“Experimental Study on Effect of GGBS on High Strength Concrete”

Ms.Shirsath K.B.[1]

[1]PG Student, Department of Civil Engineering, Dr.V.V.P, College of Engineering, Ahmednagar, Maharashtra.
kavitashirsath2020@gmail.com

Prof.Kawade U R[2]

[2]PG Guide, Department of Civil Engineering, Dr.V.V.P, College of Engineering, Ahmednagar, Maharashtra.
urmilaanagar@gmail.com

ABSTRACT*:*

Concrete is the most widely used man-made construction material in the construction world. It is obtained by mixing cement aggregate sand water in required proportion. With increase in demand of concrete, more and more new methods and new materials are being developed for production of concrete. Sometimes certain additives are added to it to improve or alter some properties. Making concrete is an art which has to be perfectly done, otherwise that will end up with bad concrete. Hence as a Civil Engineer one should be thorough with the entire factors from which a good concrete is produced. A concrete using cement alone as a binder requires high paste volume ,which often leads to excessive shrinkage and large evolution of heat of hydration ,besides increased cost .An attempt is made to replace cement by a mineral admixture ,(i.e.),ground granulated blast furnace slag (GGBS) in concrete mixes to overcome these problems. This paper presents the workability study of concrete with GGBS as are placement material for cement with addition of superplasticiser. Concrete grades of M40 have been taken for the work. The mixes were designed using IS Code method. GGBS replacement adopted was 0% to 50. Slump test, Compaction factor test, Vee Bee Consistometertest was conducted. Effect of replacement of cement by GGBS at various percentages and on the grades of concrete chosen with Superplasticiser This paper focuses on investigating characteristics of M40 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) by replacing cement 0% to 50% The cubes, cylinders and beam are tested for compressive strength, split tensile strength, flexural strength.

***KEYWORDS: GGBS, Cement, Coarse aggregate, fine aggregate, sand, super plasticizer*.**

I.INTRODUCTION

In India, we produce about 7.8 million tons of Ground Granulated blast furnace slag as a by-product obtained in the manufacture of iron and steel industry. It is a non-metallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material. The disposal of such slag even as a waste fill is a problem and may cause serious environmental hazards with the projected economic growth and development in the steel industry, the amount of production is likely to increase many folds and environmental problem will thus pose a large threat. It is seen that high volume eco-friendly replacement by such slag leads to the development of concrete which not only utilizes the industrial wastes but also saves a lot of natural resources and energy. This in turn reduces the consumption of cement. This paper presents the various study of the workability of concrete with GGBS as replacement material for cement. Workability is one of the important factors of fresh concrete. For this study the mix proportions M40 was considered with Superplasticiser. Slump test, Compaction factor test and Vee bee Consistometer test were carried out.

The present study focuses on the partial replacement of cement by waste material or by-product from manufacturing processes. The ground granulated blast furnace slag (GGBS) is a waste product from iron manufacturing industry, which is being used as partial replacement of cement in concrete because it has more cementations properties. In this experimental work the compressive strength, split tensile strength, flexural strength tests were conducted by adding ground granulated blast furnace slag (GGBS) in various percentage of 0%, 10%, 20%, 30% and 50% to the weight of cement From the test results it can be conclude that strength of the concrete increases with the increase of GGBS up to 40% and also increase in load carrying capacity of 40% GGBS beams compare to conventional beams.

The shortage of cement in developing countries, the highly energy intensive process to manufacture cement, and the necessity to preserve natural resources are some of the main reasons for the need of supplementary cementing materials. Besides, supplementary cementing materials improve the properties and durability of concrete, and reduce the unit cost of concrete production.

II.OBJECTIVES OF INVESTIGATION

1. To know the behavior of compressive and split tensile strength of GGBS concrete.
2. Utilization of GGBS will reduce the carbon di oxide emission in environment.

METHODOLOGY:

1. Cement

Ordinary Portland cement is by far the most important type of cement. The OPC was classified into three Grades viz., 33 Grade, 43 Grade and 53 Grade depending upon the strength of the cement at 28 days when tested as per IS 4031 -1988. The cement test was procured for physical requirements in accordance with IS: 12269-1987 and for chemical requirements in accordance with IS: 4032-1977.

Fig 1. Cement

These materials each contribute some portion of three essential elements of Portland cement constituents; lime, silica and alumina. Clinker is formed by burning a carefully controlled mixture of these raw ingredients to a temperature of 2,800°F to 3,500°F and then grinding the resulting mass to a very fine powder.

1.1 Cement Test Result

Table no 1 Test value of cement

Cement	Bulk density	1400 kg/m3
	Specific Gravity	3.15
	Initial Setting Time	120
	Final Setting Time	170
	Le-Chatelier Soundness test	1%

2. Cement Replacement Material

With the extensively use of cement in concrete, there has been some environmental concerns in terms of damage caused by the extraction of raw material and CO2 emission during cement manufacture. This has brought pressures to reduce the cement consumption in the industry. All the materials have two common features:

i)Their particle size range is similar to or smaller than that of Portland cement.

ii) They are pozzolana material.

