Enhancing the Durability and Ductility Property of Concrete Incorporated with GGBS and Glass Fiber

Koka Mounika, Jagadish Kumar, B. Kameswara Rao

Abstract: ***Plain concrete is widely used as a building material. But plain concrete possess low tensile strength, low ductility and durability when compared to blended concrete. The environment is rapidly effected due to energy consumption and CO_2 emission during cement production. To reduce the environment effect, Ground granulated blast furnace slag (GGBS) is used as a binding material in plain concrete which in addition improves strength, durability, workability and reduces the risk of sulphate attack and acid attack etc., simultaneously glass fibers are also added to possess high ductility in blended material (GGBS). In this paper, ductility, durability and flexural strength are the main parameters. Experimental work is conducted on M30 and M40 grade of concrete by replacing cement with GGBS by 60% and 0.4% of glass fibers are added by volume of concrete. Durability is age dependent parameter which is observed in curing with sulphate solution and acid solution for 30 days in cubes. Ductility of concrete by stress-strain behavior in cylinders. Flexural strength is assessed through load-deflection curve in beams. From the study, it is observed that use of blended concrete achieve more compressive strength, durability, ductility and flexural strength compared with conventional concrete.***

Index Terms: Durability, Flexural strength, Glass fiber and Ground granulated blast furnace slag (GGBS).

I. INTRODUCTION

Worldwide cement consumption is very high and releasing more amount of CO_2 in the environment. To reduce the CO_2 consumption other binding materials are using to reduce the effect in environment and also reduce the cement consumption by replacing the cement with pozzolonic materials. Generally Pozzolonic materials are Silica fume, Fly ash and Ground Granulated Blast Furnace Slag (GGBS) are commonly used. Among the various methods Ground Granulated Blast Furnace slag (GGBS) is widely used as binding material to improve the mechanical properties and durability of concrete.Increasingly cements are blended with cement substitutes such as Silica fume, Fly Ash (FA) and GGBS are increased. To reduce the overall impact on environment by using 100% cement with blends. GGBS is added to reduce the weight of cement and to attain the strength of concrete. GGBS can be obtained from Steel. In structural view GGBS consists of higher durability, low permeability and high resistant to acid attack and sulphate attack. Risk of acid attack and sulphate attack are reduced with replacement of GGBS in concrete.GGBS gives more strength and durability when compare to the ordinary Portland cement especially in marine structures. While using GGBS the life span of the structure increases from 50 to 100 years.

Plain concrete has low strength at tension and low strain at crack.To overcome this problem Fiber reinforcing concrete is used which consists of aggregates; cement and addition to fibers are added. Glass fiber products have excellent heat capacity. Fibers are randomly distributed to control the crack arrest and increase the tensile strength. Alkali resistance glass fibers (AR) are used to prevent corrosion and improve the properties of concrete like increase in tensile strength, increase in shear strength, improve resistant to impact, bleeding of water and permeability are reduced. Fiber controls the drying and plastic shrinkage. Fibers are used only up to 2% by its volume of concrete. Young's modulus of fiber is higher than the concrete help to carry the load by increasing the tensile strength of concrete. Glass fibers are used to control the brittle failure in concrete. It tends to bind the material and dispersed in all the directions of matrix within the material .The experimental study on M25 grade concrete to evaluate the effects on strength properties with replacement of GGBS by addition to steel and glass fibers in different percentages shows that the strength increases with increase of fiber content [1].By replacing GGBS with 30%, 40%, 50% of cement for M25 and M40 grades by adding hydrochloric acid and sulphuric acid, the durability is studied and stated that the HCL effect on strength concrete is lesser than the effect of H_2SO_4 [2].The alkali resistant glass fiber were used in the concrete by 0%,0.02%,0.04%, and 0.06% for M20 and M30 grade. The fibers increase the compressive and tensile strength with increases in percentage of glass fiber. The strength increases when the grade of concrete increases [3].Grades of M30 and M40 are used to study the flexural strength and ductility of concrete by using Glass fibers. The increase in percentage fibers gives better strength and also while using fibers chloride deterioration is very less [4].

II. RESEARCH SIGNIFICANCE

In this paper the main aim is to attain the durability and ductility properties of concrete. Properties of concrete increase with the addition of GGBS and Glass fiber.

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III. MATERIALS USED

A. Cement

53 Grade ordinary Portland cement was used. The obtained specific gravity of cement is 3.14.

B. Fine aggregates

Fine aggregate was used as natural sand which was available in the local surrounding areas of Vijayawada. The specific gravity is 2.6. The surrounding zone is zone –II it is seen from IS code of 383:1970.

