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Study on Strength Characteristics of Ground Granulated Blast Furnace Slag Modified Fiber Reinforced Concrete

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ABSTRACT
Worldwide, a great deal of research is currently being conducted concerning the use of fibre reinforced concrete. Fibre reinforced concrete application is a very effective way to strengthen structures where in order to increase their life span. Fibres are currently being specified in tunnelling, bridge decks, pavements, loading docks, thin unbounded overlays, concrete pads and concretes slabs. Fibre reinforced concrete (FRC) is concrete containing fibrous materials which increase its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres. Experimental investigation on the compressive behaviour and flexural behaviour of the fibre reinforced concrete were carried out. For this purpose, M40 mix was used, by varying fibres in to the mix. All mixes were tested for slump in fresh state, and 28 days compressive strength, flexural strength tests were carried out in hardened state. The experimental results show that the fibres used in the concrete have been enhanced the flexural behaviour of the reinforced concrete.

Keywords – Fiber reinforced concrete, GGBS, elasticity modulus, strength characteristics

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I. INTRODUCTION

Concrete is a versatile material in civil engineering because it has desirable engineering properties. It can be made on site using easily available materials. It can be moulded into any shape and the surface can be textured. Most importantly, it is produced with cost-effective materials. Concrete is used to build various civil engineering structure and elements such as culverts bridges, highways, commercial and residential buildings, dams and underground tunnels etc. Concrete is a strong and tough material. It possesses very good water-resistant properties and hence, it can be used in intake towers for drawing water, dams and water tanks for strong and canal linings for transporting water. A fresh concrete matrix consists of aggregate phase and gel phase(C-S-H). A concrete is a through mixtures of cement, coarse aggregate, fine aggregate, water and admixtures (mineral and chemical admixtures) if necessary.

Some researchers have done effect of ground granulated blast furnace slag on the fresh, hardened and durability aspects of the concrete. The following were listed below.

The possibility of utilizing steel slag as aggregates in concrete was experimentally investigated by Netinger et al (2011). Osborne (1999) has carried out studies on the performance and long-term durability of concrete where GGBS was used as a cementitious material. Pane and Hansen (2002) investigated the key properties that influence the stress development in concrete at early ages and the effect of using blended cements. Mineral additives and amount by weight of total binder used in the blended cements are GGBS (25%), ground granulated blast furnace slag (25%), and silica fume (10%). The properties investigated include tensile creep, elastic modulus, split tensile strength, and autogenous shrinkage.

Nadeem and Somnath (2013). In this study, alkali activation was done using a combination of potassium hydroxide and sodium silicate. The compressive strength results showed that there was an increase in compressive strength 22 with the increase in age of water curing. Shariq et al (2008) studied the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag.

Oner and Akyuz (2007) studied the optimum level of ground granulated blast furnace slag on the compressive strength of concrete. According to their test results, the compressive strength of ground granulated blast furnace slag concrete increases as the granulated blast furnace slag content is increased up to an optimum point about 55-59%, after which the compressive strength decreases. Wu and Roy (1982) reported that the amount of high-range water reducing admixtures required to produce flowing concrete is usually 25% less than that used in concretes containing non GGBS.

Sata et al (2007) experimentally investigated the effects of pozzolano made from various by-product materials such as Ground pulverized coal combustion Fly Ash (FA), ground fluidized bed combustion GGBS (FB), ground rice husk–bark ash (RHBA), and ground palm oil fuel ash (POFA) on mechanical properties of high-strength concrete. The results suggested that concrete containing FA, FB, RHBA, and POFA can be used as pozzolanic materials in making high-strength concrete with 28 days compressive strengths higher than 80 MPa.

This project presents the effect of GGBS and steel fibers on the mechanical properties of the hardened concrete.

II. EXPERIMENTAL INVESTIGATION

2.1Method and materials

A series of laboratory tests was conducted on fibre-reinforced GGBS modified concrete. Significant engineering properties such as compressive strength, spilt tensile strength and flexural strength of concrete were determined on fibre-reinforced bagasse ash modified concrete. The GGBS content was varied 0%, 10%, 20% and 30% by the weight of cement and the fibre content was varied as 0%, 0.5%, 1.0% and 2.0% by the volume of concrete. The super plasticizer is also used. The ingredients of concrete were thoroughly mixed in mixer machine till uniform consistency was achieved. Before casting, machine oil was smeared on the inner surfaces of the cast iron mould. Concrete was poured into the mould and compacted carefully using vibratory table. The top surface was finished by means of a trowel. The specimens were removed from the mould after 24hours and then cured under water for a period of 7, 14, and 28 days (56 days for cubes). The tests were conducted as per the relevant Indian Standard specifications**.**

Ordinary Portland cement (53 Grade), GGBS, fine aggregates (Zone-II sand IS specified) and coarse aggregates were used. The mix proportioning is done using as per IS 10262:2009 method for, M40 grade concrete. The resulting mixes are modified after conducting trials at laboratory by duly following the Indian standards guidelines to achieve following mix proportion by weight.

Table. 2.1 Mix proportions

Cement	Fine aggregate	Coarse aggregate	w/c ratio
380	828.4	1157.1	148
1	2.180	3.045	0.38

2.2 Preparation of Alkaline solution

The compressive strength of geo-polymer concrete is examined for the mixes of varying molarities of Sodium hydroxide (8M and 11M). The molecular weight of sodium hydroxide is 40. To prepare 14M i.e. 14 molar sodium hydroxide solution, 560g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 liter solution. For this, volumetric flask of 1 liter capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1liter solution. The weights to be added to get required molarity

III. RESULTS AND DISCUSSION

The compressive strength of all the mixes was examined at the different ages as mentioned. The test data was tabulated below.

