

# Influence of Glass Fiber and Polypropylene Fiber on M30 Grade Concrete and its Durability Study

Manu J Nair <sup>1</sup>, Renny Varghese <sup>2</sup>P.G. Student, Department of Civil Engineering, Ilahia Engineering College, Mulavoor, Kerala, India<sup>1</sup>Associate Professor, Department of Civil Engineering, Ilahia Engineering College, Mulavoor, Kerala, India<sup>2</sup>

**ABSTRACT:** Concrete is most widely used construction materials due to its strength, permanence and durability. Concrete is a tension weak building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. Fiber reinforced concrete is a family of composite materials that combine the high compressive strength properties of cement mortars with significantly increased impact, flexural and tensile strength imparted by the fiber reinforcement. The presence of fibers provides crack arresters. In order to improve these properties, an attempt has been made to study the effect of addition of glass fiber and polypropylene fiber in ordinary Portland cement concrete. Glass fibre and polypropylene are among the solid fibrous wastes generated by mainly packaging, glass and textile industry. In the present experimental investigation glass fibers and polypropylene fibers in different percentage has been studied. The glass fiber content varies from 0-2.0% and polypropylene fiber content varies from 0-0.8% by weight of cement. The effect on mechanical properties of concrete by carrying compressive strength test, flexural strength test and splitting tensile strength test.

**KEYWORDS:** Glass fibre, polypropylene fiber, Tensile strength, Cracks, Flexural strength.

## I. INTRODUCTION

The concrete industry is one of two largest producers of carbon dioxide (CO<sub>2</sub>), creating up to 5% of worldwide man-made emissions of this gas. The CO<sub>2</sub> emission from the concrete production is directly proportional to the cement content used in the concrete mix. Construction industry needs a huge mass of cement for the concreting process. Excessive use of cement can lead to the formation of shrinkages and cracks in concrete. The development of these micro cracks causes elastic deformation of concrete. The presence of fibers provides crack arresters. In order to improve these properties, an attempt has been made to study the effect of addition of glass fibers and polypropylene fibers in ordinary Portland cement concrete. Fiber reinforced concrete is a family of composite materials that combine the high compressive strength properties of cement mortar with significantly increased impact, flexural and tensile strength imparted by the fiber reinforcement.

The use of glass fibres in concrete is increasing nowadays. Normal concrete gives low strength, less resistant to crack. If glass fibres are added to concrete, it imparts high tensile strength, controls cracking and also reduces bleeding of water. Also the use of glass fibres yields higher flexural strength and improves ductility properties. Murthy et al (2012) replaced fine aggregate by using 25µm and 5cm long glass fibre upto 1.5% in normal M30 grade concrete and found an increase in mechanical strength. Sangeetha et al (2010) carried out experimental investigation by wrapping Glass Fibre Reinforced Polymer (GFRP) of Mat types for 42 columns, and found that confinement of columns with GFRP wrap increased the strength and ductility of concrete columns and also found that compressive strength increases with increase in number of plies of GFRP. Sathish et al (2012) carried out a research to determine mechanical properties of

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Geopolymer Concrete Composites (GCC) containing fly ash, alkaline liquid and glass fibre, from test results, it was observed that GCC reported higher strength in less curing time when compared with geopolymer and Portland cement concrete.

Polypropylene fibers belong to the newest generation of large-scale, manufactured chemical fibers, having the fourth largest volume in production after polyesters, polyamides and acrylics. Polypropylene is one of the most successful commodity fibers, reaching a world production capacity of four million tons a year. Due to its low density (0.9 gm./cc), high crystalline, high stiffness and excellent chemical/bacterial resistance, polypropylene is widely used in many industrial applications such as nonwovens, industrial ropes, packaging materials, furnishing products, etc. Polypropylene fiber has potential, high-volume applications in the carpet, textile, apparel and industrial textile markets. The following are the advantages of using polypropylene fibers-

- Easy processing
- Low specific gravity
- Almost zero water adsorption
- Good chemical resistance
- Wide availability and Low cost.

