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Strengthening of Plain Cement Concrete with Glass Fibre

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***Abstract*—Plain concrete possess very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to propagation of such micro cracks. Fibers when added in certain percentage in the concrete improve the strain properties as well as crack resistance, ductility, flexure strength and toughness. Mainly the studies and researchin fiber reinforced concrete has been devoted to glass fibers. In recent times, glass fibers have also become available, which are free from corrosion problem associated with steel fibers. The present paper outlines the experimental investigation conducts on the use of glass fibers with structural concrete. Glass fiber of diameter 5–25 micron, having an aspect ratio 800-900 was employed in percentages of 0.4, 0.8 and 1.2 by weight in concrete and the properties of this FRC (fiber reinforced concrete) like compressive strength, flexure strength, toughness, modulus of elasticity was studied.**

***Index Terms*—Ductility Flexural Strength, FRC Micro cracks, Tensile Strength**

I. INTRODUCTION

Plain concrete is known to have low strength and low strain capacity; however, these structural properties could be improved by addition of fibres. There are different fibres that are used in the concrete namely glass fibre, steel fibre, synthetic fibres and natural fibres (jute fibres). The improvement in the material behaviour of the fibre reinforced concrete depends on dosage and characteristics of the used fibres. Addition of randomly distributed glass fibre improves concrete properties, such as compressive strength, static flexural strength, ductility and flexural toughness. The large number of fibres used for concrete members enables a uniform distribution of fibres through the compound, thereby creating a composite material possessing homogeneous mechanical behaviour. They provide a cohesive mix. The important characteristic in FRC material is the bond between the fibers and the matrix. Fibres are designed in different geometries to increase the bond and interfacial friction between fine aggregates and cement paste. In addition, the deformation at peak stress is much greater than plain mortar. Fibres help to alter the behaviour of concrete after the initiation of cracking. The forces induced in GFRC when subjected to load are redistributed within the concrete, which restrains the formation and extension of cracks. The result is a more ductile reinforced concrete which is able to maintain a residual capacity in the post-cracking phase. Thus, resulting in an increased load-carrying capacity, improved shear and bending strength of concrete, superior flexural ductility, toughness, and fatigue endurance.

Pankaja B Set. al. (2018), the study is to analyze the compressive strength of concrete, when concrete is mixed with glass fiber, to meet the demands of the modern construction. The addition of Glass fibre into concrete increases the compressive strength of concrete. Tests are conducted by using glass fibre. For 1 m3 of concrete, 612grams of glass fibre for M30 grade of concrete and for M40 grade of concrete 697 grams of glass fibre for 1m3 of concrete are used. The result shows GFRC gives good compressive strength.

Samprati Mishra (2017), under this study using alkali resistance glass fibre. Glass fibre falls under the economical class i.e. without any extra expenditure can be used. The used glass fibres are of 12mm in length and 14micron diameter. Total 10 groups were prepared with different percentage of glass fibre and grade of concrete. First trial test was conducted using different percentages of glass fibre in M25 grade concrete. Since high grade concrete has been used in various constructions worldwide so this research work also kept the importance of investigate high grade concrete i.e. M40 with different fraction of glass fibre and analyzed the comparison study. The compressive strength test was conducted at 7days and 28days. The result shows the satisfactory enhancement in strength of fibre used concrete than plain concrete. KomalChawla et. al.(2013), studies of glass fiber reinforced concrete composites, this research paper outlines the experimental investigation conducts on the use of glass fibers with structural concrete. Cem-fill anti crack, high dispersion, alkali resistance glass fiber of diameter 14 micron, having an aspect ratio 857 was employed in percentages, varying from 0.33 to1 percentage by weight in concrete and the properties of this Fiber Reinforced Concrete (FRC) like compressive strength, flexure strength, toughness, modulus of elasticity was studied.

II. MATRIAL USED

Cement

Using Ordinary Portland Cement (grade 43) of specific gravity 3.14 conforming to IS 8112:2013, "ORDINARY PORTLAND CEMENT-SPECIFICATION", has been used.

Aggregates

Fine aggregates conforming to IS383:1970, "SPECIFICATIONS FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE" has been used.

Coarse aggregates conforming to IS383:1970, "SPECIFICATIONS FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE" has been used.

Water

Normal portable water fit for drinking purpose has been used to prepare fresh concrete. Specification confirming to IS 456:2000.

Concrete

The concrete is mixture of four main constituents: cement, water, coarse aggregate, and fine aggregate. The concrete was prepared of M20 for a characteristic compressive strength of 20MPa in 28 days from manufacturing.

Glass Fibre

Glass fiber is made by melting the constituent materials together and drawing the melt into a fiber. They have a diameter of 5–25 μm and are coated with a "sizing" to improve the adhesion with the matrix material.

