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Ground Granulated Blast Furnace Slag is used as Concrete Material in Construction

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Abstract: Ground granulated blast furnace slag blended with ordinary Portland cement gives lower strength in early stages of concreting and gains strength slower than normal ordinary Portland cement. Thus, concrete with ground granulated blast furnace slag have greater place-ability and workability.
Use of slag or slag cement usually improves workability and decreases the water demand due to increase in paste volume. In general, the strength development of concrete incorporating stage is slow at 1 to 5 days compared with that of the control concrete. Between 7 to 28 days, the strength approaches that of the control concrete; beyond this period, the strength of the slag concrete exceeds the strength of control concrete.
Flexural strength is usually improved by the use of slag cement, which means it beneficial to concrete paving applications.
Keywords: Ground granulated slag, GGBS, Slag, Industry waste, Slag cement.

I. INTRODUCTION

Ground Granulated Blast Furnace Slag (GGBS) is a by-product of the steel industry. Ground granulated is produced when molten slag is quenched rapidly using water jets, which produces a granular glassy aggregate.

In India, about 7.8 million tons of ground granulated is produced per year. All the blast furnace slag by quenching the molten slag by using high power water jets making 100% glassy slag granules of 2.4mm size. Ground granulated blast furnace is used as an admixture in making concrete. Now in India, since ground granulated blast furnace slag is available separately. Its use as an admixture should become more common.

The replacement of cement with ground granulated blast furnace slag will reduce the unit water content necessary to obtain the same slump. This reduction of unit water content will be more pronounced with increase in slag content and also on the fineness of slag. This is because of the surface configuration and particle shape of slag being different than the cement particles. In addition, water used for mixing is not immediately cost, as the surface hydration of slag is slightly slower than that of ordinary Portland cement. The primary constituents of slag are lime (cao) and silica (sio2). Portland cement also contains these constituents. The primary constituent of slag is soluble in water and exhibit an alkalinity like that of cement or concrete and is removed at high temperature of 1200c and greater it contains no organic matter. If slag is properly processed then it develops hydraulic property and it can be effectively be used as a pozzolanic material. The chemical composition of oxides in ground granulated blast furnace slag is similar to that of Portland cement but proportion varies.

This cementitious material has been touted for both its strength and durability enhancing characteristics when used in concrete. Ground granulated blast furnace slag has a lower heat of hydration and hence generates less heat during concrete production and curing. As a result ground granulated blast furnace slag is a desirable material to utilize in mass concrete placements where control of temperature is an issue. Percentage replacements by weight of ground granulated blast furnace slag for cement have ranged from 10 to 90%.

Transportation standard specifications allowed the use of ground granulated blast furnace slag at a maximum of 25% replacement for type1 and type2 cement. However because of its low heat hydration generating characteristics, ground granulated blast furnace slag was approved for use at a70% replacement of type2 cement. Use of slag or slag cement usually improves workability and decreases the water demand due to increase in paste volume. In general, the strength development of concrete incorporating stage is slow at 1 to 5 days compared with that of the control concrete. Between 7 to 28 days, the strength approaches that of the control concrete; beyond this period, the strength of the slag concrete exceeds the strength of control concrete.

Flexural strength is usually improved by the use of slag cement, which means it beneficial to concrete paving applications.

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II. EXPERIMENTAL INVESTIGATION

A. *Objective*

With the increase in urbanization like **INDIA & ETHIOPIA** countries, the number of industries and consequently the amount of waste GGBS is going to increase significantly in the near future. Hence, the no environmental nature of these wastes is going to be a potential threat.

1) This study can show strength of GGBS according to curing duration..
2) Therefore, it is the aim of this study to introduce an environmental friendly technology, which can benefit the society.
3) Application of used GGBS in concrete construction is a new technology.
4) Through this study, it is intended to arrive at a suitable mix proportion and percent replacement using Slag (GGBS) materials by partial replacement of the natural coarse aggregates.
5) Knowing about the stable percentage of GGBS mixing in concrete required for construction.

By conducting different laboratory tests on prepared specimens, it is intended to analyze the results.

B. *Materials Used*

The basic materials for mixing Concrete are required such as

1) Cement,
2) Sand,
3) Aggregate and
4) GGBS etc..

The cement used for the present investigation was ordinary Portland cement.
Sand is of zone-3 according to IS 383-1970, Crushed aggregate 12.5mm passing to 20mm retaining size aggregates graded as per IS: 383-1970.
Blast Furnace Slag is obtained from Vishweswariah Iron & Steel Plant Bhadravathi, dump yard, Karnataka - India.