Table 3.1. Test data of compressive strength

Compressive strength (MPa) for curing period of				
GGBS (%)	7 Days	14 Days	28 Days	56 Days
0	35.2	41.25	46.50	52.60
10	34.5	38.50	42.25	50.15
20	38.2	41.25	54.50	60.25
30	35.5	36.50	44.25	45.45

Table 3.2. Test data of flexural strength

Flexural strength (MPa) for curing periods of			
GGBS (%)	7 Days	14 Days	28 Days
0	35.25	41.25	46.50
10	34.50	38.50	42.25
20	38.25	41.25	54.50
30	35.50	36.50	44.25

Table 3.3. Test data of split tensile strength

Split tensile strength (MPa) for curing periods of			
GGBS (%)	7 Days	14 Days	28 Days
0	2.180	2.410	2.598
10	2.450	2.740	3.050
20	2.950	3.140	3.280
30	2.700	2.950	3.100

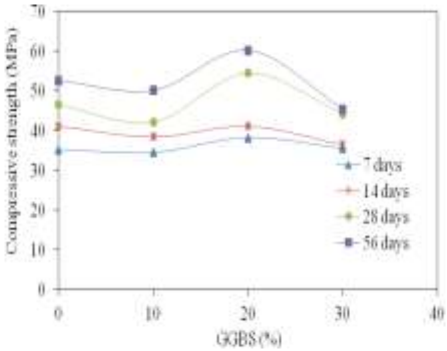

Fig. 3.1 Compressive Strength Test of Cube Specimens on Replacement of Cement with GGBS

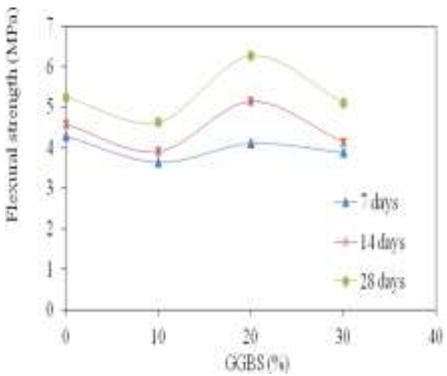

Fig. 3.2 Flexural strength Test of Cube Specimens on Replacement of Cement with GGBS

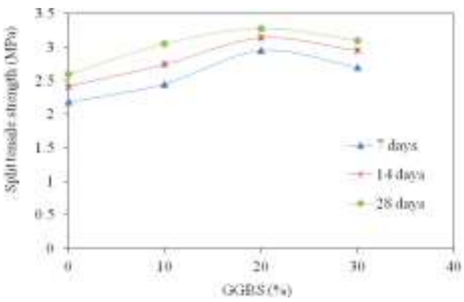

Fig. 3.3 Split tensile strength Test of Cube Specimens on Replacement of Cement with GGBS

Table 3.4 Effect of steel fiber and 20% GGBS content on the strength characteristics of the hardened concrete

Tests	7 Days Strength (MPa)	14 Days Strength (MPa)	28 Days Strength (MPa)
Compressive Strength	41	46.5	54.5
Flexural Strength	4.33	4.86	5.64
Split Tensile Strength	3.42	3.64	4.24

The test results of GGBS modified concrete by 0%, 10%, 20% and 30% weigth replacement to cement, cured in normal water for 7, 14 and 28 days (56 days for cube specimens), strengths are tabulated (i.e., table 3.1, 3.2 and 3.3).

The average Compressive strength of concrete with replacement of 20% GGBS 7, 14, 28 and 56 days strength increased by 8.92%, 9.76%, 4.17% and 5.43% to controlled M40 mix.

The average Flexural strength of concrete with replacement of 20% GGBS, 7 days strength decreased by 13.12%. The average Flexural strength of concrete with replacement of 20% GGBS for 14 and 28 days strength increased by 7.84% and 16.08% to controlled M40 mix.

The average Spilt tensile strength of concrete with replacement of 20% GGBS, 7 days, 14 days and 28 days strength increased by 23.89%, 27.18% and 21.21% to controlled M40 mix.

The average Compressive strength of concrete on addition of 1.0% Steel fibre, 7, 14, 28 and 56 days strength increased by 20.54%, 17.46%, 15.23% and 2.88% respectively to controlled M40 mix.

IV. CONCLUSIONS

From the experimental investigation the following conclusions were drawn.

1. The Specific surface area of GGBS is 470 m^2/Kg greater than 330 m^2/Kg of cement. The workability of GGBS concretes have decreased in compared with ordinary concrete. It is inferred that reduction in workability is due to large surface area of GGBS.
2. A series of laboratory experiments was conducted to find compressive strength, split tensile strength, flexural strength and modulus of elasticity of ground granulated blast furnace slag modified fibre-reniforced concrete. The effect of ground granulated blast furnace slag content, fibre content and curing period was studied. The following are the conclusions that can be drawn from the experimental investigation
3. The optimum value of GGBS content was found to be 20%. For that concrete, optimum volume fraction of crimped steel fiber was founded as 1%.
4. The test results of 20% GGBS modified concrete shows that, optimum strengths in compressive, flexural, spilt tensile and elastic modulus tests when compared to convention concrete.
5. The test results of 1.0% steel concrete shows that, the flexural strength and split tensile strength increases with increasing the percentage addition of steel fibre.

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