C. Coarse aggregate

Coarse aggregate are used which were locally available in the surrounding Vijayawada. The aggregates used in the experiment were 20mm and 12mm. The specific gravity is 2.8.

D. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is used to improve the workability of concrete.To integrity the durability and ductility properties GGBS is used. The Specific gravity is 2.81.

E. AR- Glass fiber (GF)

Alkali Resistant Glass fibers are good electronic heat resistance and insulation capacity and it resist the cracks from macro to micro. Fibers are light in weight. The length of fiber is 12mm and diameter of 12micron is used. Physical Properties of glass fibers are represented in Table I.

Table I: Physical properties of AR- Glass fiber

Density (kg/m^3)	Modulus of rupture (GPa)	Elongation (%)	Tensile Strength (MPa)
2700	72	2.3	1700

F. Water

Potable tap water is added for which pH value should not be less than 7.

G. Super plasticizer

MYK remicrete pc20 is a super plasticizer with high performance used for early increased compressive strength, and flexural strength with Specific gravity of 1.15.

IV. EXPERIMENTAL PROGRAM

A. Mix proportion

Mix design is carried out by using IS: 10262:2009 Code. The mix proportions are M30 and M40 grade.

B. Casting and curing

M30 and M40 grade mix proportion was prepared. The standard dimensions of cubes (150mm×150mm×150mm) and cylinders of 300mm height and 150 mm diameter are casted. After de-moulding, the cubes are immersed in fresh water tank and allow it for 7, 28, 60 Days.

V. TESTS AND RESULTS

A. Workability Test

Concrete is tested for slump is very important. The slump values for M30 and M40 grades are displayed in the in Table II.

Table II: Slump values for M30 and M40 grade concrete with and without GGBS and Glass fiber

Grade of concrete	GGBS (%)	Glass Fibers (%)	Slump (mm)	Compaction factor
M30	0	0	75	0.8
M40	0	0	65	0.85
M30	60	0.4	52	0.86
M40	60	0.4	50	0.89

B. Compressive Testing

The compressive testing machine is of capacity 2000kN and the compressive test for the specimens is done. Each gradation has 3 cubes. After testing the each gradation of cube the mean strength value is taken. The compressive strength values are obtained by using Eq.1.Test results are shown in Fig. 1 and 2.
Compressive strength

$$f_{ck} = P/A \quad (1)$$

Where,
f_{ck}=Compressive strength (N/mm^2)
P= Failure load at ultimate point (kN)
A=Area of cross section (mm)

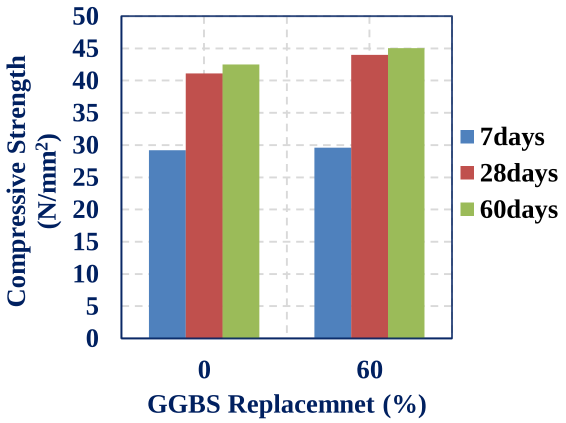

Fig. 1: M30 Compressive strength with and without GGBS and Glass fiber

C. Split tensile test

The test is conducted in Compressive testing machine under the load capable of 2000kN.Cylinder are placed in the lateral direction under the two plates and load is applied manually. The failure load was taken to find the tensile strength for M30 and M40 grade with and without replacement of GGBS and Glass fibers. The split tensile values are obtained by using Eq. 2.The test values are shown in Fig. 3 and **4.**

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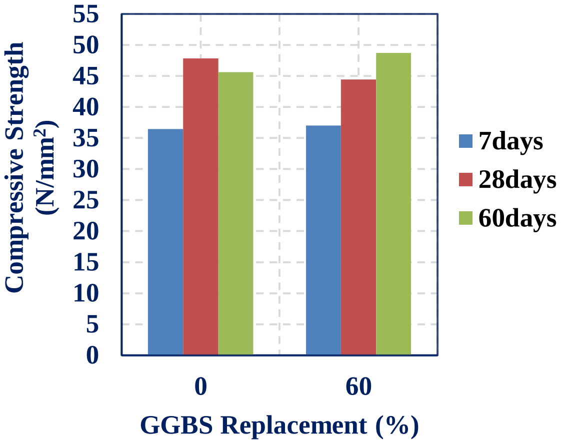

