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FIBRE REINFORCED CONCRETE

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ABSTRACT

Concrete is strong under compression yet weak under tension. As such, a form of reinforcement is needed. Non-reinforced cement-based matrix is brittle in nature, possesses little tensile strength compared to the inherent compressive strength. The purpose of reinforcing the concrete is to substantially alter the properties of the non-reinforced cement-based matrix. The principal reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength, and improve the cracking, deformation characteristics of the resultant composite.

Keywords: Compressive strength, cracks, FRC, Plain concrete, tensile strength

I.INTRODUCTION

Civil structures made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures. There are many ways to minimize the failure of the concrete structures made of steel reinforced concrete.

The custom approach is to adhesively bond the fibre polymer composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. These fibre polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the de-lamination of the composite.

Another approach is to replace the bars in the steel with fibres to produce a fibre reinforced concrete and this is termed as FRC. In order for fibre reinforced concrete (FRC) to be a viable construction material, it must be able to compete economically with existing reinforcing systems. Only a few of the possible hundreds of fibre types have been found suitable for commercial applications. This study deals specifically with the concrete reinforced with the steel fibres. The objective of this research is to explore the properties of steel fibres in specific environments to which the FRCs are exposed.

II. FIBRE REINFORCED CONCRETE

Fibre reinforced concrete is a concrete mix that contains short discrete fibres that are uniformly distributed and randomly oriented. Fibre material can be steel, cellulose, carbon, polypropylene, glass, nylon, and polyester. 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 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.

The selection of the type of fibres is guided by the properties of the fibres such as diameter, specific gravity, young's modulus, tensile strength etc. and the extent these fibres affect the properties of the cement matrix. This research focuses on steel fibres. Steel fibre length ranges from 1/4 to 3 inches (1.5 to 75 mm) and aspect ratio ranges from 30 to 100.

III. BEHAVIOUR OF FIBRES IN A CEMENT MATRIX

The behaviour of FRC under loading can be understood from the Fig.1. The plain concrete structure cracks into two pieces when the structure is subjected to the peak tensile load and cannot withstand further load or deformation. The fibre reinforced concrete structure cracks at the same peak tensile load, but does not separate and can maintain a load to very large deformations. The area under the curve shows the energy absorbed by the FRCs when subjected to tensile load. This can be termed as the post cracking response of the FRCs.

The real advantage of adding fibres is when fibres bridge these cracks and undergo pullout processes, such that the deformation can continue only with the further input of energy from the loading source.

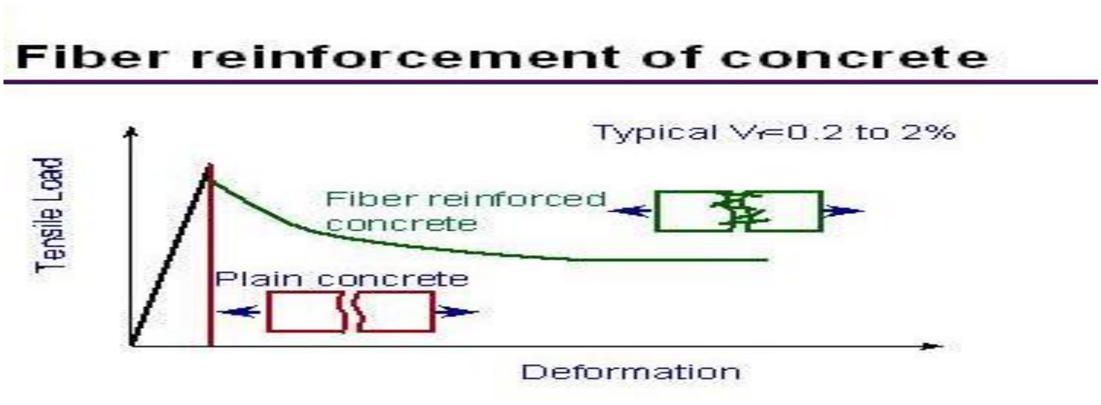

Fig.1: Tensile Load versus Deformation for Plain and Fibre Reinforced Concrete

IV.MECHANICAL PROPERTIES OF FIBRE-REINFORCED CONCRETE

4.1 Properties of fresh fibre-reinforced concrete

Achieving adequate workability is one of the most important problems generated when using steel fibre reinforced concrete. The inclusion of the fibres into the concrete mix influences its workability, with increasing in the fibre volume and aspect ratio leading to decreased workability. Incorporation of superplasticizer is essential to maintain good workability (120-150 mm).

