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Experimental Study on Effect of Fibres for Reinforced Concrete

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Abstract:- **Concrete is widely used in structural engineering with its high compressive strength, low cost and abundant raw material. But common concrete has some shortcomings, for example, low tensile and flexural strength, poor toughness, high brittleness, and so on that restrict its application. To overcome these deficiencies, additional materials are added to improve the performance of concrete. Fiber reinforced concrete is a composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural tensile strength, permeability and so on. The main purpose of this investigation is to study the effects of steel, glass and polypropylene fibers on the compressive, split tensile and flexural strength of concrete.**

CHAPTER 1

INTRODUCTION

The use of fibres to reinforce concrete materials is a well–known concept. It has been practiced since ancient times, with straw mixed into mud bricks and horsehair included in mortars. However, in our modern day construction practices we have forgotten the ancient practices to control cracks in concrete. Concrete cracking is normal. Portland cement concrete is considered to be a relatively brittle material and is prone to crack in the plastic as well as the hardened stage. Plastic shrinkage occurs when the evaporation of water from the surface of concrete is greater than the rising bleed water. As concrete is very weak in tension in its plastic stage, a volume change causes the surface to crack. As it hardens, the water present in the pores of concrete begins to evaporate. This causes the concrete to shrink due to the volume change, which is restrained by the sub grade and reinforcement. This results in a tensile stress being developed in hardened concrete, again causing the concrete to crack. Cracks lead to negative perception of quality, durability and serviceability, however in most cases they become only aesthetic problems. Cracks also results in disputes between the owner, Architect, design Engineer and contractor which results in job delays and cost increases due to work stoppages and evaluation which is more severe than the actual consequences of cracking.One of the solutions to this problem is the additions of fibres to concrete.

An attempt has been made in this Project to provide the advantages and benefits of using fibre reinforced concrete for a variety of applications. The use of fibres help in modifying properties of concrete both in plastic and hardened stage and thus results into a more durable concrete. Incorporating Synthetic fibres help to reduce thermal and shrinkage cracks. Addition of steel fibres enhances the ductility performance, post-crack tensile strength, fatigue strength and impact strength of concrete structures.

CHAPTER 2

LITERATURE REVIEW

Anshida Haneefa et al. (2008) In this work the influence of fiber content, fiber loading and hybrid effect on the mechanical properties such as tensile strength, Young's modulus, elongation at break, and flexural properties of the composites was evaluated. The volume fraction of glass fibre based on total fibre content increases all the mechanical properties, expect elongation at break. The tensile and flexural properties of composites are observed to have improved as the fibre loading (vol %) increases. On the other hand, lack of good interfacial adhesion and poor resistance to modification of the banana fibre improves the optimum fibre-matrix properties. Hybrid effect was calculated using additive rule of hybrid mixture. The comparison of theoretical and experimental values of tensile properties was determined using member of theoretical models. Expect parallel method all other shows comparable results.

K.Nagamani et al. (2008) the investigation on the contribution of steel fibres on the splitting tensile strength of high strength steel fibre reinforced concrete. Crimped steel fibre used having diameter 0.45mm and length 36mm giving an aspect ratio of 80.Splitting tensile strength tests were conducted using 150mmx300mm cylindrical specimen. The addition of steel fibers by 2.50% volume fraction results in increases of 55.9% in the splitting tensile strength compared with un-reinforced matrix. Moderate improvement in compressive strength was obtained for HSFRC. Statistical model developed found to give good correction with experimental values.

Murali Mohan rao, K. et al. (2007) studied with an aim of introducing new natural fibre used as fillers in a polymeric matrix enabling production of economical and lightweight composites for load carrying structure. An investigation of the extraction procedures of glass data and bamboo fibers has been undertaken. The cross-sectional shape, the density and tensile properties of these fibers, along with established fibre like coconut and palm, are determined experimentally.

