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A Review on Fiber Reinforced Concrete Structures

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ABSTRACT

Progression in cement-based technology has driven the development of fibre reinforced concrete (FRC) materials; such as concrete technology. Steel fibre and synthetic fibre are fundamental fibre types, which include glass, carbon, polyvinyl, polyolefin, waste fibre materials and polypropylene. The mechanical properties of FRC members are affected from these fibres individually and in hybrid aspects. The type, content and geometry of fibres are relied to these mechanical properties. A significant improvement in mechanical and dynamic properties of reinforced concrete members is enabled due to additional fibres into cementitious composites. Most mechanical properties are enhanced through intercept micro-cracks. The level of enhancement accomplished relied on the type and dosage of fibre as compared to plain concrete. Effective tensile strength, energy dissipation capacity and toughness are explained through FRC. The shear, punching and flexure are significantly increased through the level of enhancement accomplished. These fibres include polyvinyl, glass, carbon, polyolefin and polypropylene that improve the mechanical properties of concrete. The historical use of fibres and types of fibres are reported in this chapter. Similarly, the curing of steel, structural synthetic fibres, the mechanical properties of cement, the addition, placing, finishing and mixing are based on waste fibres, hybrid fibres, steel and structural synthetic.

1. INTRODUCTION

Concrete which is one of the most important construction material and is brittle in nature with very good compressive strength but weak in tension and flexure as a result concept of fibre reinforced concrete has developed. The term fibre-reinforced concrete (FRC) is defined by AC1 116R, Cement and Concrete Terminology, as concrete containing dispersed randomly oriented fibres. With time a lot of fibres have been used in order to improve the properties of concrete and even waste materials like fly ash, silica fumes have also been used. The concept of using natural fibres has also evolved but its durability remains questionable. The work done by using different fibres, waste materials and their effects are discussed below in a sequential manner.

Use of fibres in a brittle is not a new concept, the Egyptians used animal hairs, straw to reinforce mud bricks and walls in houses, around 1500 B.C. [1. Ronald F. Zollo presented a report on fibre reinforced concrete in which he had mentioned about 30 years of development and research in this filed. In the report it is claimed that the work on FRC started around 1960.Since than a lot of work has been done on FRC using different methods of production as well as different types of fibre, size of fibre, orientation and distribution. American Concrete Institute (ACI) Committee 544 divided FRC broadly into four categories based on fibre material type. SFRC, steel fibre FRC; GFRC, glass fibre FRC; SNFRC, synthetic fibre FRC including carbon fibres; and NFRC, for natural fibre FRC. The idea of fiber support has been produced in current times and weak cement based brittle matrix was strengthened with asbestos filaments when in around 1900 the alleged Hatschek innovation was created for creation of plates for material, funnels, and so forth. Later, glass fibres were proposed for fortification of concrete glue and mortar by Biryukovichs. The ordinary E-glass fibers are not durable and resistant in highly alkaline Portland cement paste.- Majumdar and Ryder invented Alkali Resistant glass fibers by adding Zircon oxide(ZrO_2). Romualdi and his co-authors published important influences of the use of steel fibre in concrete, which lead the development of steel fibre reinforced cements (SFRC). Over the last 40 years, a lot has been done to develop the cement-based matrices. The fundamental reason for short scattered filaments is to control the break opening and proliferation. Basic groups of fibres applied for structural concretes and classified according to their material are Brandt:

- Steel fibres of different shapes and dimensions, also microfibers;

- Glass fibres, in cement matrices used only as alkali-resistant (AR) fibres;
- Synthetic fibres made with different materials: polypropylene, polyethylene and polyolefin, polyvinyl alcohol (PVA), etc.;
- Carbon, pitch and polyacrylonitrile (PAN) fibres.

Steel fibres are most important for structural concrete. Studies also reveal that hooks at the end of the steel fibres, shape, size etc may improve the fiber matrix bond and also the efficiency may be increased. It has also been observed that due to the presence of fibers large cracks are replaced with dense system of micro-cracks. Opening, propagation of micro cracks are controlled by fine fibers as they are densely dispersed in cement matrix. Longer fibres 50 or 80 mm can increase the final strength of FRC and may help in controlling large cracks. The under load behaviour of a SFRC is completely modified with the increase of fibre volume and efficiency [2].

Not only steel fibers PVA fibers either monofilament or fibrillated polypropylene size varying 10 mm to 80 mm diameter varying 0.5 mm to 1.5 mm are used in high volumes (0.5-2%),it can increase the impact and fatigue strength as well as the strength and toughness of the structural concrete elements. Polypropylene fibers are low modulus and can serve two different purposes depending on the amount used in concrete. On the off case that utilized as a part of little sum (up to 1.0 kg/m3) it can control the shrinkage splitting of solid in couple of first hours of setting. During that period, the Young's modulus of cement is like that of the strands, Ramakrishnan et al. The polypropylene fibers can also serve in case of high temperature and fire and as such are used in concrete walls of apartment building, what happens is that this fibers melt and channels are created which helps in releasing the internal pressure there by delaying the destruction of concrete.

Carbon fiber reinforced mortar (CFRM) and carbon fiber reinforced cement (CFRC) are composites that have high flexural quality and durability and low drying shrinkage, notwithstanding this they have great electrical properties, for example, voltage-touchy impact. Ease pitch carbon filaments is satisfactory for scaffolds, other structural designing structures furthermore for cladding for structures, Kucharska and Brandt. In the districts with Corrosive impact of marine climate and solid winds (e.g. in Japan) CFRC is utilized as a part of scaffold auxiliary components for preferred toughness over it would be conceivable utilizing steel filaments.

