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# Strength Evaluation of Cement Concrete Pavement by Using Polypropylene and Polyester Fiber as Reinforced Material

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***Abstract:*** **Concrete has the largest volume in present construction work and it is expected that there will be no other option for concrete in the upcoming time. Since such as excessive volumes of concrete are being used for newly construction work, it is autocratic to produce better quality of concrete that will be long lasting with increase mechanical properties to enhance the service life of any structure.It is not feasible to alter its inherent breakable essence and the need of any tensile strength of concrete structure. In this condition, fibre reinforced concrete (FRC) look to be a realistic alternative. In this research study main focus on the practicability of using polypropylene fiber (pp) and polyester fiber as subordinate reinforcement to concrete to change its brittle nature. In this study M25 grade of concrete was used. Accordingly, various percentages of polypropylene fiber and polyester fiber were put into concrete and a sequence of lab experiments were control to explore the use of polypropylene fiber and polyester in cement concrete pavements. In first sample only plain, concrete mix is tested for compressive strength, flexural strength. In second sample 1.8% of polypropylene fiber is added with the concrete mix and again tested for the same three test. In the third concrete sample 0.5% of polyester fiber is used in the concrete mix and tested for compressive strength, flexural strength and split tensile strength of cement concrete. In fourth concrete sample 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 compressive strength, and flexural strength which showed the addition of fiber can improve the quality of cement concrete pavement.**

***Index Terms*** **- Polypropylene fiber, Polyester fiber, Rigid Pavement, Compressive Strength, Flexural Strength, CTM**

## I.0 Introduction

### 1.1Background

Present time roads are a necessary part of our life. Road transportation is the most widely used mode of transportation at present time, and a country's development is often measured in terms of its total constructed road. Pavements are designed engineered structures and are important for our everyday life, industries, commercial and trade, and defense also. Like any other engineering structure, pavements are expected to be adequately strong and durable for their design life. They are expected to function properly by providing a smooth surface for the traffic under various conditions of the environment. In order to ensure this, roads must be well designed, constructed, well maintained, and managed properly. Pavements can be classified into two type's flexible and rigid pavements. Pavement consists of different layers, more so in the case of flexible pavements than concrete ones. From the bottom up, these layers are known as the sub grade, sub base, base course, and binder and or surface course. There are certain pavements with asphalt surface layers on top of the concrete layers. The benefit of using rigid pavement is its strong and ability to bear hard environmental conditions. A cement concrete pavement is created from cement concrete slabs or reinforcement concrete slab. A cement concrete pavement provides an efficient, rapid, comfortable, and cost effective design for the roadways. Due to its high flexural stiffness and mechanical resistance, a cement concrete pavement allows to homogeneously transferring the wheel loads to the underlying layers, preventing load and stresses concentrations in the sub grade. But cement 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 cement concrete pavements. However, these aspects can be diminished through the implementation of fibers. FRC is a concrete which contain fibrous materials that increase the structural integrity of concrete. Different types of fibers can be used in concrete to mend the properties of concrete. fiber has the ability to improve produce greater the quality of concrete structure. 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 cement concrete pavements to improve their compressive and flexural 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.

### 1.2 Problems identification in Cement Concrete Pavement

The concrete is quite strong in compression zone but weak in tension. Concrete is designate by brittle failure, the almost complete harm to the loading ability, once it begins to fail. There are many inadequacy in cement 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 cement concrete pavement. When concrete is in plastic state that is it is fully soaked but when the water leaves sooner or later, it leaves a big void amongst the solid particles. These voids thus make the concrete brittle and even more prone to cracks. The drying shrinkage happens when the water starts to vaporized from an exposed surface and the depth of concrete slab causes strain by which tensile pressures are induced. Due to this drying shrinkage cracks are provided on the exterior of the cement concrete pavement. In concrete, micro cracks extend before structure is loaded due to drying shrinkage and other reasons of volume change. The micro cracks open up when the concrete beam is fully loaded and inelastic deformation occur in concrete due to the micro cracks.

### 1.3 Effects of Fiber on Cement Concrete Pavement

To resist plastic shrinkage cracking and drying shrinkage cracking the fiber is 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, flexural strength and eradicate temperature and shrinkage cracks of cement concrete. Each fiber used in concrete benefits to avoid the tiny cracks that can occur when concrete's tensile strength is weakest. Fiber reinforced concrete satisfies two of the much-demanded requirements of pavement material in India, economy and reduced pollution. The other many advantages of fiber are less 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 notice that the incorporation of polyester fibers and polypropylene fiber shows higher strength than non fiberios concrete. The use of fibers also developed the behavior of the fiber-matrix composite after it has cracked through refining its toughness.

