Influence of Addition of Glass Fibre on Concrete

NPannirselvam\(^1\), SManivel\(^2\)
\(^1\)Associate Professor, Department of Civil Engineering, 
\(^2\)Assistant Professor, Department of Civil Engineering, 
SRM Institute of Science and Technology, Potheri, Kattankulathur - 603203, 
Chengalpattu District, Tamilnadu, India. 
Corresponding author Email: \(\text{pannirsn@srmist.edu.in}\)

Abstract. Fibres used to develop high performance concrete. Fibres such as glass, carbon, polypropylene and aramid fibres need to be improved in view of global sustainable development. Long term durability is achieved with the development of a high alkaline resistance fibre dispersion. This system was called reinforced concrete with glass fibre alkali resistance. To decide compressive and split rigidity, modulus of elasticity, modulus of crack and quick chloride penetrability tests for concrete grade M20 and M30 with and without fluctuating level of glass strands. The specimens were cast and tested at 28 days. The percentage of addition of glass fibres marginally increased the strength of compressive, flexural, split tensile for M20 and M30 grades of concrete when specimens tested at 28 days. A reduction in bleeding and permeability is also observed.

Key words: Concrete, Glass Fibre, Strength.

1. Introduction
Concrete was durable material and requires a little or no maintenance. As per IS: 456-2000, the durability aspects of concrete, has better experiences with durability of concrete structures [9,17,18]. Glass fibres are a recent introduction to the production of concrete fibres [7,11]. During the setting phase, concrete mixtures tend to shrink plastic and lead to cracking [1,6]. Adding small quantities of fibres can effectively eliminate cracking plastic shrinkage in the early age.

2. Objectives
1. To design for M20 and M30 grade of concrete.
2. To evaluate the mechanical properties of concrete with and without glass fibre in varying percentage.
3. To estimate the durability properties of concrete with and without glass fibre in varying percentages.

3. Experimental Investigations
Investigations were carried out on 48 cubes, 16 cylinders, 8 prisms and 8 RCPT mould with and without glass fibres of varying percentages. Trials on cast specimens were carried out to determine the strength of compressive, split tensile, flexural, modulus of elasticity and rupture and durability properties of both reference concrete and glass fibre concrete mixes.

4. Materials

4.1 Cement
In the investigation, ordinary Portland cement (53 grade) available on the local standard brand market was used. The details are given in Table 1.

**Table 1. Physical properties**

| Sl. No. | Description                      | Values       |
|---------|----------------------------------|--------------|
| 1       | Consistency                      | 32%          |
| 2       | Initial setting time             | 115 minutes  |
| 3       | Final setting time               | 489 minutes  |
| 4       | Specific gravity                 | 3.49         |
| 5       | Fineness of cement               | 4%           |
| 6       | Compressive strength at 28 days  | 58.86 N/mm²  |

**4.2 Coarse aggregate**

The coarse aggregate tested for its various properties and details are tabulated in Table 2 and 3.

**Table 2. Sieve analysis**

| Sl. No. | Sieve Size(mm) | Percentage of Passing |
|---------|----------------|-----------------------|
| 1       | 40             | 100.00                |
| 2       | 20             | 82.72                 |
| 3       | 12.5           | 15.22                 |
| 4       | 10             | 2.94                  |
| 5       | 4.75           | 0.22                  |
| 6       | Less than 4.75 | 0                     |

**Table 3. Specific gravity and bulk densities for coarse aggregates**

| Sl.No. | Size of Coarse Aggregate | Specific Gravity | Bulk Density (Kg/m³) |
|--------|--------------------------|-----------------|----------------------|
|        |                          |                 | Loose    | Rodded  |
| 1      | 20 mm                    | 2.65             | 1622     | 1781    |

**4.3 Fine aggregate**

The fine aggregate tested for its physical properties and results are shown in Table 4 and 5.

