Mechanical Characterisation of Fibre Concrete with Optimum Mix Design

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Abstract. The rise of concrete as a building material has necessitated the use of a variety of additions, including chemical and mineral components, in order to maximise the material's potential. In the present age of developments, in general, innumerable types of fibers are used for crack resistance and strength improvement of concrete. Glass fibers are added to the cement in varying percentages by volume to determine the optimal compressive strength of the mix. The compressive strengths at 0%, 0.5%, 1.0%, 1.5%, and 2% of glass fibres were calculated. The cubes were tested in Compressive testing machine (CTM) of 2000 Ton in accordance with Indian standard: IS 10262:2019 to study the effect of using glass fibres in concrete compared to conventional concrete mix. The experimental results showed that using 0.5 % glass fibre as a fibre reinforced concrete material, gave good and high compressive strength, but it was still low when compared to conventional concrete, so it should be used as a hybrid fibre with other fibres to strengthen the concrete structures.

Keywords: Conventional concrete, Glass fibre, CTM, Fibres, Indian standards.

1 Introduction

The trend at the moment sees the construction sector expanding rapidly Concrete consumption has become an extensive material in the construction industry[1]. Concrete is malleable and flowable when wet, but once cured it is tough and durable. Concrete will be the most sought-after building material for the foreseeable future due to its wonderful behavior and ability to be used either hybrid or unaccompanied[2]. On the very other side of the coin, concrete has numerous undesirable properties such as: brittleness, poor fracture resistance, low impact resistance and high weight, hence the need to improve concrete properties must be considered[3]. In order to improve the properties of the concrete and make it more practical for use in the construction of various types of structures and infrastructure, the addition or substitution of materials in the concrete mix has increased to a greater extent[4][5][6]. Various researchers started experimenting with trial- and-error methods to develop a new mixture with

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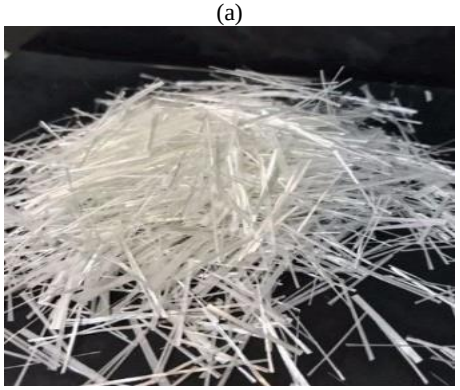
better properties[7][8][9][10]. Numerous fibers are available on the market, for example: basalt, steel, glass fibers, etc., as shown in table 1**.**

(a)



(b)

Fig. 1. Fibre: (b) Basalt Fibre (b) Glass Fibre

Due to the excellent mechanical properties, glass fibers as shown in **Figure 1(b)** are preferred to increase the compressive strength of the concrete. It was experimentally predicted that adding varying proportions of glass fibers to a concrete mix consisting of cement, fine aggregate, coarse aggregate, and water[11] improved the overall properties of the concrete mix, resulting in better structural strength.

2 Experimental procedure

In order to carry out the experiment to come to the conclusion, the setup was carried out in the laboratory and the following arrangement was made. The following table contains mix design[12] proportioning information for M30 concrete with and without glass fibers considered in this project.

2.1 Concrete Cube Mould

To proceed with the experiment setup and results, required cubes are preferred. for which it must be casted in the laboratory. Different cube sizes are available in the laboratory for casting,

in particular (150 x 150 x 150 mm), (100 x 100 x 100 mm), (50 x 50 x 50 mm). For the present experimental work, cube mould of size (150 x 150 x 150 mm) as shown in **Figure 2**. was prefered.

Fig. 2. Casting of Glass fibre concrete cubes at varying percentages

2.2 Materials

For the study's aims, ordinary Portland cement (OPC) was used[13]. The concrete was obtained from a single transfer of the same quality and source. Cement was subjected to a countable test that measured its initial and final setting times, normal consistency, and specific gravity. For the experimental work, specific gravity of fine aggregates, coarse aggregate was obtained as of 2.564 and 2.649 using pycnometer device and a buoyancy apparatus. To produce a desired mix of M30 grade concrete, glass fibers were mixed keeping the amount of cement, fine aggregate, coarse aggregate, and water constant, but varying the percentages of glass fibers. Specific gravity of glass fibre was 2.68.

2.3 Methods

Various grades of concrete are available in accordance with the Indian Standards[12]. Glass fibres of 24mm were mixed in the concrete mix at varying percentages: 0%, 0.5%, 1.0%, 1.5% and 2% of the cement volume added. The proportions obtained for different types of concrete are given in Table 1. Concrete cubes of 150MM x 150mm x 150mm was casted and tested after 7 and 28 days of curing.