## II. RELATED WORK

**Kavita Kene et al 2010** conducted experimental study on behavior of steel and glass Fiber Reinforced Concrete Composites. The study conducted on Fiber Reinforced concrete with steel fibers of 0% and 0.5% volume fraction and alkali resistant glass fibers containing 0% and 25% by weight of cement of 12 mm cut length, compared the result.

**G. Jyothi Kumari** studied behavior of concrete beams reinforced with glass fiber reinforced polymer flats and observed that beams with silica coated Glass fiber reinforced polymer (GFRP) flats shear reinforcement have shown failure at higher loads. Further they observed that GFRP flats as shear reinforcement exhibit fairly good ductility. The strength of the composites, flats or bars depends upon the fiber orientation and fiber to matrix ratio while higher the fiber content higher the higher the tensile strength.

**Yogesh Murthy, et al** studied the performance of Glass Fiber Reinforced Concrete. The study revealed that the use of glass fiber in concrete not only improves the properties of concrete and a small cost cutting but also provide easy outlet to dispose the glass as environmental waste from the industry. From the study it could be revealed that the flexural strength of the beam with 1.5% glass fiber shows almost 30% increase in the strength. The reduction in slump observed with the increase in glass fiber content.

**Priti A. Patel et al (2012)** done an experimental investigation explored properties such as compressive strength, flexural strength, split tensile strength and shear strength of polypropylene fiber reinforced concrete. Conventional concrete has two major drawbacks: low tensile strength and a destructive and brittle failure. In an attempt to increase concrete ductility and energy absorption, researcher introduced polypropylene fiber reinforced concrete (PFRC). Their study is part of a research program on evaluating the performance of polypropylene fiber reinforced concrete. The fiber volume fraction  $V_f$  0%, 0.5%, 1%, 1.5% and 2 %. No significant change is found for compressive strength when compared to the plain concrete but flexural, split tensile and shear strength improves greatly.

**Slamet Widodo (2012)** conducted the research work to evaluate the effects of polypropylene fiber addition on fresh state characteristics of SCC mixes, and investigate the effects of polypropylene fiber on some hardened properties of SCC. In their research work they were added polypropylene fiber of 0%, 0.05%, 0.10%, and 0.15% volume fraction in concrete mixes. They observed that the compressive strength of concrete specimens improved proportionally with the addition of polypropylene fiber up to 0.05 percent by concrete volume, and then tend to decrease after 0.10 percent of

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polypropylene addition in the concrete mix. They also observed that the splitting tensile strength of concrete specimens improved proportionally with the addition of polypropylene fiber up to 0.10 percent by concrete volume, and then tend to decrease after 0.15 percent of polypropylene addition in the concrete mix. According to the evaluation of fresh and hardened properties of Self-Consolidating Concrete (SCC), they concluded that polypropylene fibers allowed to be added into the concrete mixes up to 0.10 percent by concrete volume.

### III. SCOPE

- To determine fresh, hardened state properties and durability of M30 grade concrete prepared by addition of Glass fiber and Polypropylene fiber.
- To provide low cost construction material.
- To improve strength and durability of concrete by the addition of Polypropylene fiber and Glass fiber.
- To make a cement structure free from micro cracks by adding polypropylene fiber or glass fiber thereby preventing moisture from entering and migrating throughout the concrete.

### IV. METHODOLOGY

#### 4.1 Materials used

- Cement: The ordinary Portland cement of 53 grade whose specific gravity 3.15, Standard consistency of the cement was found to be 35% and the initial setting time were found as 120 min.
- Fine aggregate: Locally available Manufactured sand is used. As per IS 383:1970, sand is confirming to Zone II. Specific gravity of the sand used is 2.74 and water absorption value is 1.5%.
- Coarse aggregate: Coarse aggregate with 20 mm nominal size having specific gravity 2.74 was used and water absorption of the coarse aggregate is 0.8%.
- Glass fiber: Glass fiber were collected from the solid waste of packaging, glass and textile industry Specific gravity of Glass fiber is 1.99
- Polypropylene fiber: Specific gravity of polypropylene fiber is 0.91

#### 4.2 Mix design

Mix design for M30 concrete is done and amount of materials needed for casting cubes are calculated.

