is 230°C. It also has a fair alkaline resistance which means it will work better with cement mixture and has excellent resistance to insects and mildew. The Acrylic fibre increases the impact and flexural resistance by 50% than conventional concrete mixture.

Overall we can say that due to its tenacity and moisture regain property Acrylic can be use in some of the civil application though it can also be used with the blends for still better performances^[7].

3.5 Carbon

Many researches are going on with the Carbon fibre because of their properties. Carbon fibres are mostly used with names as Carbon fiber reinforced polymer, carbon fiber reinforced plastic or carbon fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, carbon composite or even carbon). Carbon fibres are very lustrous, lightest and strongest fibres with tenacity at 1.8 to 2.4 kN/mm² and density is 1.95g/cc. The moisture regain is 0%. The only drawback is it is having poor elasticity and cost. Carbon fibres are normally used where there is high strength to weight ratio and rigidity are needed. Some of the applications of carbon fibres are automotive, civil applications, sports and aerospace.

Overall we can say that where light weight along with strength is needed we can use Carbon fibre and we can build complex structure which can also save maintenance cost. But costing also plays important role specially in civil application, so the use of carbon fibre commercially is very limited^[8,9].

3.6 Glass

There are various glass fibres with different varieties of grade available in the market. However, for the reinforce purpose there are particular grades which are best suited for the applications such as S glass, AR glass etc.. The property of glass fibres are incombustibility, corrosion resistance, excellent strength, thermal stability, good electrical properties and are resistance to moisture.

When the glass fibres are mixed into the cement mortar it helps to achieve good properties as compared to other fibres. The glass fibre also have high strength to weight ratio and have good impact resistance^[10,11].

Glass fibres are widely used in civil construction application like facade panels, piping and channels. And offer many advantages, such as being lightweight, fire resistance, good appearance and strength^[12].

IV. OBSERVATION

By comparing the above fibre properties and their behaviour with cement mixture we can say as per below:

4.1 Polypropylene:

As per some of the experiment it has been claimed that adding of polypropylene fibres do not necessarily increases the compressive strength and elastic modulus but it will help the civil products to reduce generation of minor cracks which in turn helps to increase the strength of the concrete. The cost is also less and effective to be use in civil construction applications. In addition to this, polypropylene in concrete increases the splitting tensile strength by approx 20% to 50% as per the studies^[13].

4.2 Steel:

Using steel fibres in concrete has found increase in civil application properties like compressive strength, tensile strength and flexural strength by three times as compared to conventional concrete and also improves the resistance through wear and tear^[14]. Also it is best suited to be used in beams and facades replacing the metal bars.

4.3 Nylon:

The compressive strength in Nylon fibre have also increased due to its property like imparting impact resistance, flexural toughness, sustaining and increasing the load carrying capacity of concrete following first crack.

4.4 Acrylic:

The acrylic fibre controls the crack formation, it can make concrete less porous, also it will increase flexural strength and flexibility. As per studies, drying shrinkage reduced in the presence of acrylic fibres and enhancement in tensile strength with the addition of 0.1% acrylic fibres^[15,16].

4.5 Carbon:

Nowadays carbon fibres are also used a lot in civil applications. Still many of the applications are still in the developing stage. The carbon fibres are used to provide strength to civil structure. Many of its application are precast, bridge construction, plastic profiles etc. Carbon fibres are also successfully used in building and construction to reduce earthquake effect and also used in beams, concrete bridges etc. to increase its flexural rigidity. The properties of carbon fibres are helpful to make it use in all the above application and it has one-time expense cost.

4.6 Glass:

The materials have a good resistance for tension. It is used mostly for cladding buildings, lining, sewer pipe, shoulder of roads and etc. Along with compressive strength, modulus of elasticity and flexural rigidity also increases by the addition of glass fibres in concrete. But while adding in the mortar, care should be taken that glass fibre added mix should not be kept for more than 5 minutes else the fibres will start breaking.

V. CONCLUSION

The point is confirmed from the above properties that addition of the fibres increases the strength of concrete due to load carrying capacity. However, to mark the best fibre out of the above six is difficult to conclude since every fibres have their distinct properties. Crack in cement does not only reduce the structure quality but also make them weak and unacceptable in the market. In some studies it is mentioned that if the crack does not exceed certain width it is acceptable and they are not harmful to the structure as well. Therefore, it is important to reduce the crack width and this can be achieved by reinforcing fibres in the cement mixture. From the above fibres, the steel, carbon and glass have been successful to replace metal bars and so they can give good results in beams, buildings and construction. But they are costlier than the other fibres which will increase the manufacturing cost. Nylon, Acrylic and Polypropylene are the fibres which can be used in civil products such as cubes, hollow blocks, paver blocks etc. which have less effect on cost to achieve good strength.

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