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Strength and Fracture Properties of Hybrid Fiber Reinforced Concrete

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***Abstract*: 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 repairing and maintenance 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 reinforce concrete. The custom approach is to adhesively bond fiber 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. The main aim of this experiment is to study the strength properties of polypropylene fiber concrete for M20 grade with 0%, 1.5%, 5%, 7.5% and 10% by weight of concrete. Experimental program consisted of compressive strength test, split tensile strength test and flexural strength tests on conventional concrete and polypropylene fiber concrete. Polypropylene Fiber Concrete is an embryonic construction material which can be described as a concrete having high mechanical strength, Stiffness and durability. By utilization of Polypropylene fibers in concrete not only optimum utilization of materials is achieved but also the cost reduction is achieved. The samples with added Polypropylene fibers of 1.5 % showed better results in comparison with the others. The influence of polypropylene fibers has been studied in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. Fibers used in length of 12mm by cement weight in the mixture design. Hardened concrete properties such as: 7days, 21 days and 28 days compressive strength, splitting tensile strength, flexural strength, water absorption, and shrinkage were evaluated. Fiber addition was seen to enhance the physical and mechanical properties of lightweight concrete. Hence this hybrid fiber reinforced concrete with industrial waste fibers is doubly advantageous as it provides a superior performance without increasing the cost of the concrete**

***Key Wards*— Fiber reinforcement, high-strength concrete, mechanical properties, fracture energy**

I. INTRODUCTION

Concrete is a brittle, composite material that is strong in compression and weak in tension. The tensile strength of plain concrete is about 10% of its compressive strength. Cracking occurs when the concrete tensile stress produced from the externally applied loads, temperature changes, or shrinkage in a member reaches the tensile strength of the material. Formation of tensile cracks in reinforced concrete flexural members containing conventional, non-prestress reinforcement is usually unavoidable since concrete has a low tensile straining capacity. While cracks barely wide enough to be visible may be objectionable only because of appearance, cracks of greater width can be dangerous because of the possibility of corrosive agents attacking the steel reinforcing bars. Excessively widecracks can also that it may lead to failure of the structure. The deterioration of such structures is of great concern since the repairing and rehabilitation of these structures are time consuming and costly. Hence there is an intense need to take measures that can control the cracking of concrete and thus cause overall safety of a structure and increase its useful life. Use of short discrete fibers in cementitious composites (concrete) is one approach to mitigate the cracking and increasing the tensile straining capacity. The fiber reinforced concrete (FRC) contains randomly distributed short discrete fibers which act as internal reinforcement so as to enhance the properties of the cementitious composite.

II. BACKGROUND

Portland cement concrete is considered to be a relatively brittle material. When subjected to tensile stresses, non-reinforced concrete will crack and fail. Since mid 1800's steel reinforcing has been used to overcome this problem. As a composite system, the reinforcing steel is assumed to carry all tensile loads The problem with employing steel in concrete is that over time steel corrodes due to the ingress of chloride ions. In the northeast, where sodium chloride de-icing salts are commonly used and a large amount of coastal area exists, chlorides are readily available for penetration into concrete to promote corrosion, which favors the formation of rust. Rust has a volume between four to ten times the iron, which dissolves to form it. The volume expansion produces large tensile stresses in the concrete, which initiates cracks and results in concrete spalling from the surface. Although some measures are available to reduce corrosion of steel in concrete such as corrosion inhibitive admixtures and coatings, a better and permanent solution may be replace the steel with a reinforcement that is less environmentally sensitive. More recently micro fibers, such as those used in traditional composite materials, have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. FRC is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. Fibers help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength impact strength and eliminate temperature and shrinkage cracks. Several different types of fibers, both manmade and natural, have been incorporated into concrete. Use of natural fibers in concrete precedes the advent of conventional reinforced concrete in historical context However, the technical aspects of FRC systems remained essentially undeveloped. Since the advent of fiber reinforcing of concrete in the 1940's, a great deal of testing has been conducted on the various fibrous materials to determine the actual characteristics and advantages for each product. Several different types of fibers have been used to reinforce the cement-based matrices. The choice of fibers varies from synthetic organic materials such as polypropylene or carbon, synthetic inorganic such as steel or glass, natural organic such as cellulose or sisal to natural inorganic asbestos. Currently the commercial products are reinforced with steel, glass, polyester and polypropylene fibers. The selection of the type of fibers is guided by the properties of the fibers such as diameter, specific gravity young's modulus, tensile strength etc and the extent these fibers affect the properties of the cement matrix. The polypropylene fibre reinforced concrete(PPFRC) has seen limited applications in several structures including parking areas, drive ways, industrial floorings,water and other chemical storage tanks, walkways pavements, roof screeds, mosaic flooring, structural concrete and also in pre-cast slabs. The applications are primarily to inhibit the cracking. However due to the lack of awareness, design guidelines and construction specifications, its uses are limited by the local construction industry. Therefore there is a need to develop informationon the properties of PPFRC in which indigeneous polypropylene fibres are used.

TABLE 1

Fibres	Positive	Negative
Conventionalreinforcement steel	Provides structural integrity Widely used i.e. easy to implement with regard to guidelines &design codes. Thermal expansion normally equal to that of concrete. Inexpensive.	Might be difficult to produce effectively in arbitrary geometries. Specific concrete cover needed, i.e. not suitable for very thin structures
Fiber reinforcement	Can be added to concrete during mixing	Rarely used as primary reinforcement
Fiber reinforced polymer	Good durability with regard to corrosion. Can be used in thin concrete members.	Affected by degradation mechanisms e.g. UV- light and salts. Rare technology which can lead to high costs Generally brittle fracture. Fixed shape once produced. Thermal expansion differing from that of concrete, leading to restraint forces. Fire resistance needs to be carefully designed.