#### 4.3 Mix (M30) and specimen preparation using IS 10262:2009

- Preparation of mix by adding polypropylene fibres in the range of 0 to 0.8 %.
- Preparation of mix by adding glass fibres in the range of 0 to 2 %.
- Find the optimum percentage of polypropylene fibers and glass fibre from above mixes.
- Preparation of specimens:

Specimens to be cast are cubes of size 150x150x150mm, beams of Size 100x100x500mm and cylinders of size 300x150mm for testing compressive strength, flexural strength and splitting tensile strength for the corresponding mixes in 3, 7 and 28 days.

#### 4.4 Tests on concrete

Compressive, split tensile and flexural is conducted for Mechanical properties. Sulphate resistance test and Alkali resistance test are conducted for Durability properties.

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Table 1: Mix Designation

MIX DESIGNATION	DESCRIPTION
CM	Control Mix
GF0.5	Concrete mix with addition of 0.5% Glass fiber by weight of cement
GF1.0	Concrete mix with addition of 1% Glass fiber by weight of cement
GF1.5	Concrete mix with addition of 1.5% Glass fiber by weight of cement
GF2.0	Concrete mix with addition of 2% Glass fiber by weight of cement
PP0.2	Concrete mix with addition of 0.2% Polypropylene fiber by weight of cement
PP0.4	Concrete mix with addition of 0.4% Polypropylene fiber by weight of cement
PP0.6	Concrete mix with addition of 0.6% Polypropylene fiber by weight of cement
PP0.8	Concrete mix with addition of 0.8% Polypropylene fiber by weight of cement

## V. RESULTS AND DISCUSSIONS

### 5.1 Effect on Hardened properties of concrete

From the Fig.5.1(a) it can be seen that Glass fiber improves the compressive strength reached maximum in G1.5 mix containing 1.5% Glass fiber. As the percentage addition of Glass fiber increases, the compressive strengths increase, reach a maximum value and then decrease. By the use of Glass fiber, Bleeding property was reduced by reducing porosity and increasing ductility.

Table 2: Compressive strength

Mix Designation	Average compressive strength		
	3-day N/mm <sup>2</sup>	7-day N/mm <sup>2</sup>	28-day N/mm <sup>2</sup>
CM	17.1	30.15	39
GF1.5	24.8	33.8	41.5
PP0.6	20.8	32.1	40.6

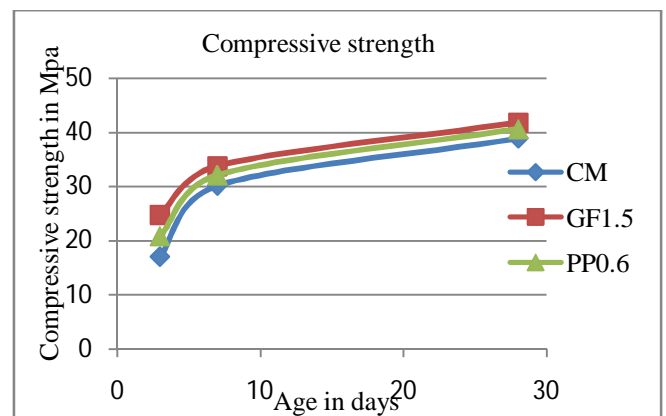


Fig 5.1.(a)

From the Fig 5.1(b), it can be seen that Glass fiber improves the splitting tensile strength in GF1.5 mix containing 1.5% Glass fiber than Polypropylene fiber mix and control mix. Concrete mix with addition of Glass fiber have considerable increase in split tensile strength and found to be 4.7 N/mm<sup>2</sup>, which is 18% higher than that of control mix.