H.Wang and A.Belarbi (2006) Develop a non ferrous hybrid reinforcement system for concrete bridge decks by using continuous fibre reinforced polymer rebars and discrete randomly distributed polypropylene fibres. Relating to the flexural behavior of the polypropylene fibre reinforced concrete beams reinforced with FRP rebars. Tests results indicated that with the addition of fibre, flexural behavior was improved with an increase of ductility index by approximately 40% as compared to the plain concrete beams. The beams were subjected to a four point flexural testing. With the addition of fibres, the crack widths are smaller at service load in the case of FRC beams as compared to plain concrete beams. With the addition of fibres, the flexural behavior exhibits an improved ductility index when compared to plain concrete beam, it was noticed that FRC beams failed in a relatively more ductile fashion. With the addition polypropylene fibre the ductility indices increases by approximately 40%.

S.Eswari, et al. (2004) this research work focuses on the polyolefin-steel hybrid fibre reinforced system. In this system, steel fibre which is stronger and stiffer improves the first crack strength ultimate strength, while the polyolefin fibre which is more flexible and ductile leads to improved toughness and strain capacity in the post-cracking zone. 100 x100x50mm prisms were tested in a loading frame. A total of 27 specimens were tested. Increasing the fibre content from 2 to 5% increases the modulus of rupture. The increases in modulus of rupture were found to be 72.52% with 5% hybrid fibre content. The increase in ultimate load was found to be 72.42% with 5% hybrid fibre content when compared to the plain concrete. The increase in ultimate and service load deflection was found to be 137.50 % and 186.49% respectively with 5%hybrid fibre content when compared to the plain concrete. The hybrid fibre reinforced concrete specimen exhibit reduced crack width was found to be 80% compared to that of plain concrete. The hybrid fibre reinforcement appreciably enhances the ductility of concrete specimen. The increase in ductility was found to be 98% and 83%in terms of energy and deflection.

N. Banthia and S.Cangiano (2003) recent investigations have shown that the combination of different fibre types provides a higher toughness. In hybrid system, micro fibres provide reinforcement mechanisms at small to medium crack openings while macro fibres would carry stresses across cracks at medium to large crack opening. In this study the benefits caused by combination of micro and macro steel fibres are evaluated under static and fatigue tests carried out on beams under four point bending and on cylinders under direct tension. The results showed the mixture of fibre permits a more effective control of the dynamic cracks development. In this study the benefits by a combination of micro and macro steel fibres are evaluated under static and fatigue tests carried out on 4PB beams and cylinders under direct tension. The results shown that the mixture of fibre allows a better control of the dynamic crack development. Four point bending tests on notched beams with a length of 600 mm and a square section with a side of 150 mm. The cyclic tensile tests were performed on cylindrical specimen with height of 210 mm and diameter of 78 mm. Static tests show that the combinations of steel fibres of different sizes show synergistic effects in terms of material toughness. Micro fibres increase the peak load from bending tests as well as the post cracking strength for small crack openings.

Nguyen Van Chanh (2002) the important properties of steel fibre reinforced concrete is its superior resistance to cracking. In this research paper the mechanical properties technologies and applications of SFRC are discussed. Fibre do little to enhances the static compressive strength of concrete with increase in strength ranging from essentially nil to perhaps 25%. Even in members who contain conventional reinforcement in addition to the steel fibres, the fibres have little effect on compressive strength. Fibres aligned in the direction of the tensile stress may bring about very large increases in direct tensile strength as high as 133% for 5% of smooth, straight steel fibres. The increases in flexural strength are particularly sensitive, not only to the fibre volume, but also to the aspect ratio of the fibres, with higher aspect ratio leading, to larger strength increases.

Kumar et al. (1995) conducted a comparative study to determine the rotational capacity and toughness of reinforced concrete beam with and without fibers. The beams had equal reinforcement on both the faces and also reinforced in the web. Experimental investigation on sixteen beams with fibers only in the tension zone and fibers for the entire depth was carried out. This choice resulted in improved rotational capacity, toughness and ultimate strength compared to conventionally reinforced concrete beam.

