# Partial Replacement of Cement by Flyash & Glass Fibre in Light Weight Fibre Reinforced Concrete

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***Abstract*— Concrete is weak in tension and is often affected by cracking and scaling which are connected to plastic state, drying shrinkage and hardened states. Concrete mainly suffers from limited ductility, low tensile strength, and slightly resistance from cracking. With increase in coal based thermal power projects there is increase in production of fly ash which is a waste material and the disposal of this fly ash is hazardous to environment if it is not disposed well. Glass fibre is obtained from the molten glass of a specific composition which is a chemically inorganic fibre as they are low-cost and ductile behavior without compromising on strength parameters. The substitution of cement with fly ash in concrete leads to environmental degradation and raises the durability and mechanical properties of concrete. Replacement of Cement by Glass fibres in different fractions with 0%, 1%, 1.5%, 2%, 2.5%, 3% and 30% of Fly ash has been used, which satisfies the various structural properties of concrete like compressive strength, flexural strength. Workability was enhanced by the inclusion of super plasticizer in concrete which was adopted up to 0.5% by the weight of cement. As per Indian Standards, standard sizes of cubes and beams were casted and tested for compressive strength, flexural strength at age of 7days, 14 days and 28 days.**

***Keywords*— Glass fibre reinforcement, fibre reinforced concrete, Compressive strength, flexural strengt, flyash, alkali resistant glass fibre.***

## I. INTRODUCTION

Concrete is considered as one of most widely used material in construction. Almost everything in our surrounding is influenced by design and construction of concrete structures such as dams, bridges, skyscrapers, water and sewerage systems, public buildings. Concrete is initially poured in the liquid matter into places which eventually becomes hard after a certain period of time like natural rock and so it is characterized as a quintessential construction material.

The global obtainable major cement replacement materials are silica fume and fly ash which is generated in thermal industries and has an adverse effect on the environment. These are predominantly used as the cement replacement in order to reduce the cement usage. Moreover, they enhance the properties of concrete like durability, sulphate resistance and impermeability. Fly ash conceives all these properties.

Fly ash initially improves the workability in the fresh state which is due to the particles of fly ash being spherical shaped and smooth. This enhanced workability permits for smaller water to cement ratio which in turn shepherd to greater compressive strength. Fly ash in the hardened state confers in a greater degree of approach such as strength and workability, which may also prosper the setting time of the concrete. Excess calcium hydroxide is removed during the pozzolanic reaction emerged from the cement reaction. Fly ash generation in India has escalated up to approximately 50% in the last decade with an output of 100 million tones and so is highly resourceful.

Fibre reinforced concrete is a concrete with a mixture of indiscriminately oriented and uniformly distributed short discrete fibre which increases the integrity of the structure. These fibres may include mostly glass or cellulose, steel, polypropylene, carbon, polyester and nylon. The total quantity of fibre added to a concrete mix is calculated as a percentage by the mass of cementitious material or total volume of the composite i.e. concrete and fibre, which ranges from 0.1% to 3%.

## II. LITERATURE REVIEW

An extensive Literature Review was carried out to investigate the lucrative effect of glass fibre and fly ash on concrete. Various researchers have come out with various conclusions.

- An extensive research study was carried out on the strength characteristics of glass fibre reinforced concrete by Dayalan J (2017) and concluded that the GFRC made with the inclusion of Portland Pozzolana Cement is an eminent alternative for complex structure as the compressive, flexural and tensile strength increases with respect to the inclusion of glass fibre by volume of concrete. Corrosion is highly subjected to steel reinforcement in marine and hydraulic structures which is counteracted by the properties of glass fibre which enhances its tensile strength and diminishes the demand for larger area of steel reinforcement which is easily subjected to corrosion. Further, an extra layer of concrete with glass fibre can be placed on the marine and hydraulic structure as its compressive and tensile strength is higher with the addition of glass fibre which results in prohibiting the elements which deteriorates the structure and subject it to further suffering. Hence, enhancing the life span of the structure.