Table 3: Split tensile strength

Mix Designation	Average splitting tensile strength	
	7 day N/mm <sup>2</sup>	28 day N/mm <sup>2</sup>
CM	2.63	3.98
GF1.5	4.1	4.7
PP0.6	3.5	4.1

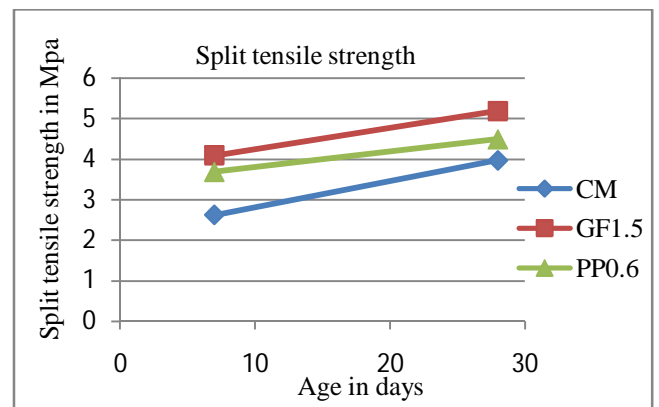


Fig 5.1 (b)

From the Fig 5.1(c), it can be seen that Glass fiber improves the flexural strength in GF1.5 mix containing 1.5% Glass fiber than Polypropylene fiber mix and control mix. Concrete mix with addition of Glass fiber have considerable increase in flexural strength and found to be 10.1 N/mm<sup>2</sup>, which is 30% higher than that of control mix.

Table 4: Flexural strength

Mix Designation	Average flexural strength	
	7 day N/mm <sup>2</sup>	28 day N/mm <sup>2</sup>
CM	5.5	7.75
GF1.5	6.9	10.1
PP0.6	6.5	8.8

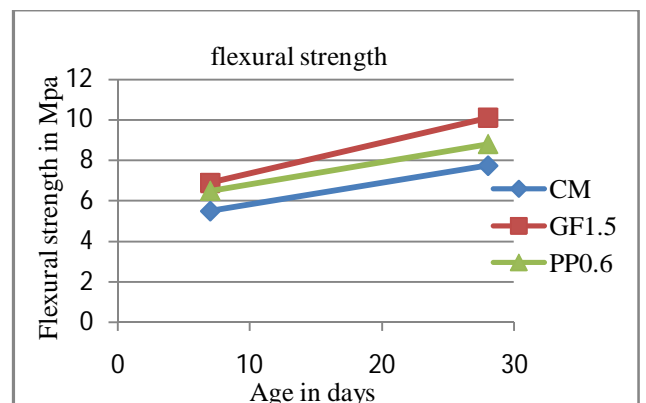


Fig 5.1 (c)

### 5.2 Sulphate attack Test

Cubes of size 150 X 150 X 150 mm are casted and are cured for 28 days. After 28 days, curing cubes are taken out and allowed for drying for 24 hours and weights are taken. For Sulphate attack and Alkali attack Test 5% dilute MgSO<sub>4</sub> and NaOH is used respectively. The cubes are to be immersed in solution for a period of 56 days. The concentration is to be maintained throughout this period. After reaching the respective days the specimens are taken from solutions. The surface of specimen is cleaned and weights are measured. The specimen is tested in the compression testing machine under a uniform rate of loading. The loss of strength of specimen due to Chemical Attack is determined for 56 and 90 days. This is then compared with cubes immersed in water. From Fig 5.2(a) it can be seen that in sulphate solution, compressive strength of concrete slightly decreases. i.e., the increasing strength of concrete gradually decreases as compared with water curing cube strength, as the days of exposure increases. This was due to deterioration of concrete

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in sulphate solution. From Fig.5.2(a), the increase in compressive strength for concrete with Glass fiber exposed to 5%  $MgSO_4$  is 3.5% compared to CM at 90 days curing.

