**ENHANCE THE QUALITY OF RIGID PAVEMENTS TO INCLUSION OF FIBERS IN CONCRETE**

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**Abstract**

Polypropylene fiber (PPF) is a polymer material known for its light weight, high strength, and corrosion resistance, which enhances the crack resistance of concrete. By incorporating PPFs into concrete, the pore size distribution is optimized, significantly improving the material's durability by blocking the penetration of water and harmful ions. This paper summarizes the impact of PPF on various aspects of concrete durability, such as drying shrinkage, creep, water absorption, permeability resistance, chloride ion penetration resistance, sulfate corrosion resistance, freeze-thaw cycle resistance, carbonation resistance, and fire resistance. The study also analyzed the effects of various factors on these durability indexes, including fiber content, fiber diameter, and fiber hybrid ratio. It was found that combining PPFs with steel fibers can further enhance the durability properties of concrete. PPF in concrete faces challenges such as imperfect dispersion within the concrete mix and weak bonding with the cement matrix. To address these issues, methods like modifying fibers with Nano active powder or chemical treatments are recommended. Lastly, the authors discuss future research prospects, emphasizing the need for continued development in PPF-concrete composites to overcome current limitations and enhance performance.

**Keywords:** Polypropylene fiber (PPF), Durability, Chemical treatments, permeability resistance, water absorption

**Introduction**

Road transportation systems provide the maximum flexibility of service from origin to destination, facilitating the safe and easy movement of vehicles. Roads are essential for the independent transportation of goods and passengers from one place to another on land. For safe and comfortable traffic movement, the road pavement must be strong. The main function of pavement is to distribute loads to the sub-base layer effectively.

Rigid pavements, known for their strength and capacity to withstand rough and tough environmental conditions, are a key component in road construction. These pavements are typically constructed using cement concrete (CC) or reinforced cement concrete (RCC) slabs. The primary advantages of using rigid pavement include its mechanical resistance and high flexural stiffness, making it an optimal choice for the design of roadways and highways.

Rigid road pavements offer a convenient, adequate, and economical solution for the construction and maintenance of road infrastructure. Their robust design ensures longevity and durability, reducing the need for frequent repairs and maintenance. This makes rigid pavements a practical choice for high-traffic areas and highways where long-term performance and minimal disruption are critical. Pavement serves to distribute vehicular loads evenly across the underlying layers, preventing load and stress concentrations in the sub-grade layer. However, cement concrete pavements can sometimes rapidly weaken, leading to ruptures, cracks, fissures, and failures. These issues can create hazardous driving conditions and result in significant infrastructure damage. The primary causes of these problems are the rigid nature of cement concrete, its limited fatigue resistance, and low resilience. One major issue in cement concrete pavements is shrinkage cracking. This problem can be mitigated by incorporating fibers into the concrete mix.

**Types of Pavements in Road Construction**

In road construction, pavements are designed to support vehicular traffic and distribute loads to the underlying soil. The choice of pavement type depends on factors like traffic volume, climate, soil conditions, and budget. The main types of pavements include Flexible Pavements, Rigid Pavements, Composite Pavements, Perpetual Pavements, and Asphalt Pavements. These pavements can be broadly categorized into Flexible Pavement and Rigid Pavement.

**LITERATURE REVIEW**

**Kanchan S et al (2022)** this study investigates the effects of incorporating polypropylene fibres into concrete mixtures, aiming to enhance the material's tensile and flexural strength while reducing plastic shrinkage and thermal cracking. Polypropylene fibres were added to the concrete mix in varying dosages from 0.5% to 2.5% of the total weight of cement. An M-30 mix was used for the experiment, and the mechanical properties of the concrete were evaluated through Compression tests, Split Tensile tests, and Flexural Strength tests at 7 and 28 days, following standard procedures. The results were compared to those of conventional concrete, revealing that the optimal fibre dosage was 1.5% by weight, which provided the highest strength and reduced self-weight. Higher dosages led to a gradual decrease in strength. The study found that adding polypropylene fibres to concrete significantly affected its mechanical properties. At a dosage of 1.5% by weight, the concrete exhibited the highest strength in both tensile and flexural tests, along with a reduction in self-weight. This optimal dosage also minimized plastic shrinkage and thermal cracking. However, increasing the fibre content beyond 1.5% led to a decline in concrete strength, suggesting an optimal range for fibre addition.