- An investigation was conducted to examine the compressive strength behavior of GFRC by Lanjewar and Rayadu (2015) and deduce out that the strength was better at 1% inclusion of glass fibre than 2%. The study showed that the strength significantly increased up to limit than started to decrease. Hence, it is preferable to use GFRC than conventional concrete as it excels the strength.
- Tajne and Bhandari (2014) carried out an investigation and significantly delineate the effect on an ordinary concrete by the inclusion of glass fibre. They deduce out the deficiency of the concrete of bleeding was abated by the addition of glass fibre in the concrete mix. The concrete mixes with different grade of proportion of glass fibre experience an enhancement of compressive and flexural strength at 28 days, which was observed to be from 12% to 18% and 16% to 20%.
- Patel et al. (2013) analyze the glass fibre in the form of an additive to increase the tensile strength of a concrete as it is weak in tension and glass fibre possess such properties that the filaments avail the particles of concrete to be sealed together and not to be separated. The compressive, flexural and tensile strength of the concrete at 28 days increased with the addition of glass fibre. However, there was a minimal increase of compressive strength and the durability and mechanical properties was appeared to be of better result with the addition of 0.1% glass fibre.

## III. METHODOLOGY

Mix Proportions: In this study, control Mix of M-25 of proportion 1: 1.5: 2.75 was designed with water cement ratio of 0.45 as per IS 10262:1982 to achieve a target compressive strength of 31.6 N/mm$^2$. In this experiment we replaced the cement with fly ash (30%) and glass fibre (0 %, 1%, 1.5%, 2%, 2.5% and 3%) by mass of cementitious material partially. Mix M-1 was taken as control mix with 0% of addition of glass fibre and fly ash. Mix M2 with 1%, M3 with 1.5%, M4 with 2%, M5 with 2.5 % and M6 with 3% glass fibre was used in the study.

1) Cement (OPC 43 grade): Ordinary Portland cement of 43-Grade was preferably used referring to IS-8112: 1989 of BIS (Reaffirmed on 2005). The grade manifest the compression strength (mpa) of the concrete that will attain after 28 days of setting. The cement having specific gravity value of 3.15, Soundness of 1 mm and normal consistency 31% was used.
2) Fly ash : Fly ash containing low calcium having color of whitish grey, specific gravity of 2.16, fineness of 327 m$^2$/kg, moisture content of 0.15% was used as replacement for cement. The fly ash will be obtained from Indira Gandhi Super Thermal Power Project which is located between Khanpur Kurd and Jharli village in Jhajjar, Haryana. To get the optimal replacement of the cement material, the particles of fly ash was passed through 90 micron sieve throughout the experimental works.
3) Glass fibre : In this experiment, alkali resistant glass fibres, 12mm long, having the tensile strength as 2.7 GPa, specific gravity value of 2.68, modulus of elasticity as 80 GPa, having an aspect ratio of 600 and filament diameter of 20 micrometers, density of 3.99 mg/m$^3$, melting point of 650˚**C** , moisture rate of 0.2 was used.
4) Fine Aggregate: The fine aggregates utilized were easily accessible from the local market. Fine aggregate can be classified as those particles which roughly pass the 4.75mm IS sieve and significantly retains on the 75micron sieve. Fine Aggregates having specific gravity value of 2.57, fineness modulus as 2.51 was used.
5) Coarse Aggregate: The aggregates passing through 40mm sieve and retain at 4.75mm sieve was used as coarse aggregate. In this experiment, natural aggregates that are available locally, formed out of the rock disintegrated naturally, which was deposited by various agents. The two sizes of coarse aggregates were used, 10 mm & 20mm, having the specific gravity as 2.72 and 2.64 respectively with the fineness modulus of 6.59.

