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# Influence of Polypropylene Fibre Additive in Cement and Glass Powder as Partial Replacement of Fine Aggregate in Compressive strength of Concrete

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**Abstract -** *Concrete is a fundamental unit for the infrastructural development of an entire world. Concrete is a mixture of cement, fine aggregate, coarse aggregate with water. Concrete has low tensile strength, limited ductility and little resistance to cracking. The presence of fibres provides crack arresters. In order to identify the compressive strength properties an attempt has been made to study the effect of addition of glass powder and polypropylene fibre in ordinary Portland cement concrete. Polypropylene fibres are used in concrete to resist cracks. In this work, natural sand is replaced with constant percentage of 20% glass powder and was taken as optimum level. Polypropylene fibre is added in the proportion of 0.4%, 0.8% and 1.2% by volume of cement and studied the compressive strength of concrete for 7, 14 and 28 days. The maximum compressive strength of 44.9 MPa was obtained at 0.8% optimum proportion of polypropylene fibre.*

***Key Words***: *M30 Grade concrete, glass powder, polypropylene fibre, compression strength*

## 1. INTRODUCTION

Concrete is a widely used material in the world. Based on global usage it is in second position after water. River sand is one of the constituents used in the production of conventional concrete has become highly expensive and also scarce. In the bleak atmosphere, there is a large demand for alternative materials from industrial waste. Alternative materials have been used as a part of natural sand. For example, fly ash, slag, red mud, ponded ashes were used in concrete as a partial replacement of natural sand. Similarly, the waste glass is collected from the shops are used.

Concrete is a widely used man made construction material and its demand is increasing day by day. The use of river sand as fine aggregate which will lead to exploitation of natural resources, lowering of water table, sinking of bridge piers and erosion of river bed. If fine aggregate is replaced by waste glass by specific percentage and in specific size range, it will decrease the ill effects of river dredging. The waste glass production has gradually increased over the recent years. Most waste glass is being dumped into landfill sites. The land filling of waste glass is non-biodegradable which makes them environmentally less friendly. Utilization of this waste is the need of the hour. Reuse of waste glass in concrete, the production cost of concrete will be less. This kind of reuse will be environment friendly and it will utilize waste in place of precious and relatively costlier natural resources. In brief, successful utilization of glass as fine aggregate will turn into a valuable resource.

The concrete industry is one of the largest producers of carbon dioxide ($CO_2$). It creates up to 5% of worldwide man-made emissions of this gas. The $CO_2$ emission 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 formation of these micro cracks causes elastic deformation in concrete. The presence of fibres provides crack arresters. In order to improve these properties, attempt has been made to study the effect of addition of polypropylene fibres in ordinary Portland cement concrete. Fibre 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 fibre reinforcement.

### 1.1 Polypropylene Fibre

Polypropylene is a thermoplastic polymer has various uses including bundling, materials (e.g., ropes, warm clothing and covers). Polymer cement is a piece of gathering of cements which uses polymers to supplement bond as a cover. It incorporates polymer-impregnated solid, polymer cement, and Polymer-Portland-bond concrete. Fibre reinforced concrete is used in a variety of engineering applications because of its satisfactory and outstanding performance in the industry and construction field. Polypropylene fibre in concrete mix design is used for multiple purposes that include rigid pavement, self-compacting concrete and other applications. The properties of Polypropylene fibre used in this work are shown in Table 1.

**Table-1:** Properties of Polypropylene fibre

| Diameter, D (mm) | Length, L (mm) | Aspect Ratio, L/D | Tensile strength (MPa) | Specific gravity |
|---|---|---|---|---|
| 0.0445 | 6 | 134.83 | 308 | 0.91 |

### 1.2. Literature review

Chaitra Patil, et. al. [1] investigated the compressive strength, split tensile strength and flexural strength of concrete produced by replacing natural sand by manufactured sand with addition of polypropylene fibre. Compressive strength follows increasing trend up to 60% replacement of M-sand after that it decreases as the percentage of M-sand increases. The percentage increase in the compressive strength at 60% replacement is found to be 35.61%. Similarly, the split tensile strength increases up to 100% replacement of M-sand and is found to be 24.94% increment at 100% replacement. For flexural strength, 60% replaced manufactured sand concrete possess higher strength compared to other mixes. The percentage increase of flexural strength found to be 19.46%.

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

Bhupinderjeet Singh and Rite S G Jain [3] used waste glass powder and prepared the concrete. From this study of work, it was observed that the waste glass powder and glass powder with aggregates can be successfully utilised in the partial replacement of fine and coarse aggregates in the concrete. The maximum compressive strength obtained at 20% replacements of fine aggregates with glass powder.

Mohammad Shoeb Sayeeduddin and F.I. Chavan [4] used waste glass powder as a partial replacement of cement in fibre reinforced concrete. From this, as the percentage of replacement of cement with glass powder increases, strength increases up to 20% and beyond that it decreases. The highest percentage increases in the compressive strength was about 23% and flexural strength was about 17% and split tensile strength was about 18% at 20% replacement level. The increases in strength up to 20% replacement of cement by glass powder may be due to the pozzolonic reaction of glass powder due to high silica content. Also it effectively fills the voids and gives a dense concrete microstructure. However, beyond 20% the dilution effect takes over and the strength starts to drop.

Manu J Nair and Renny Varghese [5] used glass fibre and polypropylene fibre in M30 grade concrete. From this study, addition of polypropylene fibre of 0.6% gives the highest average compressive strength of 40.6 N/mm$^2$ at 28 days.