**Divya S et al (2016)** India, as a leading developing country, is continuously advancing in the field of construction. High strength and high performance concrete is increasingly needed for various construction works to ensure durability, safety, and sustainability. One of the innovative approaches in achieving these properties is through the use of Fiber-Reinforced Concrete (FRC). FRC is concrete that incorporates fibrous materials to enhance its structural integrity. The addition of fibers affects the properties of the concrete, including its workability, strength, and durability. The effectiveness of FRC depends on the type of fibers used, their geometries, distribution, orientation, and densities. Polypropylene fibers are a type of lightweight synthetic fiber. When added to concrete, they help prevent crack formation, enhance structural reinforcement, and improve overall performance. This project investigates the use of blended polypropylene fibers in varying percentages to evaluate their impact on concrete properties.

**METHODOLOGY**

This chapter details the experimental programs designed to measure the fresh and strength properties of concrete mixes with varying percentages of polypropylene fiber. The chapter is structured as follows. The workability and consistency of the concrete mix are assessed using standard tests such as the slump test. The primary focus is on the compressive strength of the concrete, which is evaluated through a series of tests on prepared specimens. A brief overview of the mix design process, including the proportioning of materials and the rationale for selecting specific percentages of polypropylene fiber. Description of the curing procedures adopted to ensure the concrete reaches its desired properties. Concrete specimens are cast into molds, cured for specific periods, and then subjected to compression until failure. The maximum load at failure is used to calculate the compressive strength. In this study we used polypropylene fiber in different amount with fiber percentages ranging from 0% to 2% by weight of cement. The specific percentages used are: 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 1.75%, and 2%.

**Mix Design of M30 grade of concrete as per IS 10262-2019**

The M30 grade of concrete signifies that the compressive strength of the concrete after 28 days should be 30 Megapascals (MPa).

### **Stipulations for Concrete Mix Design**

* Grade designation : M 30
* Type of cement : OPC 53 grade confirming to IS 8112
* Maximum nominal size of aggregate : 20 mm
* Minimum cement content : 320 kg/m3
* Maximum water-cement ratio : 0.45
* Workability : 50-75 mm (slump)
* Exposure condition : Severe (for reinforced concrete)
* Method of concrete placing : Pumping
* Degree of supervision : Good
* Type of aggregate : Crushed angular aggregate
* Maximum Cement Content : 450 kg/m3

**Test Data for Materials (to be determined in the laboratory)**

* Specific gravity of cement : 3.15
* Specific gravity of  Coarse aggregate : 2.74
* Specific Gravity of Fine aggregate : 2.56

### **Target Strength for Mix Proportioning**

**ftarget = fck + 1.65 x S**

ftarget = target average compressive strength at 28 days,

 fck = characteristic compressive strength at 28 days, and

s = standard deviation

The Standard deviation, s is taken as 5.0 N/mm2 (Table I of IS 10262:2019)

Therefore, target strength = 30 + 1.65 x 5.0 = **38.25 N/mm2**

### **Selection of Water-Cement Ratio**

From Table 5 of IS [456:2000](https://civilsynergy.wordpress.com/2020/07/23/plain-and-reinforced-concrete-code-of-practice/)**,**

Maximum permissible water-cement ratio is **0.45**

### **Selection of Water Content**

From Table 2 of [IS 456:2000](https://civilsynergy.wordpress.com/2020/07/23/plain-and-reinforced-concrete-code-of-practice/), maximum water content =186 liters (for 25 to 50 mm slump range) for 20 mm aggregate.

Estimated water content for 100 mm slump =186+ (6/100) x 186 =197 liters.