## IV. EXPERIMENTAL PROGRAM

1) Compressive strength Test : Strength is the most crucial material parameter that is used to identify cement-based products. Generally, the strength signifies the crushing strength of the concrete cubes and beams casted in steel moulds. As per the guidelines mentioned in the IS Code: 4031(Part 6)-1988 (Reaffirmed 2005), the concrete cubes of size 150mm x 150mm x150mm and concrete beams of 150mm x150mm x 700mm were casted for attaining compressive strength. After casting all the cubes and beams, finishing of specimen was carried out with steel trowel which help in removing excessive quantity of concrete from the top surface of moulds. All the specimens were removed from moulds after a period of 1 day or 24-hours and then the specimens were cured in water. The water used for curing purpose is approximately at room temperature. The compressive strength test for cubes and beams was carried out at 7, 14 and 28 days. An automated CTM was used for testing all the specimens. Figure 3.7 shows the CTM used in the study. The compressive strength of the specimen was then evaluated according to the given formula below:

$$f_c = P / A$$

Where, fc = Compressive strength (N/mm2)
P = Maximum load [N]
A = Cross section of a sample [mm2]

2) Flexural strength Test: Flexural strength encounters a part of measurement of tensile strength of concrete and determines the capability of the concrete slab to resist the fracture due to bending. The flexural strength of the beam is manifested as modulus of rupture (MR) in psi (N/mm2) units and by standard test method ASTM C-293 (center point loading or ASTM C-78 (third point loading). Flexural test is to be subjected to adequate handling of beams as they are heavy and can get damaged while the preparation

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and curing of specimen should be executed conventionally to achieve the desired result.

For carrying out this test, beams of dimension 150mm x 150mm x 700mm were casted. Functionally, the type, volume and size of coarse aggregate determine the flexural modulus of rupture which is predominantly about 10%-20% of compressive strength. The flexural strength of the specimen was then evaluated according to the given formula below:

$$Fb = PL / bd^2$$

Where, fb = flexural strength (N/mm2)
Where, P = Maximum load [Kg]
b = width of specimen [cm]
d = depth of specimen at point of failure [cm]
L= length of specimen on which the specimen was supported [cm]

## V. RESULTS AND DISCUSSION

Various tests were performed in glass fibre reinforced concrete and the results were discussed elaborately.

1) Compressive Strength

i) Testing of specimen: Concrete cubes were loaded in a compressive testing machine. (CTM) to ultimate stress and breaking load was obtained.

ii) Results: The testing was carried out for 18 cubes at 7 days, 18 cubes at 14 days and 18 cubes at 28 days. The compressive strength results are given below in Table 4.1

The compressive strength of the reinforced concrete increases monotonously with the increase in its fibre content.

TABLE 1: Compressive Strength Of Concrete

| Mix | Percentage of Glass Fibre (%) | Compressive Strength ( ) | | |
|---|---|---|---|---|
| | | 7 Days | 14 Days | 28 Days |
| M 1 | 0 | 18.67 | 21.59 | 28.41 |
| M 2 | 1.0 | 16.48 | 18.07 | 22.48 |
| M 3 | 1.5 | 16.95 | 18.96 | 24.0 |
| M 4 | 2.0 | 18.37 | 22.07 | 27.26 |
| M 5 | 2.5 | 17.28 | 20.04 | 25.07 |
| M 6 | 3.0 | 17.81 | 20.81 | 25.48 |