Dwarakanth and Nagaraj (1987) Conducted experimental studies on flexural behavior of large size reinforced concrete beam. Beam size of 1800 mmx208 mmx100 mm was used. The beams reinforced high strength deformed bars, both under reinforced, over reinforced with fibers over entire depth and over half the depth and beam in tension side was consider for the investigation. They noticed that partial inclusion of steel fibers over the half depth, in the case of under reinforced beam was equally beneficial as the full depth inclusion in controlling cracking and deflection and in increasing the stiffness of the beam. Over reinforced beam, fibers used in small quantities were not found to be effective in any appreciable modification in the deformation behavior of the beam.

Neven Krstulovi-opara et. Al (1994) Effect of increased tensile strength and toughness on reinforcing bar bond behavior. The research reported has investigated the pull out behavior of deformed reinforcing bars embedded in fiber reinforced concrete and high performance fiber reinforced concrete matrices exhibiting increased tensile strength and toughness increased strength and toughness of the embedding matrix resulted in a significant increased in pull out strength, strain capacity and over all ductility as well as more stable crack development. Additionally, when sufficient lateral constraint (i.e. cover thickness) was provided, the use of an HPFRC matrix exhibiting strain-hardening behavior resulted in a slip hardening pull out response.

Moens and Nemegeer (1991) explained the procedure for designing fibre reinforced concrete based on toughness characteristics of steel fibre reinforced concrete. They commented that the basic properties of steel fibres are to be well known as for conventional reinforcement, to aid the design of steel fibre concrete. According to the type of application. Various requirements like minimum energy absorption capacity of steel fibre concrete etc. must be established for designing the steel fibre concrete. They specify that in each of these cases, the quality of fibres needed to ensure that a given reference concrete will comply with the relevant quantity requirements can be inferred from identify charts drawn for a specific fibre type.

CHAPTER 3

FIBRES

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The Fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the Fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Types of Fibres

A wide variety of Fibres have been used in concrete. For each application it needs to be determined which type of Fibre is optimal in satisfying the concrete application. The different types of Fibres used as concrete reinforcement are synthetic Fibres and steel Fibres. The different types of synthetic Fibres used are Polypropylene, Nylon, Polythene, Polyester and Glass Fibres.For architectural and decorative concrete products and for prevention of early age cracking, synthetic Fibres may be used. Steel Fibres are used for applications where properties of concrete in the hardened stage have to be modified, namely, post crack flexural strength, abrasion resistance, impact resistance and shatter resistance of concrete.

Following are the different type of Fibers generally used in the construction industries.

- Steel Fiber
- Polypropylene Fiber
- Glass-Fiber
- Asbestos Fibers
- Carbon Fibers
- Organic Fibers

Steel Fiber

A number of steel Fiber types are available as reinforcement. Round steel Fibre the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel Fibres having a rectangular c/s are produced by silting the sheets about 0.25mm thick. Fibre made from mild steel drawn wire. Conforming to IS: 280-1976 with the diameter of wire varying from 0.3 to 0.5mm has been practically used in India. Round steel Fibres are produced by cutting or chopping the wire, flat sheet Fibres having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed Fibre, which are loosely bounded with water-soluble glue in the form of a bundle are also available. Since individual Fibres tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding Fibres bundles, which separate during the mixing process.

Polypropylene Fibre

Polypropylene is one of the cheapest & abundantly available polymers polypropylene Fibres are resistant to most chemical & it would be cementitious matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degree centigrade) may be sustained for short periods without detriment to Fibre properties.Polypropylene Fibres being hydrophobic can be easily mixed as they do not need lengthy contact during mixing and only need to be evenly distressed in the mix. Polypropylene short Fibres in small volume fractions between 0.5 to 15 commercially used in concrete.