## 2. MATERIALS USED

A. Cement:
53 grade OPC and the Specific gravity was 3.15.

B. Fine Aggregate:
Fine aggregate passing through 4.75mm was used in this study. Specific gravity was determined as 2.64 (Followed the guidelines according to IS 388: 2016 [6])

C. Coarse Aggregate:
20mm size angular crushed granite metal having specific gravity of 2.91 (Followed the guidelines according to IS 388: 2016 [6])

D. Polypropylene fibre:
Polypropylene fibre of length 6 mm and specific gravity of 0.91 was used and shown in Figure 1.

**Figure-1:** Polypropylene fibre

E. Glass powder:
20 mm glass powder and specific gravity of 2.36 was used and is shown in Figure 2.

**Figure- 2:** Glass Powder

### 2.1. Mix Ratio and Mix Design

M30 grade of concrete is designed in accordance with the guidelines of code book IS 10262:2009 [7] with 20% replacement of fine aggregate by glass powder. Mix proportion obtained is 1: 1.39: 2.13 (C: FA: CA) with water cement ratio of 0.4. Polypropylene fiber is added at 0%, 0.4%, 0.8% & 1.2% to the cement. The cube specimens are casted and cured in water for 7 days, 14 days and 28 days. Mix quantities and ratio is tabulated in Table 2.

**Table- 2:** Mix design

| Material | Quantity (kg/m³) | Ratio |
|---|---|---|
| Cement | 492.5 | 1 |
| Natural sand (80% of FA) | 547.36 | 1.39 |
| Glass powder (20% of FA) | 136.86 | |
| Coarse aggregate | 1049.76 | 2.13 |
| water | 197 | 0.4 |

## 3. TESTS, RESULTS AND DISCUSSIONS

The compressive strength tests were conducted using Digital compression testing machine as shown in Figure 3 for the cubes prepared without polypropylene fibre and with polypropylene fibre of 0.4%, 0.8%, & 1.2% by volume of cement. The results variation of the three samples for each proportion were checked according to the guidelines given in IS: 456-2000 [8].

For all the cubes preparation, glass powder is added at constant 20% by weight of fine aggregate. 9 cubes are prepared without glass powder and without polypropylene fibre to observe the strength for 7 days, 14 days and 28 days. The test results for the 7days, 14 days & 28 days curing are tabulated in Table 3.


. **Figure -3:** Cubes kept under Compression using Digital compression testing machine

**Table- 3:** Compressive strength of Concrete

| Polymer (%) | Glass Powder (%) | 7 days strength (N/mm²) | 14 days strength (N/mm²) | 28 days strength (N/mm²) |
|---|---|---|---|---|
| 0 | 0 | 19.5 | 30.96 | 37.50 |
| 0 | 20% | 21.04 | 26.41 | 39.67 |
| 0.4 | 20% | 22.3 | 27.5 | 40.5 |
| 0.8 | 20% | 23.69 | 32.61 | 44.92 |
| 1.2 | 20% | 23.52 | 29.32 | 36.50 |

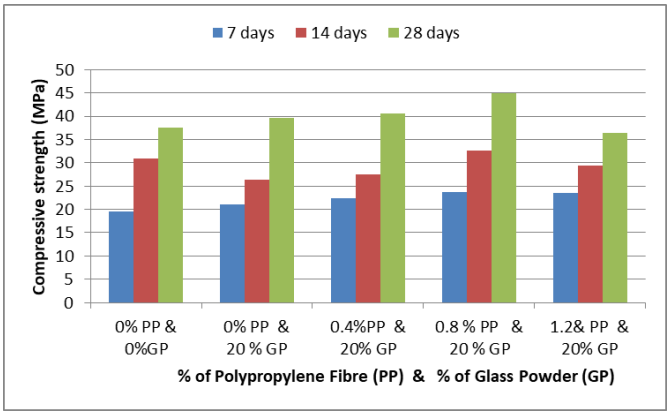


**Figure- 4:** Compressive strength of 7 days, 14 days and 28 days cured various concrete cubes

Figure 4 shows the average strength of the concrete for the five sets of cubes prepared with various percentages of Glass powder and Polypropylene fibre after cured them for 7 days, 14 days and 28 days. First set of cubes prepared without polypropylene fibre and glass powder. From the second set to the fifth set, the cubes were prepared with 20% constant glass powder and varying the polypropylene fibre percentages as 0%, 0.4%, 0.8% & 1.2%.

As calculated earlier, the target strength of concrete to be achieved is 38.25 MPa after 28 days curing. One can depict from the Figure 4, the compressive strength achieved for the concrete cube prepared without adding polypropylene fibre and glass powder is 37.50 MPa, which is 98% of target strength.

For the cubes prepared with 1.2% polypropylene and 20% glass powder, 64% of 28 days strength was achieved after 7 days; and 80% of 28 days strength was achieved after 14 days which can be depicted from the Figure 4.

After 28 days, highest strength of 44.9 MPa was achieved for the cubes prepared with 0.8% polypropylene and 20% glass powder and it can be depicted from the Figure 4. This is about 20% higher strength compared to the cubes prepared without polypropylene fibre and glass powder.

## 4. CONCLUSIONS

Influence of polypropylene fibre additive in a concrete prepared with partially replaced glass powder as fine aggregate was investigated in this study. From the experimental investigation the following conclusions were determined.

- 0.8% of polypropylene fibre by volume of cement and 20% glass powder by weight of fine aggregate influence in concrete shows optimal value and by which the compressive strength of concrete achieved was 44.9 MPa.
- About 20% more strength was achieved with the influence of 0.8% polypropylene fibre compared to

the concrete prepared without adding either polypropylene fibre or glass powder.

- And hence by using waste glass in concrete, one can eradicate the disposal problem and will preserve the one of the natural resources particularly river sand.
- Since the polypropylene fibre which is available as waste from the textile industry; and waste glass were used in concrete it becomes economically viable solution.

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