3 Results and Discussions

The study aims to consider the compressive energy and stress-strain behavior of various parameters on M30 grades with and without glass fibre, and the control effects are mentioned here.

3.1 Workability

After the M30 grade concrete was ready in the mixer, the slump test was performed once on concrete with and without glass fibers at a certain percentage, and the slump was derived to

understand the workability of concrete types as shown in Table 2 and **Figure 3**.

Fig. 3. Concrete Slump Test Apparatus

Table 2. Workability of concrete at varying % of Glass Fibres

	% Of Glass Fibres added *(in%)*	**SlumpValue(***in mm)*
Percentages of Glass Fibres added	0.0	65
	0.5	45
	1.0	40
	1.5	35
	2.0	33

3.2 Mechanical Properties

3.2.1 Compressive strength

A device known as a compression testing machine (CTM) of 2000 Ton[4], as shown in **Figure 5**, was used to measure the compressive strength of several cubes that had different percentages ofglass fibres added to them at 7 and 28 days of curing. **Figure 4 (a)-(b)** illustrates the cubes used in CTM machine. Six sets of cubes were taken for each varying percentages , i.e 6 cubes were usedfor conventional concrete, while the same number of cubes were used for 0.5, 1, 1.5 and 2% of glass fibre reinforced concrete.

(a)

(b)

Fig. 4. Sample (a) 0% glass fibres (b) Varying % of glass fibres

Fig. 5. Compressive testing machine (CTM) Apparatus

After Checking the Mechanical characteristics of cubes after 7 and 28 days of curing of cubes, compressive strengths obtained for conventional concrete as well as glass fibre reinforced concrete cubes are illustrated in graph in **Figure 6**.

As graph in **Figure 6** reflects compressive strengths at 7 days of curing as : 22.40,19.76,12.81, 7.43and 6.739 N/mm^2 whereas 29, 26.6, 17.09, 10.08 and 9.53 N/mm^2 at 28 days of curing for conventional concrete (0% fibre additive) and at 0.5,1,1.5 and 2% glass additives.

Addition of 0.5 % glass fibre in conventional concrete mix gives good and high compressive strength than other percentages of glass fibres addition(1%,1.5%,2%). Further, when compared with the conventional concrete(0% glass fibres) reflects higher compressive strength than 0.5 % glass fibre reinfored concrete.

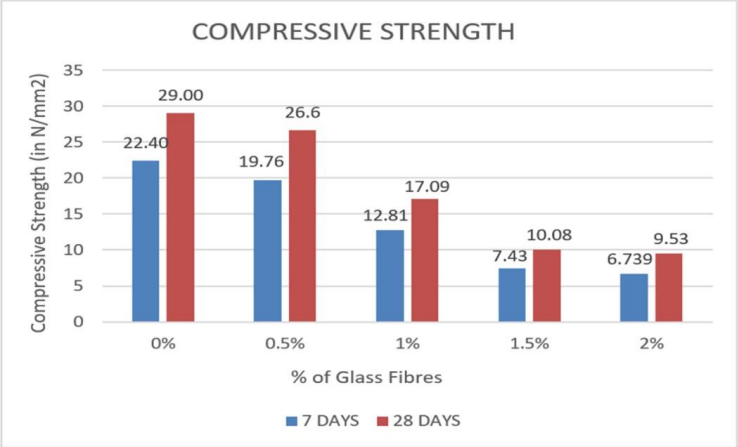


Fig. 6. Comparison between Compressive strength of concrete mix at varying percentages of glass fibres

4 Conclusions

After 7 days of curing, conventional concrete mix with no fibre content has a compressive strength of 22.4 N/mm^2, whereas concrete containing 0.5%, 1%, 1.5%, and 2% glass fibres achieves a compressive strength of 19.76, 12.81, 7.43, and 6.739 N/mm^2 respectively. On the other hand, compressive strengths of 29.00, 26.6, 17.093, 10.08, and 9.34 N/mm^2 were achieved after curing for a period of 28 days.Hence, the compressive strength of concrete at varying percentages of addition of glass fiber found to be decreasing when compared to the conventional concrete (0% glass fibres). When adding glass fibre to M30 grade concrete, the maximum compressive strength was 0.5% and the lowest was 2%. After 28 days, the conventional concrete mixture for M30 grade concrete mix has stronger compressive strength than the concrete with varying fibre percentages.Glass fibers as an additive affects the range of compressive strength by reducing the compressive strength compared to the identical conventioanl concrete mix. Decrease in the compressive strength is caused by the inclusion of the fibers in the cement matrix of the concrete, which, due to their lower bond strength, form a disruption in the C-S-Hbond between the cement and the surrounding aggregate.

The findings from this experimental study has shown that the M30 grade concrete with glass fibers has a low compressive strength, but it turns out to be more durable and economical, so it should be used as a hybrid fiber in combination with some other fibers to give it more strength concrete structure.

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