**Table 4. Sieve analysis.**

| Sl. No. | Sieve size (mm) | Cumulative percentage of passing | Remarks                        |
|---------|-----------------|---------------------------------|--------------------------------|
| 1       | 10.0            | 100.00                          |                                |
| 2       | 4.75            | 94.90                           |                                |
| 3       | 2.36            | 93.30                           |                                |
| 4       | 1.18            | 71.90                           | The tested sand belongs to Zone – II category. |
| 5       | 0.600           | 40.80                           |                                |
| 6       | 0.300           | 8.50                            |                                |
| 7       | 0.150           | 1.30                            |                                |

**Table 5. Specific gravity and bulk densities of supplied fine aggregate.**

| Sl. No. | Fineness modulus | Specific gravity | Bulk density (Kg/m³) |
|---------|------------------|------------------|----------------------|
|         |                  |                  | Loose | Rodded |
| 1       | 2.76             | 2.62             | 1598  | 1732   |


4.4 Glass fibres

Cem-FIL® Anti–Crack High Dispersion used for the experimental study and their properties were furnished by the manufacture. The samples of Cem-FIL® Anti–Crack High Dispersion are presented in Figs. 1 and 2.

![Sample of Cem-FIL Anti-Crack HD Fibre.](image)

**Figure 1.** Sample of Cem-FIL Anti-Crack HD Fibre.

![Microscopic Structure of Cem-FIL Anti-Crack HD Fibre.](image)

**Figure 2.** Microscopic Structure of Cem-FIL Anti-Crack HD Fibre.

4.5 Water

Water used for making concrete from the laboratory used for drinking.

4.6 Concrete Mix Design

Concrete design for grades M20 and M30 as per IS: 10262 – 2019 and the proportions are presented in Table 6.

| Grade of Concrete | Cement (kg) | Fine Aggregate (kg) | Coarse Aggregate (kg) | Water (Lts) | W/C Ratio | Glass Fibres |
|------------------|-------------|---------------------|-----------------------|-------------|-----------|--------------|
| M 20             | 320         | 731                 | 1119                  | 176         | 0.55      | 0.03, 0.06 & 0.10% by concrete volume |
| M 30             | 350         | 686                 | 1137                  | 175         | 0.50      |              |

5. Casting of test specimens

The present experimental study includes casting and testing of specimens for compressive, split tensile, flexural strength and rapid chloride permeability test are performed. The specimens are casted using concrete design mixes.

5.1 Mixing
Pan mixing is adopted throughout the experimental work (Figure. 3) for casting of the specimens.

![Figure 3. Mixing of Concrete (Pan Mixer).](image)

### 5.2. Cast specimens

A standard moulds of size 100x100x100 mm cubes, 150 mm diameter x 300 mm height and 100mm diameter x 200mm height cylinders and 100x100x500 mm beam moulds are used. The specimen after casting is shown in Figure 4.

![Figure 4. Specimens after Casting.](image)

### 5.3. Compaction of concrete

In the present investigation, the table vibrator is used for compacting the concrete as shown in Figure 5. Compaction of concrete by vibration makes the concrete better quality, higher strength with given cement content with less mixing water.
5.4. Curing of specimen

The cast specimens are removed from the mould which left for a day at room temperature following curing. The samples are submerged in the curing tank for 28 days. After curing the specimens dried in sunlight and tested to evaluate its hardened strength.

6. Testing of specimens

The cast specimens are tested after it hardens.

6.1. Compressive strength

The test was performed on a 2000kN hydraulically operated digital CTM (Compression Testing Machine) and represented in Figure 6.

6.2. Split tensile strength

The test is performed horizontally on hardened specimen between a CTM’s loading surfaces and the load is applied along the vertical diameter until the cylinder fails. The details of the setup are shown in Figure 7.
6.3. Flexural strength

Two point loading is applied to estimate the strength of concrete by conducting flexural test. The details of the specimen are presented in Figure 8.

6.4. Secant modulus of elasticity

Secant modulus elasticity of cement is 33 percent ultimate strength as shown in Figure 9.
6.5. Testing for Rapid Chloride Permeability Test

The RCPT specimens (cylinder diameter of 150mm and height of 200mm) are cast and cured for 28 days and loaded in the cells as shown in Figure. 10.