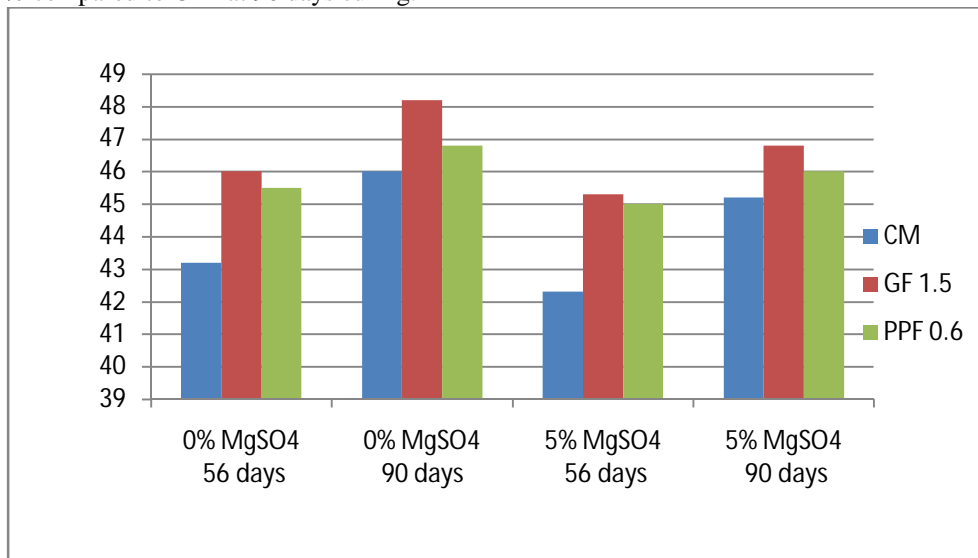


Fig 5.2(a) Loss of compressive strength in  $MgSO_4$

### 5.3 Alkali attack Test

From Fig 5.3(a) it can be seen that in alkali solution, compressive strength of concrete slightly decreases. i.e., the increasing strength of concrete gradually decreases as compared with water curing cube strength, as the days of exposure increases. This was due to deterioration of concrete in alkali solution. From Fig.5.3(a), the increase in compressive strength for concrete with Glass fiber exposed to 5% NaOH is 2.7% compared to CM at 90 days curing.

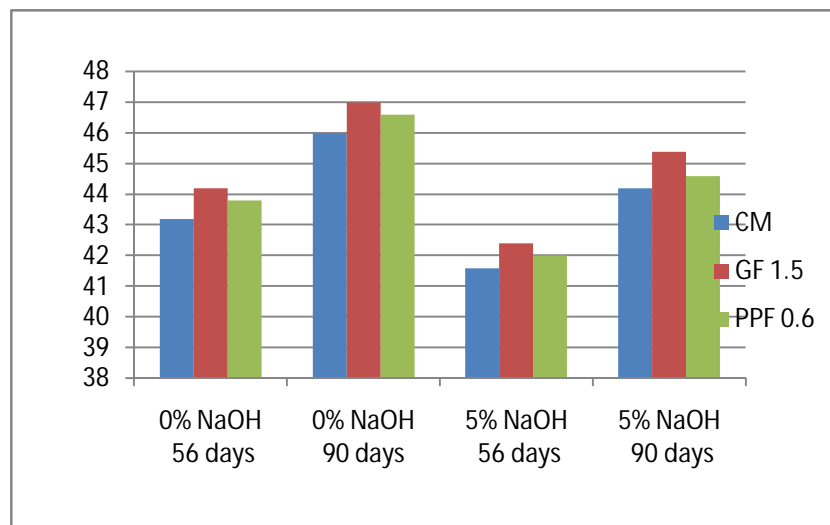


Fig. 5.3(a). Loss of compressive strength in NaOH

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### 5.4 Weight loss (%) of cube dipped in various solution

From Fig.5.4 (a),(b) and (c) shows the percentage of weight loss of conventional concrete, concrete with Polypropylene fiber and concrete with Glass fiber with Sodium Chloride, Magnesium sulphate and alkali solution. This is due to the deterioration of concrete. Weight loss is more in Sodium hydroxide solution than Magnesium sulphate solution. Weight loss of concrete with Glass fiber (GF1.5) cube is less than that of conventional concrete, due to lesser water absorption of fibrous material.