Fig. 2: M40 Compressive strength with and without GGBS and Glass fiber

Split tensile strength

$$T = {}^{2P}/_{\Pi DL} \quad (2)$$

Where,
T= Split tensile strength (N/mm^2)
P= Load at failure (kN)
D= Diameter of cylinder (mm)
L=Length of the cylinder (mm)

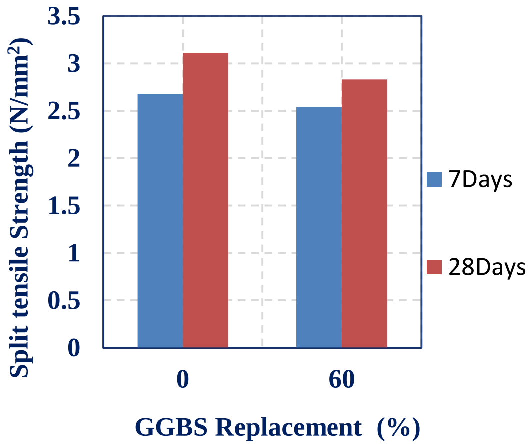

Fig. 3: Split tensile strength for M30 grade of concrete with and without GGBS and Glass fiber

D. Ductility of concrete

Ductility test was performed on cylinders under Universal testing machine by attaching a dial gauge to the upper plate to find out the stress-strain curves.The concrete ductility nature is seen through stress-strain curve.Cylinders of M30 and M40 grade are tested after 28days.The curves are shown in Fig. 5 and 6.

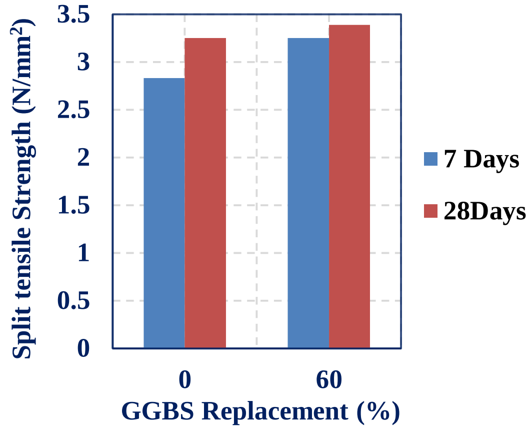

Fig. 4: Split tensile strength for M40 grade of concrete with and without GGBS and Glass fiber

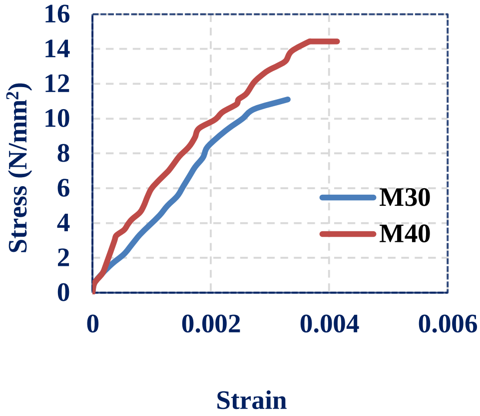

Fig. 5: M30 and M40 stress-strain curve for concrete

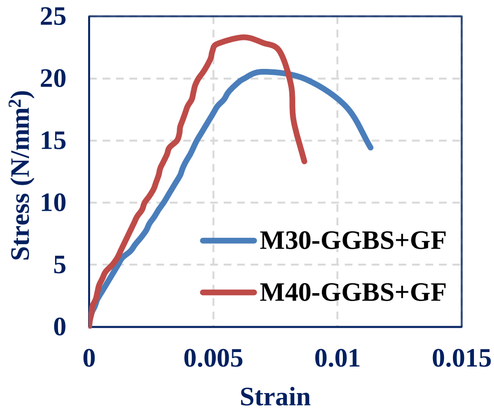

Fig. 6: M30 and M40 stress-strain curve for concrete with GGBS and Glass fiber

E. Durability

The durability of concrete was studied by using H_2SO_4 and $MgSo_4$ solutions. M30 and M40 grade cubes are casted for 5% of $MgSo_4$ and 5% of H_2SO_4 concentration for 30 days curing. The leaching effect is less in GGBS concrete. The acid attack and sulphate attack cubes are shown in Fig .7 and 8.The test results are shown in Table III and IV.