Water-cement ratio =0.45

Cement content = 197/0.45 = **437.7 kg/m3 (440 kg/m3)**

From Table 5 of IS 456, the minimum cement content for ‘**Severe** ‘exposure condition is 320 kg/m3

In our case, it is 440 kg/m3 which is greater than 320 kg/m3, hence satisfied.

### **The Proportion of the Volume of Coarse Aggregate and Fine Aggregate Content**

From Table 3 of IS 10262 : 2019, the Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate **(**Zone II) for a water-cement ratio of 0.50 = 0.62.

 Therefore, volume of coarse aggregate = 0.63 x 0.9 = 0.567.

 Volume of fine aggregate content =1 – 0.567 =0.433

### **Mix Calculations**

Volume of concrete = 1m3

Volume of cement = (Mass of cement/specific gravity of Cement) X (1/1000)

= (440/3.15) X (1/1000)

= 0.140 m3

Volume of water = (Mass of water/specific gravity of water) X (1/1000)

= (197/1) X (1/1000)

= 0.197 m3

 Volume of all aggregate = (a – (b + c + d))

= 1 – (0.140 + 0.197)

= 0.663 m3

Mass of coarse aggregate = Volume of all Aggregate X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000

= 0.663 x 0.567 x 2.74 x 1000

= 1030 kg

Mass of fine aggregate = Volume of all Aggregate X Volume of Fine Aggregate X Specific Gravity of Fine Aggregate X 1000

= 0.663 x 0.433 x 2.56 x 1000

= 735 kg

**Table 1 Cement, Fine and Coarse Aggregate for M30 grade concrete**

|  |  |
| --- | --- |
| **MATERIALS** | **QUANTITY** |
| Cement | 440kg |
| Fine Aggregate | 735 kg |
| Coarse Aggregate (20mm) | 1030 kg |
| Water | 197L |

To find the design mix ratio, divide the calculated value of all materials by the weight of cement. Therefore Mix Design Ratio of M30 Grade concrete by weight is Cement: F.A: C.A: Water = 1: 1.67: 2.34: 0.45.

**RESULT ANAYLISIS**

The durability of concrete is influenced by a combination of factors including the quality and proportioning of its ingredients, proper curing, and the specific environmental conditions it is exposed to. By optimizing these factors, durable concrete structures can be created, contributing to environmental sustainability by reducing the need for repairs and replacements and minimizing the depletion of natural resources and the associated pollution. To evaluate the durability of specimens when immersed in a 5% H2SO4 (sulfuric acid) solution for 28 days. In this study we used different amount with fiber percentages ranging 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 1.75%, and 2%.

**Weight Loss (%) =** $\frac{(Initial Weight-Final Weight)}{Initial Weight}$ **X 100**

**Table 2 Durability test of concrete**

|  |  |  |  |
| --- | --- | --- | --- |
|  **% of Fiber** | **Normal weight (Kg)** | **Weight after** **Immersed in Solutions (kg)** | **% Reduction in weight** |
| 0 | 8.45 | 7.95 | 5.92 |
| 0.25 | 8.40 | 8.00 | 4.76 |
| 0.5 | 8.40 | 8.05 | 4.17 |
| 0.75 | 8.15 | 7.85 | 3.7 |
| 1.0 | 8.00 | 7.75 | 3.12 |
| 1.25 | 7.95 | 7.70 | 3.41 |
| 1.50 | 7.90 | 7.65 | 3.16 |
| 1.75 | 7.95 | 7.80 | 1.89 |
| 2.0 | 7.70 | 7.40 | 3.90 |

Sulfate corrosion is the most common and extensive form of chemical corrosion affecting concrete structures. This process involves the infiltration of sulfate ions into the concrete matrix, where they react with the hydration products, leading to the formation of expansive compounds. These expansive compounds exert internal stresses, causing the concrete to crack and deteriorate over time.

**CONCLUSION**

An experiment where we tested the durability of concrete with varying amounts of polypropylene fiber added to it. It's interesting that adding the fiber initially increased durability, but then there was a peak at 1.75% where the durability was best before it started to decrease again. This pattern suggests there might be an optimal ratio of polypropylene fiber to concrete for maximizing durability.

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