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USE OF DISCRETE FIBERS IN ROAD CONSTRUCTION

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Abstract:

Concrete is strong in compression but weak in tension and brittle also. Cracks also start forming as soon as the concrete is placed. These 3 drawbacks don't permit the use normal concrete in pavements as they lead to lack of ductility along with fracture and failure. These weaknesses in concrete can be mitigated by using fibers as reinforcement in the concrete mix. Waste materials in the form of polyethylene and tires cause environmental pollution which leads to various health problems. Polyethylene and waste tires can be recycled and used effectively in the concrete as reinforcement in the fiber form. Polyethylene is a synthetic hydrocarbon polymer which can improve the ductility, strength, shrinkage characteristics etc. This paper deals with the effects of addition of polyethylene fiber on the properties of concrete. Polyethylene and tire fibers were cut into the size of 30mm x 6mm and they were used 1.5% each by volume. Grade of concrete used were M30, M35 and M40. IRC 44:2008 was followed for the design of concrete mix. In this study, the results of the Strength properties of Polyethylene fiber reinforced concrete have been presented. 4 point bending test and double shear test were performed in the laboratory for flexure and shear strength determinations. There was seen an increase of 18% in the 28 day compressive strength along with an increase of 39% in flexure and 32% in shear strength. 22% decrease in 4 point bending test and 36% decrease in double shear test in deflection was found out from the experiments. Theoretical analysis of deflection was carried out by the help of energy methods. Practical values were verified with the theoretical values within the permissible limits. Finally it can be concluded that polyethylene and tire can be used effectively in reinforced cement concrete.

Key Words : Cracks, Concrete, Fibers, Polythene, Compressive Strength.

I. INTRODUCTION

For a developing nation such as India, road networks play a crucial role in providing a durable and comfortable surface for vehicles. Pavements are mostly made using bitumen. However, in certain situations concrete pavements are also preferred. Many additives have been explored for beneficial use of concrete as a paving material. A recent research has shown that fiber reinforced concrete (FRC) can be used for the construction of pavements as it is found to be very good in strength and it also exhibits other desirable properties. The definition of FRC given by ACI Committee 544 is "fiber reinforced concrete is a concrete which is made of cements containing fine and coarse aggregates along with water for obtaining cementious properties and discontinuous fibers". The fibers used are of various types such as steel fibers, polymer or natural fibers etc. . As said earlier, fiber reinforced concrete is that form of concrete where fibers are put into the concrete as reinforcement in order to increase the strength characteristics and other mechanical properties of the concrete. Fiber reinforced concrete is not just provided for local strengthening in tensile region but it is provided for obtaining a gain in compression and tension along with reduced deflections and shrinkage and increased ductile property.

Apart from the above mentioned properties, polymeric fibers also help in corrosion reduction. Commonly, Recron 3s, polyester and polypropylene have been used for the purpose of FRC. Recently, other forms of recycled fibers like plastic, disposed tires, carpet waste and wastes from textile industry are also being adopted for the same purpose. Basic function of these fibers is to act as crack arresters. Fibers help in resisting the minor cracks and would not let them grow into macro cracks. Hence, the material transforms into a material with improved ductility and toughness to failure .

Fig.2: Steel fiber

Fig.2: Polypropylene fiber

Since it has been established that fiber introduced concrete has the property of obtaining extra strength in flexure, compression, fatigue and impact, it can successfully be reinforced in concrete to get more strength as a whole and use it for pavements as concrete in itself is weak in tension and impact. Fibers in combination with concrete also results in a mix with improved early resistance to plastic shrinkage cracking, reduced water absorption, greater impact resistance, enhanced flexural strength and tensile strength of concrete and thereby protects the concrete from drying shrinkage cracks. Standard documents such as IS: 456:2000 – Amendment No.7, 2007 and IRC: 44-2008 – Cement Concrete Mix Designs for Pavements with fibers, IRC: SP: 76:2008 – Guidelines for Ultra-Thin White Topping with fibers, Vision: 2021 by Ministry of Surface Transport, New Delhi etc. include the use of polymer fibers with concrete [27]. Many national bodies such as Central Public Works Department (CPWD), Airport Authority of India, Military Engineering Services, Defense Airfields, NF/Southern Railway, ISRO (Bangalore) etc. have also approved the use of polymer fiber reinforced concrete.

USE OF WASTE POLYETHYLENE AND TIRES

Plastics are very strong and non-biodegradable in nature. The chemical bonds in plastics make it extremely sturdy and impervious to ordinary common techniques of degradation. The daily use of plastics has increased very rapidly and it has become a common habit of people to just throw out the plastic and causing environmental pollution. Over 1 billion tons of plastic have been produced since 1950s, and the same is likely to remain as such for many years [28]. These wastes get mixed with MSW or they are simply thrown causing nuisance to the society. There is a big need of recycling of the plastics as well waste tires because we don‟t have any other option of disposing them without securing environment from pollution. For example, there are two processes for the disposal of wastes: land filling and incineration. If the wastes are simply dumped, they cause soil and water pollution and if they are incinerated, they cause air pollution. Hence, there is a need to recycle the

wastes into something useful which will not hamper the environment and the process in which it is used

OBJECTIVE

The present work is aimed at using two polymeric waste materials, such as polyethylene and tire fibers as reinforcement in concrete pavement. The basic objective of this work is to assess the advantages of using such waste materials such as increase in compressive, flexure and shear strength and decrease in deflection characteristics of the resultant concrete and also the determination of the deflection in the laboratory testing then its comparison to the theoretical deflection and check whether the errors are in the permissible limits of 20%.The main goal of the study is to utilize waste materials polyethylene and tire to achieve greater concrete strength properties in order to recycle them into something very useful and helping in reducing the environmental impact that the both of them have.