C. *Ground Granulated Blast Furnace Slag*

Ground granulated blast furnace slag is a byproduct produced in the manufacture of pig iron. If the cooling of the slag is done with a large excess **o**f water, granulated slag is formed which is used in the manufacture of blast furnace slag cement. If cooling is done with a limited amount of water in such a way as to strip streams I mass, it produces a porous, honeycombed material, which resembles pumice. Sometimes, the molten slag is rapidly agitated with limited amount of water and the stream and gas produced are made to get entrapped in the mass. Such a product is also called foamed slag or expanded slag.
In India foamed slag is manufacture in many steel mills in V.I.S.L Bhadravathi, large quality of foamed slag being manufactured.



Figure 1 GGBS used in the present investigation

D. *Mix Proportion*

1) Concrete blocks were prepared using Ground granulated blast furnace slag as a replacement of cement. The percentages of replacement were 10% to 70%.
2) Concrete blocks were prepared using Ground granulated blast furnace slag as a replacement of fine aggregates. The percentages of replacement were 10% to 40%.
3) The blast furnace slag was added to concrete as partial replacement of cement. The different percentages were 10, 20, and 30%.

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III. EXPERIMENTAL PROGRAM

A. *Workability Aspect*

1) *Slump Test:* The replacement of cement by GGBS effects on the workability of the concrete. The workability of concrete with GGBS shows an increase in slump with increase of GGBS content of total cement volume. The result of the normal concrete mix showed an increase in workability, but it can be summarized that the workability is adversely affected by the incorporation of chipped GGBS. The results of the slump test are as shown

B. *Hardened Concrete Properties*

1) *Compressive Strength:* Compression test according to IS: 516(1959) is carried out on these cubes. The specimens were loaded at a constant strain rate until failure. The compressive strength is decreased with an increase in the percentage of the GGBS.

After curing, with the help of compressive testing machine, the specimen is compressed till the failure occurs in the cub as per IS : 516-1959 code of practice.

In the compression testing, first the cube is placed and then the load is applied on the cube. As the cube fails the load is noted and then compressive strength is calculated.



Figure 2 GGBS used Concrete under compressive test

C. *Initial Setting Time*

1) 400 gm of cement sample and placed it on a non-absorbent surface.
2) Water is added to it by 0.85 times required to prepare the paste of standard consistency and stop watch is started simultaneously.
3) Mix cement and water thoroughly and place the vicats mould so that the gauging time is between 3-5 min.
4) Keep the mould in its place with 1.13mm φ needle attached to the plunger.
5) Gently bring the plunger down so that plunger touches the paste surface and release the plunger and note down the time elapsed when the needle fails to penetrate by 5-7 mm from the bottom. This represents the initial setting time.

% of blast furnace slag replaced	Initial setting time in min
0%	65
10%	60
20%	50
30%	45
40%	35
50%	30

Table 1 Initial setting time

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% blast furnace slag	Days	Compressive strength (N/mm²)		Average (N/mm²)	Workability in mm
		Specimen1	Specimen 2		
0	7	32	32.5	32.25	20
	28	48	47	47.5	
10	7	30	29	29.5	10
	28	40	40	40	
20	7	31	32	31.5	5
	28	42.5	41	41.75	
30	7	32	32.5	32.25	0

Table 2 Compressive strength of concrete with blast furnace slag used as cement replacement cured in water.

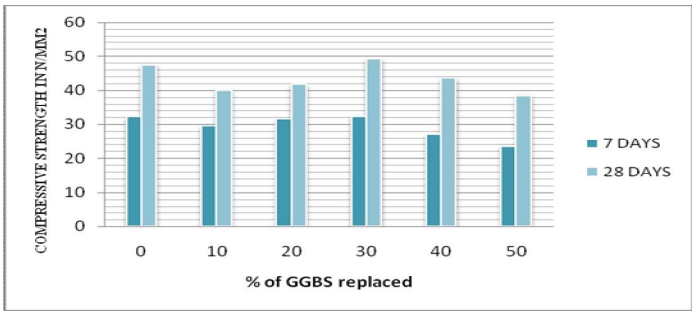


Fig 3 Comparison of compressive strength of concrete with % increase in replacement of GGBS

IV. CONCLUSION

1) The rate of strength developed in GGBS concrete is slow at early ages this may be delayed due to Pozzolanic activity how ever in the later stage strength development increases from this it can be concluded that GGBS concrete should cured for a long duration.

2) GGBS concrete develops it at a slower rate and hence heat of hydration is also less thus these concrete does not develop any thermal cracks.

3) In practice usually a water cement ratio of 0.5 is adopted with this water cement ratio and with a replacement level of 30% M25 concrete is adopted. Hence by using GGBS concrete 30% of the cement can be saved worth addition to economy.

4) Blast furnace slag is a low cost material, which can be converted into useful building material.

5) Blast furnace slag, which is an environmentally hazardous material, can be converted into useful constructional material.