7. Results and discussion

The information acquired from exploratory examinations on the modulus of elasticity, modulus of crack, compressive strength, split tensile strength and fast chloride penetrability test results are introduced in the accompanying areas. The expansion of glass filaments and their conduct of the cast examples are additionally exhibited.

7.1. Compressive Strength

The compressive strength for M20 and M30 grades with different percentage of fibres for 7 and 28 days are presented in Table 7.
Table 7. Compressive Strength for different mix proportions.

| S.No | Grade | 0%  | 0.03% | 0.06% | 0.10% | 0.15% |
|------|-------|-----|-------|-------|-------|-------|
|      |       | 7day| 28 days| 7      | 28 days| 7      | 28 days|
| 1    | M20   | 16.68| 27.37 | 17.75  | 34.84  | 18.47  | 36.28  |
| 2    | M30   | 17.3 | 5      | 26.0   | 44.5   |

7.2. Split Tensile Strength

M20 and M30 grade’s split tensile strength is determined with various level of fibres at 28 days are enlisted in Table 8.

Table 8. Split Tensile Strength for various percentage of Glass Fibre.

| S.No | Grade | 0%  | 0.03% | 0.06% | 0.10% | 0.15% |
|------|-------|-----|-------|-------|-------|-------|
| 1    | M20   | 3.61 | 4.05  | 4.33  | 4.45  | 4.15  |
| 2    | M30   | 4.23 | 4.68  | 4.89  | 5.12  | 4.56  |

7.3. Modulus of Elasticity

M20 and M30 grade’s modulus of elasticity is determined with various level of fibres at 28 days are enlisted in Table 9.

Table 9. Modulus of Elasticity for various percentage of Glass Fibre.

| S.No | Grade | 0%  | 0.03% | 0.06% | 0.10% | 0.15% |
|------|-------|-----|-------|-------|-------|-------|
| 1    | M20   | 22478 | 24356 | 23486 | 23260 | 23140 |
| 2    | M30   | 28643 | 28978 | 27978 | 27618 | 27149 |

7.4. Modulus of Rupture of Beams

The modulus of rupture of beams for M20 and M30 grades with different percentage of fibres at 28 days are presented in Table 10.

Table 10. Modulus of Rupture of Beams for various percentage of Glass Fibre.

| S.No | Grade | 0%  | 0.03% | 0.06% | 0.10% | 0.15% |
|------|-------|-----|-------|-------|-------|-------|
| 1    | M20   | 3.52 | 3.96  | 4.18  | 4.29  | 4.12  |
| 2    | M30   | 4.12 | 4.57  | 4.96  | 4.98  | 4.16  |

7.5. Rapid Chloride Permeability Test

RCPT for M20 and M30 grades with different percentage of fibres at 28 days are presented in Table 12.

Table 11. RCPT for various percentage of Glass Fibre.

| S.No | Grade | 0%  | 0.03% | 0.06% | 0.10% | 0.15% |
|------|-------|-----|-------|-------|-------|-------|
| 1    | M20   | 3950 | 3343  | 3472  | 3600  | 3750  |
| 2    | M30   | 2962 | 2272  | 2343  | 2355  | 2487  |

8. Conclusions

1. The rate increment in compressive strength of various glass fibre concrete proportion is seen from 20 to 40 percent contrasted with 28 days compressive quality.
2. The rate increment in flexural and split tensile strength of glass fibre solid blends of various evaluations is seen from 15 to 25 percent contrasted with 28 days.
3. Reduced bleeding is observed by adding glass fibres which improves its homogeneity and reduces cracking.
4. For higher concrete evaluations, the penetrability of glass fibre strengthened chloride concrete shows less chloride porosity.
5. Generally, glass fibres reduce cracks that cause vacuum interconnection to be minimal.
6. The penetrability of cement with the addition 0.03% of glass fibres in M20 and M30 grades diminishes at 28 days by 15.37 and 23.29%.

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