EFFECTS OF FIBER ON CONCRETE

To resist plastic shrinkage cracking and drying shrinkage cracking the fiber are provided as reinforcement in concrete. The sponginess of concrete and reduction of bleeding of water can also be achieved by fibers. The resistance to impact, abrasion can be provided by various fiber in concrete.Fibers help to recover the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eradicate temperature and shrinkage fissures. Each fiber used in concrete benefits to avoid the tiny fissures that can occur when concrete‟s tensile strength is weakest. FRC satisfies two of the much-demanded requirements of pavement material in India, economy and reduced pollution. The other many advantages of fiber are low maintenance cost, less fuel intake, longer life, improved load capability, impermeability of water over flexible pavements and good riding feature . One of the properties that fiber provides to concrete is the energy absorption ability to the concrete and the surge in its ductility and the preventing of the crack development. If the length or amount of the fiber is increased, the energy concentration measurements of plate concretes also increase. It has been observed that the incorporation of steel fibers and polypropylene fiber shows higher strength than non fiberios concrete. The use of fibers also recalibrates the behaviour of the fiber-matrix composite after it has cracked through refining its toughness .

II. MATERIAL USED

Basic materials

The basic materials which compose concrete are:

1. Water
2. Cement
3. Fine aggregate
4. Coarse aggregate
5. Admixture

In case of polymer fiber reinforced concrete fibers are added. For this experiment 2 types of fiber are chosen. The fibers to be used in the concrete mix are:

1. Polyethylene fiber
2. Tire (Nylon) fiber

Both fibers to be used in concrete matrix will be made from the waste materials. The wasted pouches of OMFED milk will be used for making the polyethylene fiber whereas wasted tire will be used to prepare nylon fiber.

WATER

Water is the most important material in concrete. It performs the following roles in concrete matrix:
It gives cement the adhering property. The quality, quantity, stability and rate of formation of the adhesive material that binds the aggregates depend on the quality and quantity of water added. It also controls the workability of concrete. The more the water content (up to certain limit) the more is the workability.

CEMENT

Cement is a material which when combined with water exhibits cohesive and adhesive properties that helps in holding the aggregates together to form a concrete mass. It is also called as hydraulic cement as it gets its adhering property in an exothermic hydration process and forms a water resisting material.There are different types of cement. Some common types of cement are:

ORDINARY PORTLAND CEMENT (OPC)

It is a normal cement made by burning calcareous (Calcium carbonate) and argillaceous (Clay) together at a very high temperature and then grinding the resulting calcined product known as clinker with a minute amount of gypsum (for quicker hardening) into fine powder.
There are three grades of OPC available:

- 33 grade OPC (follows IS 269)
- 43 grade OPC (follows IS 8112)
- 53 grade OPC (follows IS 12269)

FINE AGGREGATE

Regular sand is generally used as the fine aggregate. In some cases quarry dust or dust from stone crushers are also used as fine aggregate. It contributes to a major portion of concrete matrix. Both natural and artificial sand can be used as fine aggregate.

ADMIXTURES

The admixture is a chemical compound mixed with other ingredients of concrete before or during mixing to make concrete achieve certain required properties.
Chemical admixtures are generally used for following reasons:

1. Reduce the cost of construction.
2. Modify properties of hardened concrete.
3. To retain quality of mix during transportation and placing.
4. Achieve certain properties after or before time.

FIBERS

These are short discrete materials, may be metallic or polymeric, used as composing reinforcement for concrete structures. These are mixed with other components of concrete to form the matrix and add certain properties to it.
These are generally used to:

1. Improve tensile strength
2. Increase impact, crushing and abrasion resistance.
3. Increase flexural and shear strength.
4. Reduce the effect of temperature change on concrete.

Polymer fibers are corrosion resistant and can be used in saline environment.

MATERIAL PREPARATION

The materials used in the concrete mix are:

1. 53 grade OPC.
2. Zone – iii sand as fine aggregate.
3. 10mm and 20mm coarse aggregate.
4. Sikament – 170 admixture
5. Polyethylene fiber
6. Tire fiber

The aggregates of different grade to be used for preparing concrete mixes are sieved through different IS Sieves and they are kept in different containers with proper marking.

PREPARATION OF FIBERS

The polythene used in OMFED milk packets is used as raw material for preparation of the fiber. These polythene packets are collected; they are washed and cleaned by putting them in hot water for 3- 4 hours. They are then dried.