## II. MATERIAL AND METHODOLOGY

In order to make proper mix of fiber Reinforced concrete following materials are to be used:

### 2.1 Cement

The Aditya Birla brand of Ordinary Portland cement (OPC) of grade-43 used in this study was purchased from the local market. Cement is an artificial material, generally available in powder form, which can be made into paste form by the mixing of water and it will set into solid mass when it is moulded or poured.

**Table No 2.1.1 Physical Properties of OPC**

| S No | Properties | Value |
|---|---|---|
| 1 | Specific Gravity | 3.12 |
| 2 | Normal Consistency | 29% |
| 3 | Initial Setting time | 65min |
| 4 | Final Setting time | 275 min |
| 5 | Fineness | 330 kg/$m^2$ |
| 6 | Soundness | 2.5mm |
| 7 | Bulk Density | 830-1650 kg/$m^3$ |

### 2.2 Sand

Fine aggregate is a naturally occurring granular material. Sand is collected of finely divided rock and mineral particles. The main ingredient of sand is, in non-tropical coastal settings and inland continental settings, is silica (SiO2), usually it is in the form of quartz. It is the most usual mineral resistant to weathering. It is used as fine aggregate in concrete and mortar. Sand is a collection of grains of mineral matter derived from the disintegration of rocks. Sand is specifying from gravel only by the size of the particles or grains, but is differ from clays which contain organic materials. Sands that has been and separated from the organic material by winds or by the action of currents of water across arid lands are generally quite uniform in size of the grains. Commonly, commercial sand is obtained from sand dunes formed by the action of winds and from riverbeds.

### 2.3 Coarse Aggregate

Crushed stone aggregate with particle size less than 20mm size was used for the present investigation. The specific gravity of the coarse aggregate was tested as per IS 2386:1963 (PART 3) and it was found to be 2.89. Aggregates are immobile granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are a basic ingredient in concrete. For an actual concrete mix, aggregate needs to be cleaned, hard, strong particles unconfined of absorbed chemicals and other fine materials that could end the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are split into two distinct categories--fine and coarse. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the residue. 20mm size of Coarse aggregate was used for this study.

### 2.4 Fiber

The fiber used for the study is Polyester and Polypropylene. These fibers have hydrophobic surface. Usage of these fibers as reinforcement material diminishes permeability, shrinkage resistance, mends both compressional and tensile strength of concrete. The fibers used for this study was Polypropylene (PP) and polyester fiber.

**a)Polypropylene fiber:** Polypropylene fiber reinforced concrete (PFRC) is also known as polypropene or PP. It is a synthetic fiber, transformed from propylene, and used in a variety of applications such as construction. These fibers are usually used in concrete to manage cracking due to plastic shrinkage and soaking shrinkage. They also decrease the permeability of concrete and thus decrease the bleeding of water. Polypropylene fiber belongs to the group of polyolefins and is partially crystalline and non-polar. It has similar properties as polyethylene, but it is harder and more heat resistant material. It is a white resilient material with high chemical resistance. Polypropylene is produced from propylene gas in the presence of a catalyst such as titanium chloride. Polypropylene fiber displays good heat-insulating properties and is highly resistant to acids, alkalies, and organic solvents.

**b)Polyester fiber:**Polyester fibers are used in fiber-reinforced concrete (FRC) for pavements and overlays and precast structures. Polyester micro and macro fibers are used in cement concrete to provide superior resistance to the formation of plastic shrinkage cracks versus welded wire fabric and to enhance toughness and the ability to deliver structural capacity when properly designed, respectively. In this study polyester fiber used as reinforced material to enhance mechanical properties of cement concrete pavement.

**Table No 3.4.1 Properties of Synthetic Fiber**

| S No | Properties | Polyester Fiber | Polypropylene Fiber |
|---|---|---|---|
| 1 | Shape | Triangular | Triangular |
| 2 | Cost Length (mm) | 12 | 12 |
| 3 | Dia (Micron) | 30-35 | 34 |
| 4 | Specific Gravity | 1.34 | 0.91 |
| 5 | Melting Point (Degree.c) | 250-265 | 160-165 |
| 6 | Tensile Strength (kg/cm2) | 4000-6000 | 4000-6000 |
| 7 | Alkali Resistance | Very Good | Very Good |
| 8 | Electrical Conductivity | Low | Low |
| 9 | Thermal Conductivity | Low | Low |
| 10 | Acid and salt Resistance | Excellent | Excellent |

### 2.5 Water

If the water contains ample amounts of chlorides may bring about efflorescence and dampness. So the water utilized having pH esteem value 7 and free from salts. Potable water is used in this study.