Figure 1: Glass Fibre

III. EXPERIMENTAL SETUP

A. Specimen layout

A total of 36 concrete specimens were prepared and tested in the experimental program having the size of 150mm×150mm×150mm. M20 grade of concrete has been as per the requirement for axial load design. Each cube specimen consists of a 150 mm square cross section and a depth of 150 mm. 9 plain concrete specimens (no replacement) were prepared and 27 glass fibre mixed concrete with different percentage of replacement were prepared. These specimens were prepared for 7, 14 and 28 days of curing respectively. The specimens were numbered as PC11, GC11, GC12 and so on, where the letter "P" indicates Plain and "G" and "C" are indicating Glass Fibre and Concrete respectively. "C" indicates concrete which is the second word in abbreviation and the numeric value indicates the sequence in which they were tested in different group.

In this study, the glass fibres were mixed homogeneously in the concrete mixture where they were integrated into the cube to form a full composite action. The first step in the strengthening process involved sizing, shaping, dressing, cleaning and removal of moisture (by drying) from the glass fibre. During mixing we ensured the uniform distribution and shape of glass fibre. Accurate percentage weight has been taken during the preparation of specimens. These all parameters have been maintained in every specimen preparation.


Figure 2: Shaping & Sizing of Glass Fibre


Figure 3: Uniform Distribution of Glass Fibre

B. Testing Programme

These specimens were subjected to axial compressive load using compressive testing machine of 2000KN capacity. The surface area of each specimen was 22500mm2. Ultimate load readings were taken to study the compression performance of the specimens. Prior to testing, all specimens were wiped off the water by a cloth and cleaned the surfaces of concrete and leave them at the room temperature for drying. After all these actions, putting the specimen by possessed a thick layer of paper fixed at the top and bottom surface of the specimen in order to ensure that the contact surface remained parallel and that the applied load remained concentric. The results of tested specimens were tabulated below, these results were recorded in ultimate loads at which the failures of specimens occurred and further these loads are converted in ultimate stress that is ultimate load divided by cross sectional (surface area) area in which the load was applied.