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Fig. 7: Acid attack (H_2SO_4)

Table III: Acid attack compressive test results

S.No	Grade of concrete	GGBS (%)	Glass Fibers (%)	Average Compressive strength (N/mm^2)
1	M30	0	0	27.11
2	M30	60	0.4	30.22
3	M40	0	0	37.77
4	M40	60	0.4	40.88

Fig. 8 : Sulphate attack ($MgSO_4$)

Table IV: Sulphate attack compressive test results

S.No	Grade of concrete	GGBS (%)	Glass Fibers (%)	Average Compressive strength (N/mm^2)
1	M30	0	0	31.11
2	M30	60	0.4	32.88
3	M40	0	0	40.44
4	M40	60	0.4	42.66

F. Flexural strength

The beam specimen of dimensions (2200×150×300) mm is reinforced by 3∅12mm steel bars at tension and by 2∅10mm steel bars at compression are considered. The specimens are tested by placing the specimen in the loading frame with supports of one end is fixed and other end is roller. Load is gradually applied to the beam under 4-point load at l/3 distance. The loading cell gives the load to the specimen and the LVDT is also kept touched to the beams for displacement readings. The beam design and experimental set up is shown in Fig. 9 and 10.The flexural strength values for obtained by Eq.3.The load vs. deflection curve is seen in Fig. 11 and 12.

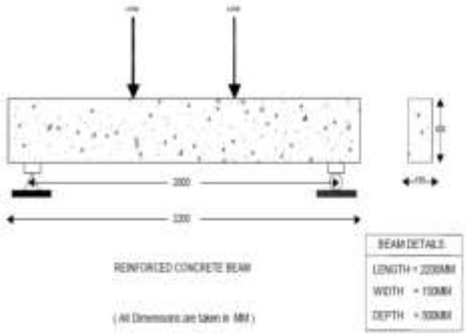

Fig. 9: Beam Design under 4-Point load

Fig. 10: Experimental set up under 4-point loading

Flexural Strength,

$$f_{cr} = {}^{Pl}/_{bd^2} \quad (3)$$

Where,
f_{cr} =Flexural strength (N/mm^2)
P= Ultimate load (KN)
L= Length of the beam (mm)
B=Breadth of the beam (mm)
D=Depth of the beam (mm)

The flexural strength of beam for M30 grade of concrete is 24.52N/mm^2.

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The flexural strength of beam for M40 grade of concrete is 24.94N/mm^2.

The flexural strength of beam for M30 grade of concrete with addition to GGGBS and Glass fiber is 24.81N/mm^2.

The flexural strength of beam for M40 grade of concrete with addition to GGBS and Glass fiber is 25.45N/mm^2.

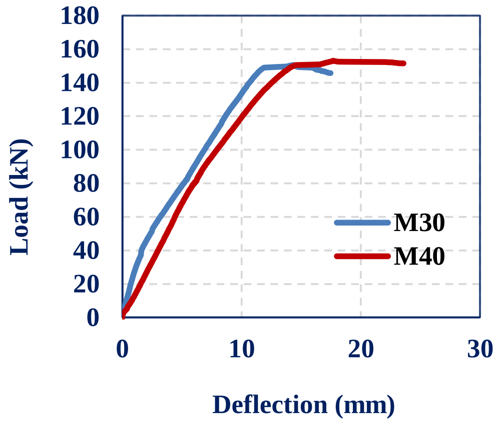

Fig. 11 : Load Vs. Deflection curve for M30 and M40 Grade of concrete

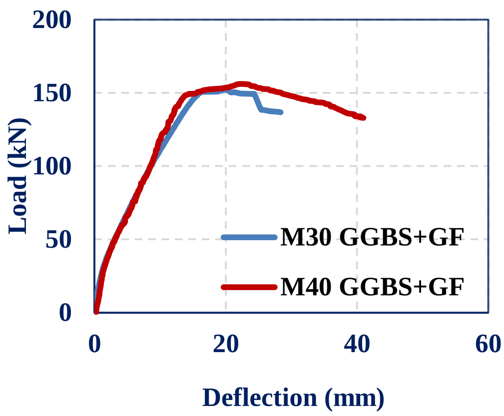

Fig. 12: Load Vs. Deflection curve for M30 and M40 concrete with GGBS and Glass fiber

VI. CONCLUSION

From the research, optimum value of 60% GGBS and 0.4% Glass fiber are considered for all experimental investigation.

1. From the study, it is observed that concrete with GGBS and Glass fiber shows much better results (as compared with) than the conventional concrete.
2. As age increases the concrete with GGBS and Glass fiber shows higher compressive strength than conventional concrete.
3. M40 Concrete with GGBS and Glass fiber gives better results in tensile strength compared to M30 grade of concrete.
4. M30 grade with GGBS and Glass fiber shows better ductility characteristics than M40 grade of concrete.
5. From the experimental results, M30 and M40 GGBS concrete gives more durability than conventional concrete.
6. M40 grade beam with GGBS and Glass fiber gives higher flexural strength than M30 and conventional beams.
7. M40 grade beam with GGBS and Glass fiber shows more load-carrying capacity than M30 and conventional beams.

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