A. Recommendations

1) Even though the use of GGBS for various applications by traditional recyclers has been a common practice in **Ethiopia** so far, with the increase in urbanization and the change in the living conditions of the society, the old ways cannot continue with time. Hence, there will be a potential accumulation of waste GGBS especially in the larger cities of the country.

2) Since the use of GGBS in concrete construction is not a common trend in country like India, more studies and research works need to be done in this area and academic institutions should play a great role.

3) GGBS producing industries and importers should be aware of the environmental consequences of ggbs and they should have research centers that promote an environmental friendly way of ggbs reprocessing.

4) Since the long-term performance of these mixes was not investigated in the present study, the use of such mixes is recommended in places where high strength of concrete is not as important as the other properties.

5) Future studies should be continued in the following areas as part of the extension of this research work.

a) In this research, a constant dosage of admixture was used for a particular mix category.

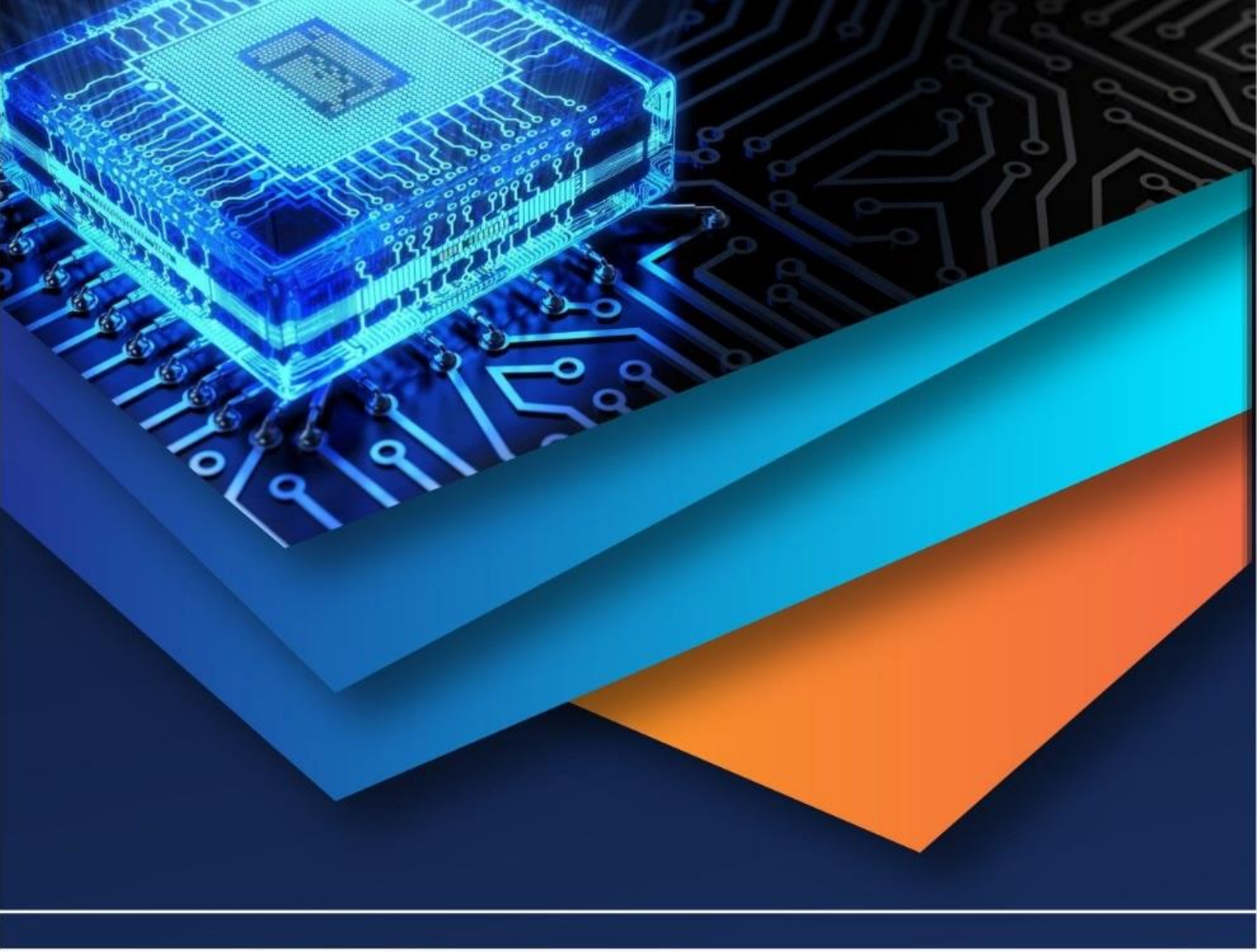
b) This research was done by preparing GGBS concrete with 30% replacement.Besides to this, the effects in different percentage replacements other than those made in this research needs to be investigated.

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