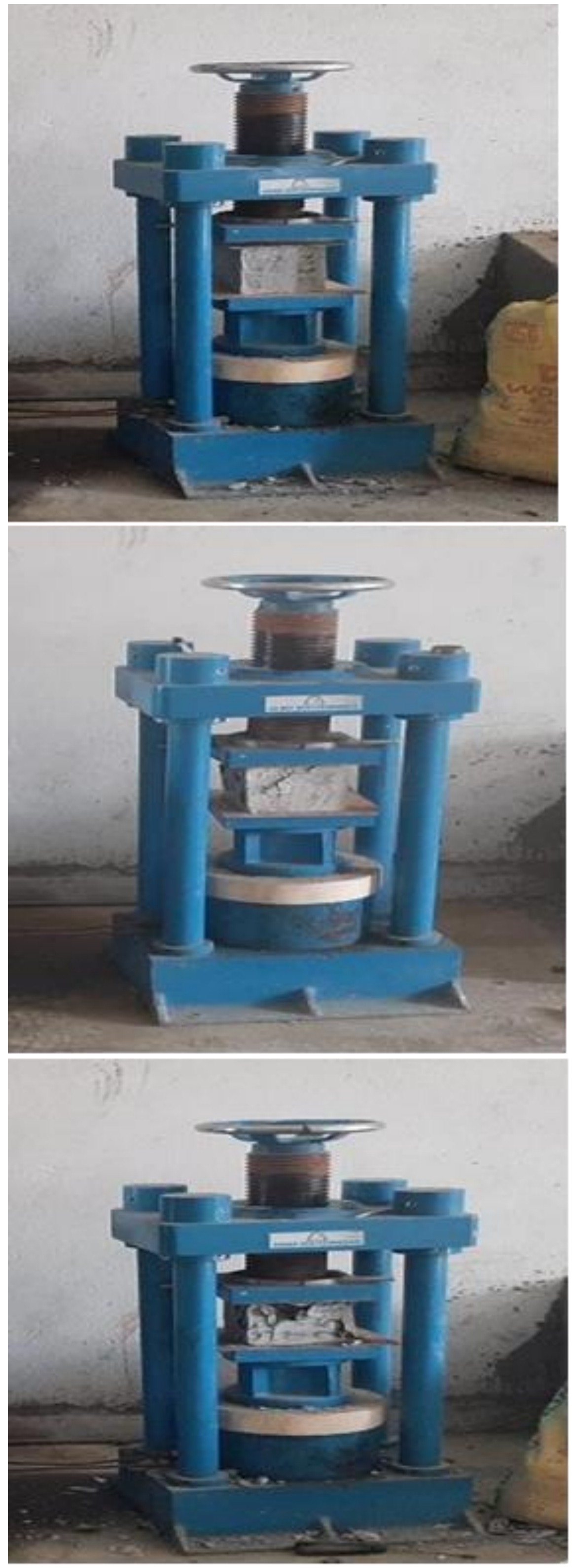


Figure 4: Arrangement & Failure of Specimen

IV. EXPERIMENTAL RESULT

Table 1: Results obtained for concrete specimen7 Days Curing

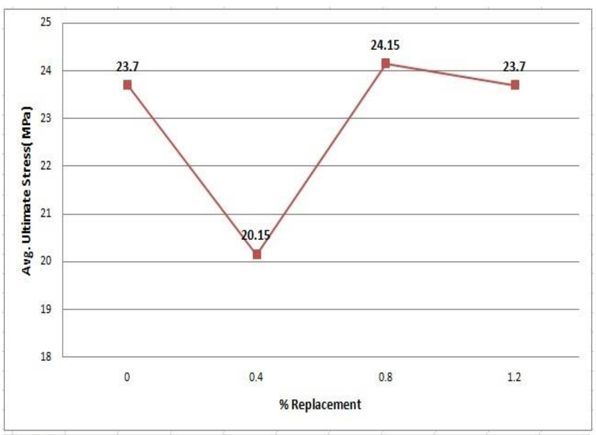
Specimen Name	Percentage Replacement	No. of Cube	Pult(KN)	σult(Pult/A)(MPa)
Plain Concrete (PC) $(PC_{11}+PC_{12}+PC_{13})/3$	0	3	534	23.7
Glass Fibre Concrete (GC_{11})	0.4	3	530	20.15
Glass Fibre Concrete (GC_{12})	0.8	3	540	24.15
Glass Fibre Concrete (GC_{13})	1.2	3	530	23.70

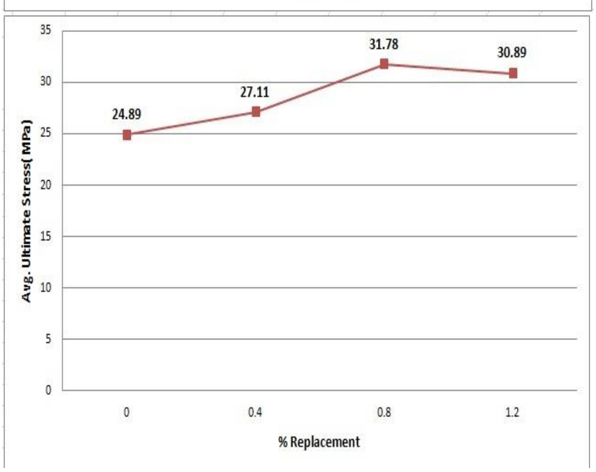
14 Days Curing

Specimen Name	Percentage Replacement	No. of Cube	P_{ult} (KN)	σult(Pult/A)(MPa)
Plain Concrete (PC) $(PC_{21}+PC_{22}+PC_{23})/3$	0	3	540	29.2
Glass Fibre Concrete (GC_{21})	0.4	3	510	22.67
Glass Fibre Concrete (GC_{22})	0.8	3	655	29.11
Glass Fibre Concrete (GC_{23})	1.2	3	600	26.67

28 Days Curing

Specimen Name	Percentage Replacement	No. of Cube	P_{ult} (KN)	σult(Pult/A)(MPa)
Plain Concrete (PC) $(PC_{31}+PC_{32}+PC_{33})/3$	0	3	560	24.89
Glass Fibre Concrete (GC_{31})	0.4	3	610	27.11
Glass Fibre Concrete (GC_{32})	0.8	3	715	31.78
Glass Fibre Concrete (GC_{33})	1.2	3	695	30.89





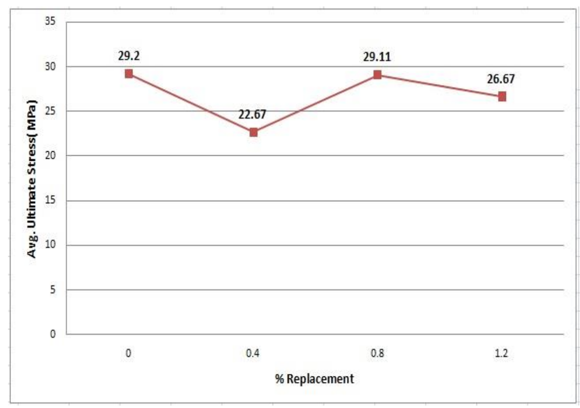


Figure 5: % Replacement VS Ultimate Stresses fo 7, 14 & 28 Days Cured Concrete

Stresses for Replaced & Without Replaced Concrete The concrete specimens, when replaced with glass fibre up to 0.8% recorded the higher stress than plain concrete stress. Beyond this limit concrete was not able to bear the same stress.

V. CONCLUSION

36 concrete specimens designated as PC11, PC12, GC11, GC12 and so on were tested under axial compressive loading in compression testing machine

of 2000KN capacity having the surface area 22500mm2. Comparative study has been
carried out between plain concrete and glass fibre mixed concrete (PC & GC). This research work shows the following results.

1. Specimens mixed with glass fibres, shows the good increment in strength as we replace the glass fibre by 0.4% and 0.8%.
2. Up to this limit concrete shows the good compressive as well as flexural strength.
3. Beyond 0.8% limit i.e. 1.2% replacement of glass fibre starts reducing the strength.
4. Mixing of glass fibre up to 0.8%, concrete shows the good cracking resistance and bonding strength.

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