4.2 Properties of hardened fibre-reinforced concrete

The most significant consequence of fibre addition to concrete is the delay and control of tensile cracking in the composite material. Through intercept micro-cracks, many of the mechanical properties of the composite are improved. The level of improvement achieved, compared to plain concrete, depends on the dosage rate and type of fibre. Fibres improve the ductility of concrete under all modes of loading. But their effectiveness in improving strength varies among compression, tension, shear, torsion and flexure.

Compressive strength is slightly affected by the presence of fibres, with observed increases ranging from 0 to 15%, on the other hand, direct tension improved significantly, with increases of the order of 30 to 40%, similarly, shear and torsion generally increased although there are little data dealing strictly with the shear and torsion.

The post-crack flexural performance is a most important part of the commercial uses of fibre concrete enabling reductions of thickness to be made in sections subject to flexure or point load. Impact strength and toughness, defined as energy absorbed to failure are greatly increased, the increased in toughness results from the increased of the area under the load deflection curve in tension and flexure. Increased resistance to dynamic load and fatigue is often claimed, it seems to be related to the distribution of the fibres in concrete. Also, it has 15% higher resistance to wear than plain concrete.

Modulus of elasticity and Poisson ratio are generally taken as equal to those of similar non-fibrous concrete when the volume percentage of fibre is less than 2%. Generally, fibre concrete is more durable than plain concrete, having a positive influence on the shrinkage behaviour of concrete by reducing the number and controlling the width of cracks. Fibres reduce the deterioration caused by freeze-thaw cycling, and they also reduce the permeability of cracks even at low volume.

V.Developments in Fibre Reinforced Concrete

An FRC sub-category named Engineered Cementitious Composite (ECC) claims 500 times more resistance to cracking and 40 percent lighter than traditional concrete.ECC claims it can sustain strain-hardening up to several percent strain, resulting in a material ductility of at least two orders of magnitude higher when compared to normal concrete or standard fibre-reinforced concrete. ECC also claims a unique cracking behaviour. When loaded to beyond the elastic range, ECC maintains crack width to below 100 μm, even when deformed to several percent tensile strains. Field results with ECC and The Michigan Department of Transportation resulted in early-age cracking.

Recent studies performed on a high-performance fibre-reinforced concrete in a bridge deck found that adding fibres provided residual strength and controlled cracking. There were fewer and narrower cracks in the FRC even though the FRC had more shrinkage than the control. Residual strength is directly proportional to the fibre content.

A new kind of natural fibre-reinforced concrete (NFRC) made of cellulose fibres processed from genetically modified slash pine trees is giving good results. The cellulose fibres are longer and greater in diameter than other timber sources. Some studies were performed using waste carpet fibres in concrete as an environmentally friendly use of recycled carpet waste. A carpet typically consists of two layers of backing (usually fabric from polypropylene tape yarns), joined by $CaCO_3$ filled styrene-butadiene latex rubber (SBR), and face fibres (majority being nylon 6 and nylon 66 textured yarns). Such nylon and polypropylene fibres can be used for concrete reinforcement. Other ideas are emerging to use recycled materials as fibres: recycled Polyethylene terephthalate (PET) fibre.

VI.CONCLUSION

It has been found by the literature study of Fibre reinforced concrete that the use of fibres in the structures like beams, columns, slabs etc can increase the mechanical properties of the material as well as the improved micro structure of the structures with this material can reduce the propagation of cracks and hence increase the durability.

The fibres being cheaper can also completely eliminate the use of rebars in the structures which are responsible for increasing the cost of the structures, hence they can economise the construction in another way. For promoting the use of fibres in concrete, a particular specification standardised by the authorities need to be introduced.

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