### 2.6 Mix Proportion

Grade Designation = M25 (1:1.5:3)
Type of Cement = OPC 43
Size of the Coarse aggregate = 20mm
Fine Aggregate = River sand
Min cement content = 330 kg/cu-m
Max W/C ratio = 0.55
Type of aggregate = Crushed Angular

## III. RESULTS AND DISCUSSION

### 3.1 Compressive Strength of Concrete at 7 and 28 Days

It is the characteristic strength of concrete. It is the most important aspect of concrete to withstand in compressive force. Cubes of M25 grade concrete of size 150x150x150 mm cube were casted and tested after curing. This test was performed on CTM machine. Concrete cubes for compressive strength trail at 7 days and 28 days.

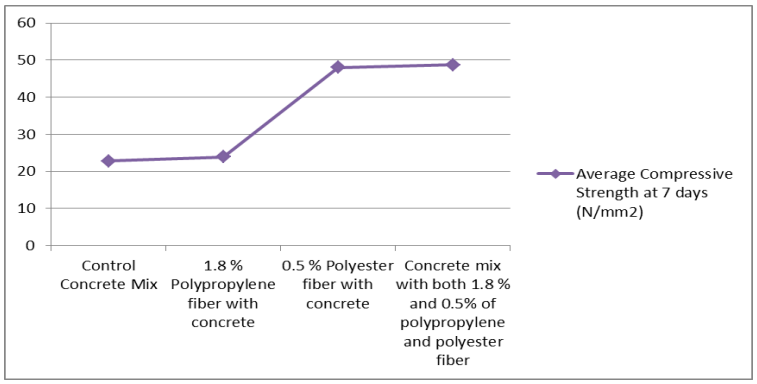


Figure No 3.1.1 Compressive Strength at 7 Days (N/mm2)

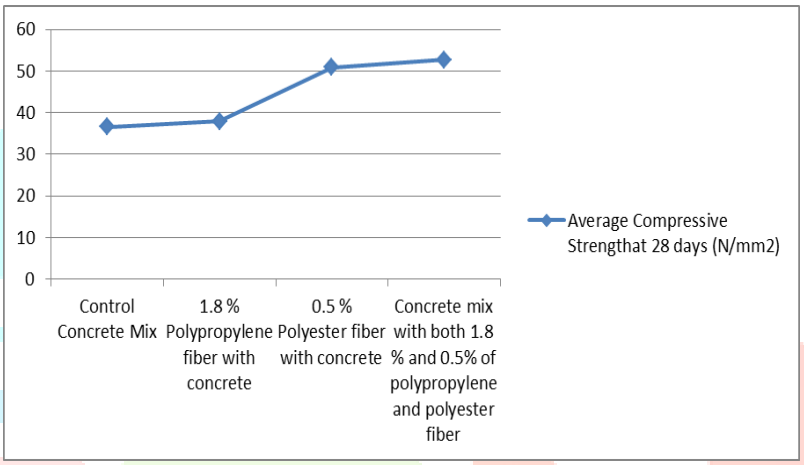


Figure No 3.1.2 Compressive Strength at 28 Days (N/mm2)

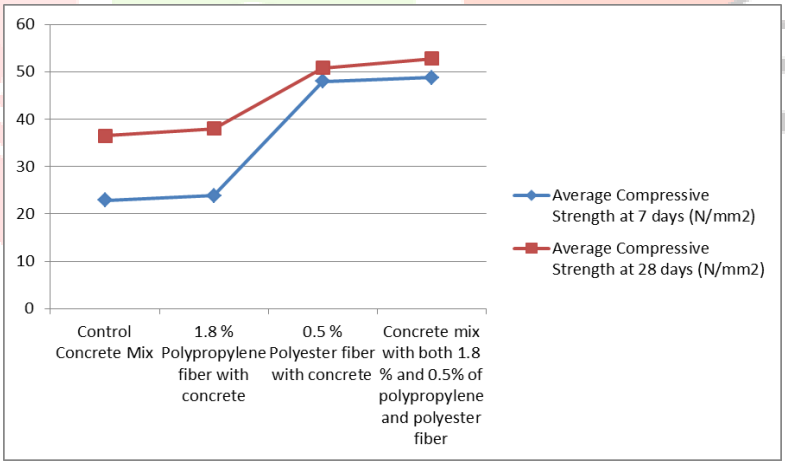


Figure No 3.1.3 Comparison of Compressive Strength at 7 and 28 Days (N/mm2)

### 3.2 Flexural Strength of Concrete at 7 and 28 Days

Cement Concrete pavement resists the entire load due to flexural action of slab. So this flexural strength is very important aspect of rigid pavement. For flexural strength test beam samples of dimension 100x100x500 mm were casted. These flexural strength specimens were tested under four point loading as per IS 516 1959, using universal testing machine. M25 grade concrete specimen was casted as a beam for testing of flexural strength of concrete, and trail at 7 day and 28 day.