III. FABRICATION OF POLYPROPYLENE FIBER REINFORCED CONCRETE

Polypropylene fibers are added to the concrete in several different forms and by using various techniques. The fibers can be incorporated into concrete as short discrete chopped fibers, as a continuous network of fibrillated film, or as a woven mesh. The form of the available fiber decides the method of fabrication. Each and every method has its own limitations. The choice of the method is guided by the volume percentage of the fibers that can be obtained during fabrication using a particular technique Also it produced concrete panels reinforced with chopped mono-filament polypropylene fiber by a'spraysuction de- watering' technique. Fiber volume content up to 6% can be achieved by using the spray suction de- watering techniques. Composites incorporating chopped monofilament and chopped fibrillated polypropylene film are produced using a mixing, dewatering and pressingtechnique. Fiber volumes up to 11% have been obtained by mixing chopped fiber directly into the matrix at high water- cement ratios and then removing the excess water through suction and pressin

IV. LIMITATIONS AND SOLUTIONS

Natural fibers possess some disadvantages when considered as building materials such as variability in properties, less durability due to high moisture and chemical absorption, generation of concrete cracks due to swelling and volume changes, weakening due to alkaline environment of cement and poor interface between natural fibers and polymeric or cementitious matrices. Besides using low alkaline cement, some other approaches based on fiber modification have been reported to overcome the drawbacks of natural fiber such as treatment with alkali, silane and various water repelling agents. There are also very recent reports on the plasma modification of natural fibers. This technique usually reduces the water absorption of natural fiber either by removing hemicellulose and lignin or by imparting hydrophobicity. These fiber modification techniques were also found advantageous to improve the interface between natural fiber and various matrices. This study shows that conventional steel reinforcement cannot easily be set aside when designing load carrying concrete structures, as none of the other reinforcement types discussed can provide such integrity in all applications. Furthermore, conventional reinforcement also increases the applicability of the new construction concept devised, as it is well known and regulated by standards worldwide. However, alternative reinforcement techniques e.g. steel fiber reinforcement, can be included to contribute additional structural integrity in terms of ductility. Based on the evaluation of reinforcement alternatives, it was decided to continue developing a reinforcement solution for load-bearing tailor-made concrete structures by utilizing both conventional reinforcement and steel fiber reinforcement, separately or in combination. Textile reinforcement might be interesting; however, limitations are set by the exibility of the textile. It may, simply put, be impossible for robots to handle such materials.

V. ADVANTAGES OF COMPOSITES

- ❖ Composites are more brittle than wrought metals and thus are more easily damaged. Cast metals also tend to be brittle.
- ❖ If rivets have been used and must be removed, this presents problems of removal without Causing further damage.
- ❖ Repair at the original cure temperature requires tooling and pressure
- ❖ Composites must be thoroughly cleaned of all contamination before repair
- ❖ •Composites must be dried before repair because all resin matrices and some fibers Absorb moisture

VI OBJECTIVES

1. To study the effect of hybrid fiber with 0%,1.5%,5%,7.5% and 10% volume fraction by volume of concrete on normal concrete
2.To study the mechanical properties of hybrid fiber with different hybridization ratio at 0%,1.5%,5%,7.5% and 10% volume fraction of concrete
3. To evaluate the strain energy absorbed at its ultimate level for SFRC at 0%,1.5%,5%,7.5% and 10% volume fraction
4. To evaluate the strain energy absorbed at its ultimate level for PFRC at 0%,1.5%,5%,7.5% and 10%volume fraction
5. To evaluate the strain energy absorbed at its ultimate level for hybrid fibers at 0%,1.5%,5%,7.5% and 10% volume fraction with normal concrete

VII. OBJECTIVES AND APPLICATIONS TESTING OBJECTIVES

A) Workability
B) Compression Strength
C) Split Tensile Strength
D) Flexural Strength

1. To study the effect of hybrid fiber with 0.5% volume fraction by volume of concrete on normal concrete
2. To study the mechanical properties of hybrid fiber with different hybridization ratio at 0.5%volume fraction of concrete
3. To evaluate the strain energy absorbed at its ultimate level for SFRC at 0.5% volume fraction
4. To evaluate the strain energy absorbed at its ultimate level for PFRC at 0.5% volume fraction
5. To evaluate the strain energy absorbed at its ultimate level for hybrid fibers at 0.5% volume fraction with normal concrete.

VIII. APPLICATIONS

Polypropylene fibers are versatile and widely used in many industrial applications such as ropes, furnishing products packaging materials, etc. they are also used in p ckaging, labeling, carpets, textile, apparel markets, stationary, plastic parts, reusable containers, laboratory equipment automotive components, loud speakers, etc. Polypropylene fibers reinforced concrete is used in roads and pavements, drive ways, overlays and toppings, ground supported slabs, machine foundation, off shore structures tanks and pools etc

IX. CONCLUSION

- Polypropylene fibers reduce the water permeability, plastic, shrinkage and settlement and carbon depth
- Workability of concrete decreases with increase in Polypropylene fibers volume fraction. However, higher workability can be achieved with the addition of HRWR admisture even eith w/c ratio of 0.3.
- Polypropylene fibers enhance the strength of concrete, without causing the well known problems normally associated with steel fibres.
- The problem of low tensile strength of concrete can be overcome by addition of Polypropylene fibers to concrete.
- Notable increase in compressive strength is reported with addition of Polypropylene fibers.
- The failure is gradual and ductile in Polypropylene fibers reinforced concrete.
- The durability of concrete improves and addition of Polypropylene fibers greatly improves the fractures parameters of concrete.
- The compressive strength split tensile strength flexural strength and modyules of plasticity increase with the addition of fiber content as compared with convectional concrete.

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