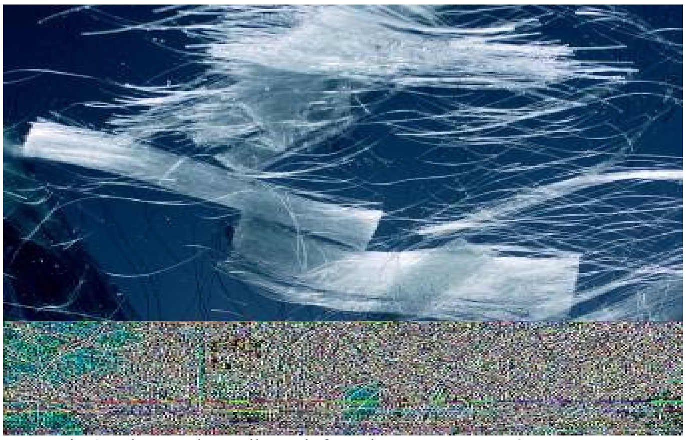

Fig.1 Polypropylene Fiber reinforced cement-mortar & concrete.

Glass-Fibre

Glass Fibre is made up from 200-400 individual filaments which are lightly bonded to make up a stand. These stands can be chopped into various lengths, or combined to make cloth mat or tape. Using the conventional mixing techniques for normal concrete it is not possible to mix more than about 2% (by volume) of Fibres of a length of 25mm.

Fig.2 Glass-Fiber reinforced concrete

The major appliance of glass Fibre has been in reinforcing the cement or mortar matrices used in the production of thin-sheet products. The commonly used verities of glass Fibres are e-glass used. In the reinforced of plastics & AR glass E-glass has inadequate resistance to alkalis present in Portland cement where AR-glass has improved alkali resistant characteristics. Sometimes polymers are also added in the mixes to improve some physical properties such as moisture movement.

Carbon Fibres

Carbon Fibres from the most recent & probability the most spectacular addition to the range of Fibre available for commercial use. Carbon Fibre comes under the very high modulus of elasticity and flexural strength. These are expansive. Their strength & stiffness characteristics have been found to be superior even to those of steel. But they are more vulnerable to damage than even glass Fibre, and hence are generally treated with resign coating.

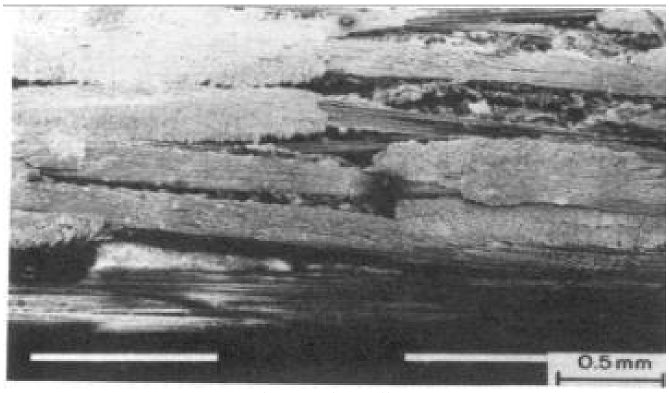

Fig.3 Carbon Fibers

Asbestos Fibers

The naturally available inexpensive mineral Fiber, asbestos, has been successfully combined with Portland cement paste to form a widely used product called asbestos cement. Asbestos Fibers here thermal mechanical & chemical resistance making them suitable for sheet product pipes, tiles and corrugated roofing elements. Asbestos cement board is approximately two or four times that of unreinforced matrix. However, due to relatively short length (10mm) the Fibre have low impact strength.

Fig.4 Asbestos Fiber

Organic Fibers

Organic Fiber such as polypropylene or natural Fibre may be chemically more inert than either steel or glass Fibres. They are also cheaper, especially if natural. A large volume of vegetable Fibre may be used to obtain a multiple cracking composite. The problem of mixing and uniform dispersion may be solved by adding a super plasticizer.