Fibre-reinforced polymer (FRP) bars can be used to replace steel reinforcement conventional steel has the inherent problem of corrosion as a result of which it undergoes expansion and concrete cracking may occur; therefore FRP rebar may be used as an alternate. The use of this fibres excludes the problem of corrosion and increases the ductility of the FRP-reinforced concrete beams but the load deflection was found to be higher.(Mohamed S. Issa, Ibrahim M.Metwally, Sherif M. Elzeiny 2010).

SIFCON (slurry penetrated fiber cement) is an in number composite in which a high volume of steel filaments is utilized by unique innovation. Strands are preplaced in a mold and the fiber framework got is invaded by cement slurry. Fiber volume may achieve 8–12%, occasionally significantly higher, and filaments 100–200 mm long may be utilized. The concrete slurry is loaded with fine sand, small scale total and exceptional added substances like fly-ash and silica fumes. The high smoothness (low consistency) of the slurry is vital for satisfactory infiltration of the thick fiber frameworks in a mold. High-quality and resistance against nearby effects and infiltration of shots describe the components made with SIFCON. At the point when rather than single filaments the woven or plaited mats are utilized, then the name SIMCON (slurry penetrated mat cement) is utilized [3].

2. WASTE FIBROUS MATERIALS

Huge amount of waste materials are produced in our country. These waste materials are both organic and inorganic. The amount of inorganic waste material produced is increasing day by day and to dispose them of without causing any harm to environment is a big problem. Many researches are now trying to use the waste material as construction materials. Also natural fibres are available in abundant and can be an alternate for use in construction of cost effective materials in urban and rural buildings [4-6].

3. INORGANIC FIBERS

Kenneth W. Stier and Gary D. Weede (1999) investigated the feasibility of recycling commingled plastics Fibre in Concrete.It was found that the mechanical properties of concrete such as compressive and flexural strength showed improvement but however the durability aspect was questionable. Sekar (2004) studied on fibre reinforced concrete from industrial lathe waste and wire winding waste and found that this waste significantly improved the compressive, split-tensile strength and the flexural strength values of concrete. It also stated that wire drawing industry waste decreased the strength values. Effect of re-engineered plastic shred fibre were studied by Anbuvelan et al (2007). The engineering properties Compressive, split tensile, flexural, abrasion, impact strength and plastic shrinkage of the concrete was found to have improved [7].

4. NATURAL FIBRES

Natural fibres were traditionally used in the past as reinforcing materials and their use so far has been traditional far more than technical. They have served useful purposes but the application of natural fibre as a reinforcing material for concrete is a new concept. Improved tensile and bending strength, , greater resistance to cracking and hence improved impact strength and toughness ,greater ductility are some of the properties of natural fibre reinforced concrete. Ramakrishna et al (2002) looked at the hypothetical and exploratory examinations on the compressive quality and elastic modulus of coir and sisal fibre strengthened cements for different volume divisions. It was watched that both the exploratory and analytical values of flexible modulus had indicated 15% error, which can be viewed as relatively little. Rheological properties of coir fiber strengthened cement mortar were done by Ramakrishna and Sundararajan (2002).Flow value, cohesion and angle of internal friction were resolved for three different mix ratios and four different aspect ratios and fibre contents. In view of the rheological properties of fresh mortar, it was prescribed to use short filaments with low fibre-content for achieving workability and higher fibre content for better cohesiveness in wet state. Composites of blast furnace slag BFS based cement mortar strengthened with vegetable strands were presented by Holmer

Savastano Jr et al (1998). Composites were produced through a straightforward and low-vitality expending strategy, including standard vibration and curing in a wet chamber. Eucalyptus pulp, coir fibres and with a mixture of sisal fibre and eucalyptus pulp gave a suitable performance but the performance deteriorated with time. The natural fibre composites may undergo a decrease in strength and toughness as a result of debilitating of fibres by the combination of alkali attack and mineralization through the migration of hydrogen products to lumens and spaces. Romildo D. Toledo Filho et al (2003) reported their study on development of vegetable fibre-mortar composites of improved durability. So a few methodologies were proposed by the authors to enhance the solidness of vegetable fiber-concrete composites. These incorporate carbonation of the grid in a CO2- rich environment; the drenching of strands in slurried silica fume earlier to joining in Ordinary Portland Cement lattice; incomplete substitution of Ordinary Portland Cement by undensified silica fume or blast furnace slag. The execution of adjusted vegetable fiber-mortar composites was investigated in terms of impacts of maturing in water, presentation to cycles of wetting and drying and open air weathering on the microstructures and flexural conduct. It was recommended that submersion of common strands in a silica seethe slurry before the expansion to the bond based composites was discovered to be an successful method for decreasing embrittlement of the composite in nature. Additionally early cure composites in a CO2- rich environment and the fractional substitution of OPC by undensified silica smoke were the proficient methodologies in getting regular strands with enhanced sturdiness [9,10].

5. SUMMERY

An extensive study of literature suggests that glass fibres may enhance the toughness, flexural strength, tensile strength, impact strength, fatigue performance as well as the failure mode of the concrete when compared to plain concrete. The fire resistance of glass fibre reinforced concrete is also good.

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