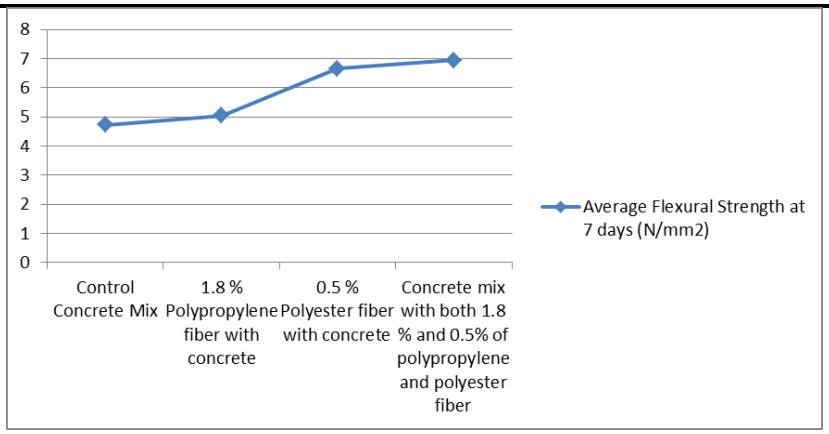


Figure No 3.2.1 Flexural Strength at 7 Days (N/mm2)

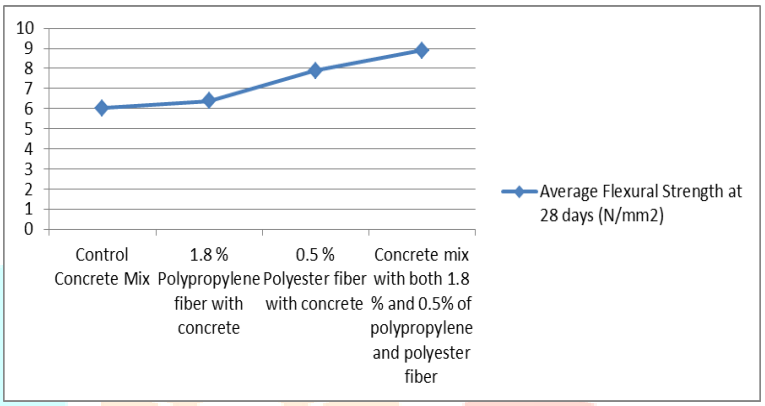


Figure No 3.2.2 Flexural Strength at 28 Days (N/mm2)

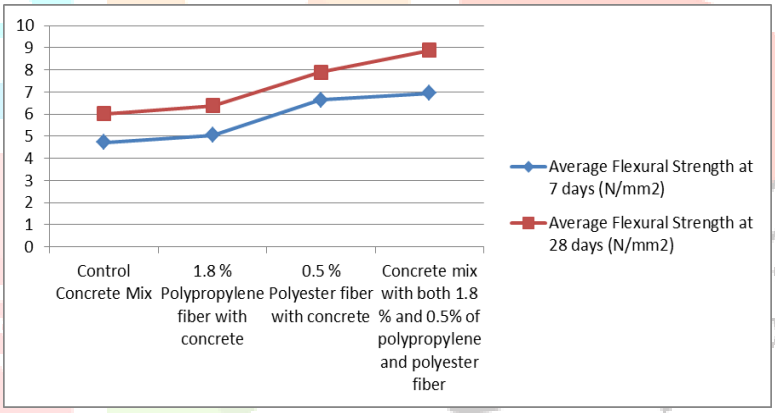


Figure No 3.2.3 Comparison of Flexural Strength at 7 and 28 Days (N/mm2)

## IV. CONCLUSION

- The Compressive Strength of Control mix concrete is less than the rest of the three mixes but the mix of concrete with polyester and polypropylene increased the compressive strength of the concrete.
- According to result we found that the compressive strength of Concrete mix with both 1.8 % and 0.5% of polypropylene and polyester fiber is 48.76 N/mm2 at 7 days and 52.76 N/mm2 at 28 days.
- The flexural strength of Control mix 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 fiber shows a great increase in the flexural strength in the concrete mix.
- The average Flexural strength of Concrete mix with both 1.8 % and 0.5% of polypropylene and polyester fiber is found 6.95 N/mm2 at 7days and 8.89 M/mm2 at 28 days.
- The addition of polyester fiber in concrete showed a great increment in the strength than the polypropylene fiber.
- The difference between the strength enhance 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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