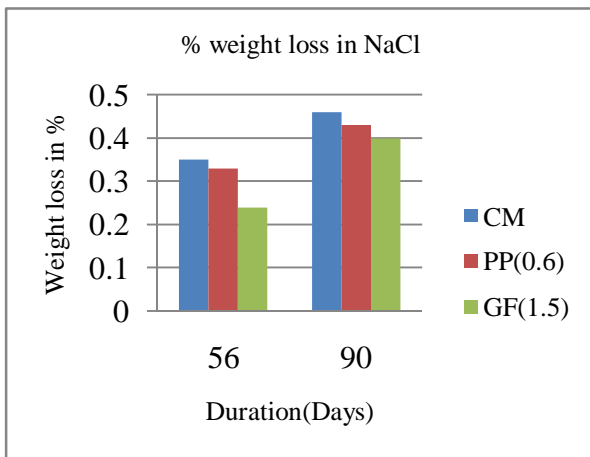


Fig 5.4(a) Weight loss of various cube immersed in sodium chloride solution

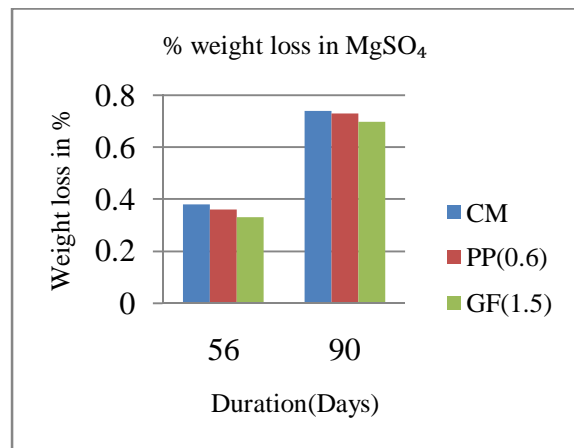


Fig 5.4(b) Weight loss of various cube immersed in Magnesium sulphate solution

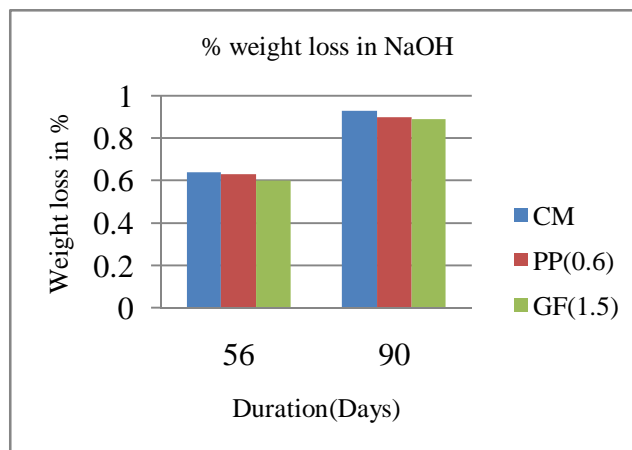


Fig 5.4(c) Weight loss of various cube immersed in Sodium Hydroxide solution

### VI. CONCLUSION

The study was carried out on M30 grade concrete. Properties of concrete were studied in present study with addition of glass fiber and polypropylene fiber in concrete mix. Three different mixes was studied M30, glass fiber mix with

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0.5%,1%,1.5%,2% and polypropylene fiber mix with 0.2%,0.4%,0.6%,0.8%. Test results indicate that glass fiber can be used in concrete mix for better strength.

The following conclusions were obtained from the studies.

- The compressive, split tensile and flexural strength of M30 grade concrete increased with the addition of glass fiber and polypropylene fiber.
- The mix containing 1.5% glass fiber with concrete gives greater strength as compared to other mixes and taken as the optimum value.
- Crack resistance to structural members can be improved with addition polypropylene fiber and glass fibre as tensile strength increased considerably.
- Strength of concrete can be improved economically as glass fiber and polypropylene is a low cost material.
- Percentage loss of strength for concrete mix prepared with glass fiber and polypropylene fiber is less in NaCl, MgSO<sub>4</sub>, NaOH solutions compared to control mix.
- Weight loss of the specimen prepared with glass fiber and polypropylene fiber when immersed in Chloride, sulphate and Alkali solution is lower as compared to control mix
- Concrete mix with addition of glass fiber attained its maximum strength compared to control mix and polypropylene fiber mix and exhibits higher durability and lower rate of weight loss.

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