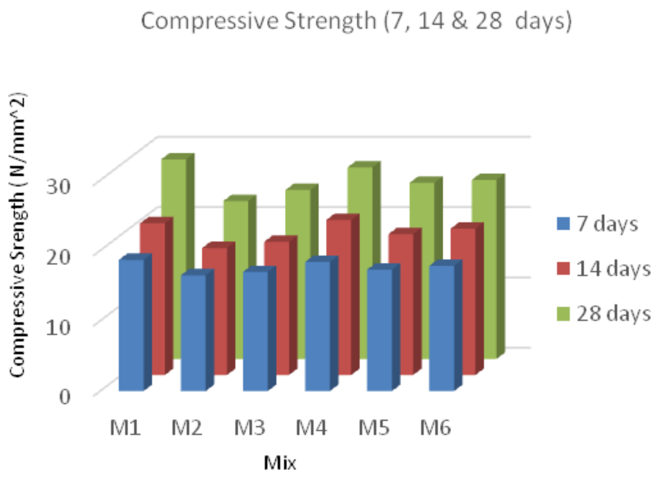


Fig. 1. Compressive Strength Vs Design Mix

2) Flexural strength

i) Testing of specimen: Concrete beams of size (150mm x 150mm x 700mm) were loaded in a Flexural testing machine (FTM) to ultimate stress and breaking load was obtained.

ii) Results: The testing was carried out for 8 beams at 7 days, 8 beams at 14 days and 8 beams at 28 days. The Flexural strength results are given below in table 4.2.

The Flexural strength of the reinforced concrete increases monotonously with the increase in its fibre content.

The maximum increase in Flexural strength of beams up to 5.39 is obtained at 28 days with 2% of fibre content for M-25 grade.

TABLE 2: Flexural Strength Of Concrete

| Mix | Percentage of Glass Fibre (%) | Flexural Strength ( ) | | |
|---|---|---|---|---|
| | | 7 Days | 14 Days | 28 Days |
| M 1 | 0 | 4.5 | 4.9 | 5.18 |
| M 2 | 1.0 | 3.94 | 4.24 | 4.78 |
| M 4 | 2.0 | 3.94 | 4.24 | 4.78 |
| M 6 | 3.0 | 4.15 | 4.77 | 4.96 |

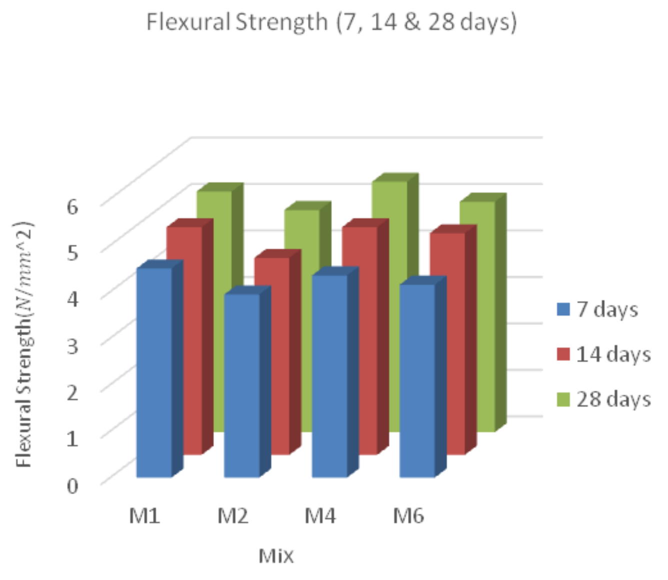


Fig. 2. Flexural Strength Vs Design Mix

## VI. CONCLUSIONS AND MAJOR FINDINGS

- The inclusion of the glass fibre into the mixture of concrete did not improve its compressive and flexural strength. However at the age of 28 days, the values of M4 mix are comparable to the controlled concrete mix M1.
- The strength results of 2% of glass fibre by mass of cementitious material in the concrete mix M4 is comparable to the control concrete mix M1.
- The average compressive strength of cubes at 7 days as per the IS Code: 10262:2009, should not be less than 65% of the targeted strength and at 28 days, should not be less than 90% of the targeted strength and the values obtained in this study came out to be quite significant and applicable.
- Flexural strength of beams is within the permissible limit as per the codal provsions. It is observed from the results that the maximum increase in flexural strength of beams up to 5.39 $N/mm^2$ is obtained at 28 days with 2% of fibre content which is comparable to ordinary mix M1 with 0% of fibre at 28 days.

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