Similarly waste tires are collected. The steel wires inside them are striped out of the tires. They are washed in hot water and then dried. The dried polyethylene packets and the tires are cut into pieces of size 30mm x 6mm size. This is to ensure that when the fibers are mixed with the cement and aggregate the mixing will be proper and the fibers will be randomly distributed over the concrete matrix evenly.

CERTAIN PROPERTIES OF MATERIALS USED:

- Specific gravity of cement = 3.04
- Grade of cement = OPC 53
- Specific gravity of fine aggregate = 2.6
- Zone of sand = Zone – iii
- Specific gravity of coarse aggregate = 2.7
- Dimension of fibers = 30mm x 6mm
  Specific gravity of polyethylene = 0.94
  Specific gravity of tire = 1.14

The above data is used for mix design and batching of material to prepare concrete of required characteristic strength.

III. EXPERIMENTAL WORK

METHODOLOGY

To study the various parameters of polymeric fiber reinforce concrete that affect the service life of a pavement with minimal maintenance, the following experiments are needed to be carried out:

1. **Test of aggregates**

- Abrasion resistance of aggregates
- Impact resistance of aggregates
- Crushing resistance of aggregates

2. **Test of concrete**

- Physical inspection of concrete
- 28 day compressive strength test
- Flexural strength test
- Shear strength test

The flexural strength test to be conducted is 2-point load test (4-point bend test) and the shear strength test to be conducted is double shear test.

Table-1: Test on aggregates

L.a. abrasion test	Impact value test	Crushing value test
Maximumvalue allowed in fiber introduced concrete = 30%	Maximumvalue allowed in fiber introduced concrete = 45%	Maximumvalue allowed in fiber introduced concrete = 30%
Test results on average= 23.6%	Test results on average= 21.8%	Test results on average= 23.6%

MIX DESIGN

The proportion of concrete mix is to be designed to ensure the workability of concrete and to make the concrete possess the required strength, toughness and durability at the hardened condition.

The design mixes M30, M35 and M40 are carried out in accordance to codes IRC 44:2008. The specifications of material used are

- Cement :- OPC 43 grade
- Fine aggregate :- Zone 3
- Coarse aggregate :- Crushed rock (10mm and 20mm)
- Admixture :- Plasticizer
- The water cement ratio for design was chosen in between 0.4 to 0.45.
- The coarse aggregates 10mm and 20mm are used in ratio 90 to 10.
- In case of fiber introduced concrete, the polyethylene fibers and tire fibers each are used in 1.5% v/v of concrete mass.
- Specific gravity of polyethylene = 0.94
- Specific gravity of tire (without steel wires) = 1.14

Table-2: Comparison of theoretical and experimental deflection

Type of concrete	Grade of concrete	Mean theoretical deflection (mm)	Mean experimental deflection (mm)	Percentage of variation
Conventional concrete	M30	0.0945	0.09	4.76
	M35	0.091	0.085	6.59
	M40	0.088	0.077	12.5
fiber introduced concrete	M30	0.0796	0.07	13.7
	M35	0.0786	0.065	17.3
	M40	0.0756	0.061	19.31

IV. CONCLUSIONS

The following inferences have been drawn from the experiments done on concrete with polyethylene and tire fibers:

- There is a gain of 17.93%, 15.98% and 16.1% in compressive strength of M30, M35 and M40 grade concrete respectively.
- Gain in flexural strength were found to be 37.34%, 39.70% and 39.66% for M30, M35, and M40 respectively. And respective reduction in deflection were 22.22%, 23.53% and 20.78%.
- There is a significant amount of gain found in shear strength. Gain in shear strength were found to be 31.33%, 32.56% and 32.72% for M30, M35, and M40 respectively. And respective reduction in deflection were 38.69%, 36.23% and 33.75%.
- From the above observations it can be seen that the gain in flexural strength is more than gain in shear strength. However the center point deflection due to shear force is much more reduced than deflection due to flexure.
- From theoretical analysis of results it is observed in case of 4-point bend test that the percentage of variation of deflection in fiber introduced concrete is much higher than that of conventional concrete and it goes on increasing with increase in characteristic strength for both conventional concrete and fiber introduced concrete.
- The percentage of variation of deflection in conventional concrete is found to be 4.76%, 6.59% and 12.5% for M30, M35 and M40 respectively and for fiber introduced concrete it is found to be 13.7%, 17.3% and 19.31%.
- However in case of double shear test that the percentage of variation of deflection in fiber introduced concrete is nearly equal to that of conventional concrete and it goes on increasing with increase in characteristic strength for conventional concrete and

decreases for fiber introduced concrete beams.

- The percentage of variation of deflection in conventional concrete is found to be 12.19%, 17.86% and 19.5% for M30, M35 and M40 respectively and for fiber introduced concrete it is found to be 16.98%, 13.72% and 10.41%.

From the above mentioned findings it can be concluded that the wasted polyethylene and tire fibers can be used effectively to positively influence the mechanical properties of the fiber reinforced concrete.

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