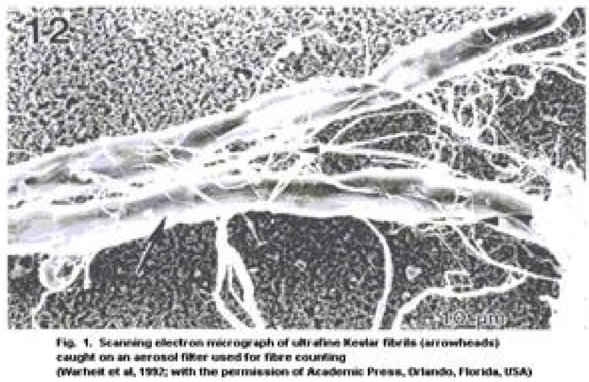

Fig.5 Organic Fiber

Natural Fibers

Natural fibers include those of vegetable origin constituted of cellulose, a polymer of glucose bound to lignin with varying amounts of other natural materials. They include the hard leaf fibers such as abaca (Manila hemp), sisal and henequen; bast fibers from the soft bast tissues or bark such as flax, hemp, jute, and ramie; and seed-hair fibers including cotton, kapok and the flosses.

Types of natural fibers

a. Coconut fiber
b. Sisal fiber
c. Sugar cane bagasse fiber
d. Bamboo fiber
e. Jute fiber
f. Other vegetable fibers

a. Coconut fiber. A mature coconut has an outer covering made of fibrous material. This part of the coconut, called the husk, consists of a hard skin and a large amount of fibers embedded in a soft material. The fibers can be extracted simply by soaking the husk in water to decompose the soft material surrounding the fibers. This process, called retting, is widely used in the less developed countries. Alternatively, a mechanical process can be used to separate the fibers. Coconut cultivation is restricted to the tropical regions of Africa, Asia, and Central America.

b. Sisal fiber. In Australia, sisal fibers have been successfully used for making gypsum plaster sheets. A considerable amount of research has been carried out in Sweden for developing good quality concrete products reinforced with sisal fibers. These fibers are stronger than most of the other natural fibers, as can be seen from the table below.

c. Sugar cane bagasse fiber. Sugar cane is cultivated in both tropical and sub-tropical regions. Sugar cane bagasse is the residue remaining after the extraction of the juice and contains about 50 percent fiber and 30 percent pith with moisture and soluble solids constituting the remaining 20 %. In order to obtain good quality fibers, the pith and other solids are removed from the fibers. The properties of bagasse fibers depend, to a very large extent, on the variety of the sugar cane, its maturity, and on the efficiency of the milling plant.

d. Bamboo fiber. Bamboo belongs to the grass family and can grow to a height of 15 m with diameters varying within the range of 25 to 100 mm. It grows naturally in tropical and sub-tropical regions. Dried bamboo stems are commonly used for building temporary structures such as scaffolding. They may also be fabricated to form a continuous reinforcing material for concrete. Bamboo fibers are strong in tension and can be used as a reinforcing material. However, they have a high water absorption capacity, low modulus of elasticity, and special equipment may be needed to extract them from the stems.

e. Jute fiber. Jute is grown mainly in India, Bangladesh, China, and Thailand. It is grown solely for its fiber, which is traditionally used for making ropes and bags to transport grains and other materials ranging from cement to sugar. Strong in tension, jute fiber can also be used in a cement matrix. The process of obtaining jute fibers is very simple. Mature plants are cut and soaked in water for about four weeks, which completely decomposes the bark. The fibers thus exposed are then stripped from the stem, washed, and dried.

f. Other vegetable fibers. Of the various vegetable fibers, only a few have been found to be potentially suitable as reinforcing materials. The mechanical properties of the more promising fibers, namely elephant grass, water reed, plantain, and musamba, are listed. Investigations have also been carried out to explore the possibility of using other natural fibers such as palm fiber and akwara fiber as reinforcing materials for concrete. These fibers are usually removed manually from the stem of the plant.

g. Flax. Flax is a slender and erect plant grown mainly for its fiber. Both the tensile strength and the modulus of elasticity of flax are extremely high compared to those of other natural fibers.

Necessity of Fibers

1. It increases the tensile strength of the concrete.

2. It reduces the air voids and water voids the inherent porosity of gel.

3. It increases the durability of the concrete.

4. Fibers such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibres have a significant influence on the creep performance of rebars/tendons.

5. Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fibre and the concrete as the matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized.