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Use of Discrete Fiber in Road Pavement

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Abstract - *Concrete roads are very conventional roads and can provide a safe and smooth flow of traffic. Due to the use of concrete in roads it has become quite an advantage for a greater life span and low maintenance. But concrete roads may undergo cracking, spalling and concrete is weak in tension and also little ductility. So as to mitigate these problems Inclusion of fiber can provide a great benefit to concrete pavement. This Research "The Use of Discrete Fiber in Road Pavements" is done so as to improve the quality of concrete pavement. In this research the fiber used is polypropylene fiber and polyester fiber. The concrete mix used is M25. In one specimen only plain, concrete mix is tested for compressive strength, flexural strength and split tensile strength. In second specimen 1.8% of polypropylene fiber is added with the concrete mix and again tested for the same three tests. In the third sample 0.5% of polyester fiber is used in the concrete mix and tested for compressive strength, flexural strength and split tensile strength. In fourth specimen both 1.8% of polypropylene fiber and 0.5 % of polyester fiber is mixed with the concrete mix and tested for the three tests It was seen a great increment in the strength which showed the addition of fiber can improve the quality of concrete.*

Key Words: **Concrete pavement, compressive strength, flexural strength, split tensile strength, polypropylene fiber, polyester fiber.**

1. INTRODUCTION

Roads are chief means of transportation. It is used for the safe movement of vehicles. It is important to maintain for its long service. For the safe movement of traffic, the road pavement should be durable enough. The most important purpose of a pavement is to transfer loads to the sub-base. The benefit of using rigid pavement is its sturdiness and capability to tolerate hard environmental conditions. A rigid pavement is created from cement concrete or reinforcement concrete slab. A rigid road pavement provides an efficient, comfortable, and cost-effective design for the roadways and highways. Due to its high flexural stiffness and mechanical resistance, a rigid pavement allows to homogeneously transfer the vehicular loads to the underlying layers, preventing load and stress concentrations in the subgrade. But concrete pavements may suffer quick weakening, in the form cracks, fissures and failures, which can cause loss of serviceability and unsafe driving situation. This occurrence is chiefly due to the stiff behavior of cement concrete together with its little resistance to fatigue phenomena and its small resilience. Shrinkage cracking of concrete is a major problem in basic cement concrete pavements. However, these aspects can be diminished through the implementation of fibers. Fiber reinforced concrete (FRC) is a concrete which contain fibrous materials that increase the structural integrity of concrete. Different sorts of fibers can be used in concrete to mend the properties of concrete. Each fiber has the ability to improve produce greater the quality of concrete. The fiber is added during the mixing of the concrete blend. The amount to be added is expressed in percentage to the total volume. . The fibers that can be used in concrete pavements to improve their strength are steel fiber, polypropylene fiber, and synthetic fiber. Each fiber has different properties which can enhance the quality of concrete. It depends on the quantity of the fiber added to the concrete mix by which it can improve the behavior of the concrete

1.1 Problems in Concrete

The concrete is quite strong in compressive but weak in tension. Concrete is categorized by brittle failure, the almost complete harm to the loading ability, once it begins to fail. There are many defects in concrete pavement but the most common of them is cracking. Cracking can be of many types such as plastic shrinkage cracking, drying shrinkage cracking, expansion concrete cracking and many more. The plastic contraction cracking is common in concrete pavement. When concrete is in plastic state that is it is fully saturated but when the water leaves sooner or later, it leaves a big void amongst the solid particles. These voids thus make the concrete fragile and even more prone to cracks. The drying shrinkage happens when the water starts to evaporate from an exposed surface and the depth of slab causes strain by which tensile pressures are induced. Due to this drying shrinkage cracks are provided on the exterior of the concrete pavement. In concrete, micro-cracks grow before structure is loaded due to drying shrinkage and other reasons of volume change. The micro-cracks open up when the concrete is fully loaded and inelastic deformation occur in concrete due to the micro-cracks.

1.2 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[1].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 [2]. 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 [3].

1.3 Fiber Used

Polypropylene Fiber

The Polypropylene fiber, correspondingly known as polypropene or PP, is a synthetic fiber, altered from 85% propylene, and is used in a variety of uses. . As we know concrete provides a strong road pavement but it may undergo plastic and shrinkage cracking. So to mitigate these problems polypropylene fiber-reinforced concrete (PFRC) has provided for improving these deficiencies. The accumulation of fibers in concrete increases the stiffness, flexural strength, tensile strength and bearing strength. The polypropylene fiber also reduces the steel reinforcement requirement and also improves the ductility.

Fig -1 Polypropylene fiber

POLYESTER FIBER

Polyester fiber is an artificial fiber which can be used in the pavement construction to avert micro cracking and also helps to increase flexural strength, compressive strength of pavement. These fiber also reduce drying shrinkage as well. The use of polymeric fiber has been increased nowadays because there is no menace of decay and is very cost effective. There is no risk of corrosion because polyester fiber are alkali resistant. Generally polyester fibers can be used in industrial and warehouse floor, pavements and even in overlays and pre-cast products. Polyester macro-fibers can be used as a true substitute to welded wire fabric, steel fibers and conventional light gauge steel reinforcing for pre-cast slabs on grad and shotcrete applications [4]. The properties of polyester fiber-reinforced concrete concluded that by adding polyester fiber at 1% (by size) of concrete improved the impact strength by 75%, the split tensile strength by 9%, and the flexural strength by 7%, and the compressive strength by 5% [5].

Fig-2 Polyester fiber

1.4 Objectives

- To study the variation in compressive strength in concrete pavement with the incorporating the mixture of different amounts of polypropylene and polyester fibers.
- To control the cracking due to plastic shrinkage and to drying shrinkage which is the major problem in the concrete pavements
- To study the changes in tensile strength in concrete pavement with the addition of mixture of different amounts of polypropylene and polyester fibers.
- To compare the changes in strength in concrete with and without fiber.

2. METHODOLOGY

Mixing of FRC can be accomplished by lots of methods. Most importantly the mix should have a unvarying scattering of the fibers in order to avert segregation or balling of the fibers during mixing. Most balling happens for the duration of incorporation of fiber process. Upsurge of aspect ratio, capacity percentage of fiber, and size and quantity of coarse aggregate will surge the balling affinities and decline the workability. So as to coat the huge surface area of the fibers with paste, practice directed that a water cement ratio between 0.4 and 0.6, and least cement content of 400 kg/m are required. Matched to plain concrete, fiber Ferro concrete mixes are generally characterized by higher cement factor, higher fine aggregate content and smaller size coarse aggregate. A fiber mix commonly involves more vibration to unite the combination. External vibration is better to prevent fiber segregation. Metallic trowels, tube floats and rotating power floats are often wont to polish the surface. Accumulation of fibers to concrete influences it is mechanical properties which significantly depend upon the sort and percentage of fiber. The alike equipment and procedure as used for standard concrete also can be used. The tests required are Flexural test, Compressive strength test, Split tensile strength test. All the tests were conducted on a set of 4 specimens for each mixture. The fibers used in the test will be polyester and polypropylene. The concrete grade used is M25 grade. One specimen will be simple conventional concrete, other with 0.5 % polyester, other with the addition of 1.8% polypropylene and the last specimen with the mixture of both the fibers. All these specimen are compared for their mechanical properties. The ordinary Portland cement issued in all mixtures. The location for the research work is Residency Road Srinagar.

2.1 Materials

In order to make proper mix of Fiber Reinforced concrete Following materials are to be used:

1) Cement: In this test Khyber cement Grade M53 OPC is used. When water is added to it paste is formed which hardens with time. This cement grade is used for focused works such as pre stressed concrete components, precast items such as paving blocks, building blocks, etc., runways, concrete roads, bridges, and other RCC works where the grade of concrete is M25 and above

2) Aggregates: Aggregates are one of the vital constituents of the concrete which gives body to the concrete and also reduce shrinkage. For a good concrete mix aggregate need to be clean, hard, and strong. Generally two types of aggregates are used Fine Aggregate and Coarse Aggregate.

a) Fine Aggregate: These are typically sand or crumpled stone that are less than 9.55mm in diameter. Sand was used as a fine aggregate. Fine aggregate is used to improve workability and consistency. The general fineness of sand is given by variable called fineness modulus. The fineness modulus of sand varies from 2.0 to 4.0.

b) Coarse aggregate: These are particulates that are greater than 9.55mm. Coarse aggregate used for this research is 20mm.

3) Fiber: The fiber used for the test are Polyester and Polypropylene. These fibers have hydrophobic surface. Usage of these fibers as reinforcement diminishes permeability, shrinkage resistance, mends both compressional and tensile strength of concrete.

The fiber used for this test were Polypropylene and polyester fiber

a) Polypropylene fiber: The polypropylene fiber is brought online from Ahmadabad. The fiber length used is 20mm with tensile strength of 0.67 KN/m2, specific gravity 0.92 g/cc, Melting point 1650 and elongation 12 to 17%.

b) Polyester fiber: The polyester fiber is brought online from Surat Gujarat. The Grade standard A, size 125gram is used.

4) Water: The water used should be free from impurities so as it does not affect the mix. If the water contains extensive amounts of chlorides may bring about efflorescence and dampness. So the water utilized having pH esteem value 7.0 and free from salts.

2.2 Mix Proportion

- Grade designation = M25
- Type of cement = Ordinary Portland Cement grade M53
- Max nominal size of the aggregate = 20mm
- Min cement content = 330 kg/cu-m
- Max W/C ratio = 0.55
- Type of aggregate = Crushed angular

2.3 Test Procedure

Compressive Strength Test

In this test, cubes were casted and the dimension of these cubes was taken as 150*150*150mm.In first mold only conventional concrete mix with M25 mix design was prepared. The second cube with same dimension was prepared with the incorporation of polypropylene fiber of 1.8%. The third cube with same mix proportion was made with the inclusion of polyester fiber of 0.5% and the last cube was prepared with the mix design with the addition of both polypropylene and polyester fiber with the same percentage 1.8% and 0.5%. The casting molds are chosen to be made of cast iron and must be cleaned with oil on inner side for easy removal of cubes. The specimen must be cast in 3 layers (5cm each) and appropriately compacted in order that honeycombing creation does not take place. The casted specimens are kept for 24 hours until it sets. After setting the specimens are detached from the mold and submerged underwater for stipulated time. The cube test for Compressive strength was done on 7 and 28 days respectively. Before placing on the UTM the specimen were completely dried. Then these testing specimens were placed in the space between bearing surfaces. The loading is applied axially on specimen without any shock and increased at the rate of 140kg/sq. cm/min. till the specimen downfall. Due to the constant application of load, the specimen starts cracking at a point & final failure of the specimen is noted.

Flexural Strength Test

For flexural strength test beam samples of dimension 100x100x500 mm were casted. These flexural strength specimens were tested under four point loading as per I.S. 516-1959, using universal testing machine. In this test the required apparatus is mold in which specimen is casted, tampered rod for tamping purpose and flexural testing machine. The test specimen were prepared by filling the concrete into the mold in 3 layers of almost equivalent thickness. In first mold only conventional concrete mix with M25 mix design was prepared. The second cube with same dimension was prepared with the addition of polypropylene fiber of 1.8%. The third cube with same mix proportion was made with the addition of polyester fiber of 0.5% and the last cube was prepared with the mix design with the addition of both polypropylene and polyester fiber with the same percentage 1.8% and 0.5%. Each layer was tampered 35 times using the tamping bar as specified above. Tamping ought to be distributed evenly over the entire cross-section of the beam mold and all the way to the depth of each layer. Then the bearing surfaces of the supportive and loading rollers were organized, and any slack sand or other material from the surfaces of the specimen was removed when they were to make contact with the rollers. Circular rollers manufactured out of steel having cross section with diameter 38 mm were used for giving support and loading points to the samples. The span of the rollers shall be at least 10 mm more than the width of the test specimen. An over-all of four rollers were used, three out of which shall be capable of rotating along their own axes. The sample which was kept in water was tested instantly on elimination from water; whilst they are still damp. The test specimen was positioned in the machine fittingly centered with the longitudinal axis of the sample at right angles to the rollers. For molded specimens, the mold filling direction shall be normal to the direction of loading. The load was applied at a rate of 180 kg/min for the 10.0 cm specimens.

Split Tensile Strength

In this test the sample size is cylinder of diameter 15 cm and height of 30 cm. The mold used is metal with mean internal diameter of the mold is 15 cm ± 0.2 mm and the height is 30 +/- 0.1 cm. The molds were coated with a thin film of mold oil before use to prevent adhesion of concrete. All the 4 concrete mix were placed into the molds in layers of almost 5 cm thickness. Each layer was compacted either by hand. After packing the top layer, the external of the concrete was done level with the top of the mold, using a trowel and was enclosed with a metal plate to avert departure of water. The test specimens were kept in a place at a temperature of 27° +/- 2°C for 24 hrs. After this time, samples were detached from the molds to be sunken in unpolluted fresh water for 28 days. The water was changed every 7 days. . After curing the water was wiped from the surface of specimen, then by using a marker diametrical lines were drawn on the two ends of the specimen to verify that they are on the same axial place. Then dimensions of the specimen was measured. The plywood strip was reserved on the lower plate and the specimen was positioned. The sample was aligned so that the lines marked on the ends are vertical and centered over the bottom plate. Then the further plywood strip was located above the specimen and the upper plate was taken down to touch the plywood strip. The load uninterruptedly without shock at a rate of approximately 14-21 kg/cm2/minute (Which corresponds to a total load of 9.9 ton/minute to 14.85 ton/minute). Then the breaking point was noted for each specimen.

3. RESULT

Table -1: Compressive Strength Test

S.NO.	DESCRIPTION	7 days Avg. (N/mm2)	28days Avg. (N/mm2)
1	Normal concrete Mix	22.63	36.33
2	Concrete mix with 1.8% polypropylene fiber	23.76	38.19
3	Concrete mix with 0.5% polyester fiber	47.55	50.65
4	Concrete mix with both 0.5% and 1.8% of polypropene and polyester fiber	48.68	52.51

Table -2: Flexural Strength Test

S.NO.	DESCRIPTION	7days Avg.(N/mm2)	28 days Avg. (N/mm2)
1	Normal Concrete Mix	4.53	5.87
2	Concrete Mix with 18% of polypropylene fiber	4.96	6.23
3	Concrete Mix with 0.5% of Polyester fiber	6.5	7.8
4	Concrete mix with both 0.5% and 1.8% of polypropene and polyester fiber	6.85	8.65

Table-3: Split Tensile Strength Test

S.NO.	DESCRIPTION	7 days Avg. (N/mm2)	28 days Avg. (N/mm2)
1	Normal Concrete Mix	3.56	4.9
2	Concrete Mix with 18% of polypropylene fiber	3.78	5.61
3	Concrete Mix with 0.5% of Polyester fiber	4.55	5.28
4	Concrete mix with both 0.5% and 1.8% of polypropene and polyester fiber	4.87	5.94

4. CONCLUSIONS

- The Compressive Strength of Normal concrete mix is less than the rest of the three mixes but the mix of concrete with polyester and polypropylene increased the most compressive strength of the concrete.
- The flexural strength of Normal concrete is less than the other three mixes but the concrete mix with 0.5% polyester and the mix with both the polypropylene and polyester showed a great increase in the flexural strength in the concrete mix.
- The split tensile strength of Normal concrete mix is less than the other three but only the concrete with polyester fiber of 5% and the mix of both polypropylene and polyester increased the strength.
- The addition of polyester fiber in concrete showed a great increment in the strength than the polypropylene fiber.
- The difference between the strength increment in concrete mix with polyester fiber and the concrete mix with both the polyester fiber and polypropylene fiber is not so much high.

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