The cement replacement materials in used as Ground Granulated Blast Furnace Slag (GGBS)

2.1 Ground Granulated Blast Furnace Slag (GGBS):

The GGBS used in research is obtained from JSW Cement Plant (Pune, Maharashtra). The glass content of GGBS affects the hydraulic property; chemical composition determines the alkalinity of the slag and the structure of glass. The compressive strength of concrete varies with the fineness of GGBS.Ground granulated blast furnace slag now a day's mostly used in India. Recently for marine out fall work at Bandra, Mumbai. It has used to replace cement to about 70%. So it has become more popular now a day.

Fig 2.GGBS

2.1 GGBS Test Result

Table shows the physical properties of ggbs material

Table 2 Physical properties of GGBS

GGBS	Bulk Density	1150kg/m3
	Specific gravity	2.9
	Moisture content	1.3%

3. Aggregate

A good quality, well graded coarse aggregate of size 20 mm and 10 mm were used in the preparation of all test specimens. Both coarse and fine aggregates are in saturated-surface-dry condition.

3.1 Fine Aggregate: (Natural Sand):

Concrete is a mixture of individual pieces of aggregate bound together by cementing material, its properties are based primarily on the quality of cement paste. This strength is dependent also on the bond between the cement paste and aggregate.

3.2 Coarse Aggregate:

The maximum size of coarse aggregate should be large within the specified limits but in no case greater than one fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form.

4. Water

In this work portable water is used for mixing as well as curing of concrete which is free from organic substance.

5. Superplastisizer-

SNF (Sulphonated Naphthalene Formaldehyde)

Super plasticizer are chemical admixtures that can be added to concrete mixtures to improve workability.

Mixing and Curing of GGBS concrete:

IS 10262-2009: method of mix design is used for mix design of M 40 grades of concrete. The procedure of selecting quantity of ingredient materials and mix proportions as per design is as follows:

Mix Design for Grade M 40:
Assumptions for M40:
Characteristics Strength required at 28 days = 40Mpa
Max size of Aggregate = 20 mm
Degree of quality control = Good
Type of exposure = sever.

Procedure of Mix Design

Step 1:
Target mean strength, fck = fck + t x S
Where, t = a statistical value depending on expected proportion of low result t = 1.65
S = Standard deviation from Table 3.6
For M40 grade concrete & good quality control, S = 5
Target mean strength = 40 + (1.65 x 5) = 48.25Mpa

Step 2**:**
To decide water /cement ratio, this will give 48.25Mpa
Select water /cement ratio (w/c) = 0.4; this is lesser than 0.45

Step 3:
Selection of water content:
For 20 mm size of aggregate use maximum water content 186 lit.
For 100 mm slump = 186 + (6/100) ×186 = 197litre
As super plasticizer is used, the water content reduced up 20 percent and above.
Based on trials with super plasticizer water content reduction of 25% has been achieved. hence, the arrived water is 197x0.75=148 liter

Step 4:
Calculation of cement content:
Water cement ratio=0.40
Cement content: 148/0.4 = 370 kg/m^3
370 kg/m^3 > 320 kg/m^3 … OK

Step 5:
From table no. 3, volume of course aggregate corresponding to20mm size aggregate and fine aggregate (zonel) for water-cement ratio of 0.50=0.60
Water cement ratio is 0.40. therefore volume of coarse aggregate is required to be increase to decrease the fine aggregate content. as the water cement ratio is lower by 0.10 the proportion of volume of coarse aggregate is increased by 0.02(at the rate of -\+ 0.01 for every +\- 0.05 change in water cement ratio)
Therefore, Volume of C.A. = 0.56 and Volume of F.A. = 0.44.

Step 6
Volume based calculation
Volume of concrete=1m^3
Mass of cement=370kg
Mass of water=148lit.
Mass of fine aggregate=879kg
Mass of coarse aggregate=1081kg

Mix proportions –
WA: C: FA: CA
0.40:1:2.38:2.92

Table 3: Mix Proportion Details of one meter cubes quantity.

MIX	M0	M1	M2	M3	M4	M5
Cement(kg)	370	333	296	259	222	185
Sand(kg)	879	879	879	879	879	879
C A(kg)	1081	1081	1081	1081	1081	1081
Water(lit)	148	148	148	148	148	148
GGBS(kg)	00	37	74	111	148	185

RESULTS:

The initial setting time of concrete is dependent on the concrete's constituents, curing conditions and its application use.

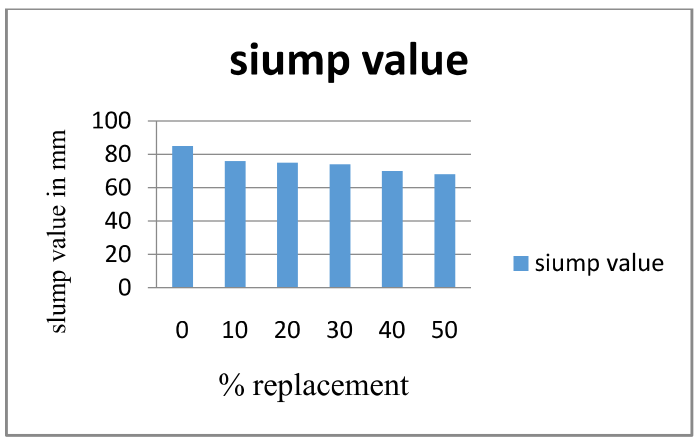
Slump Cone Test

Slump Cone test was conducted for investigation of workability of fresh concrete. Cement replaced with 0%, 10%, 20% ,30%,40% &50% GGBS

Table 4: Slump values

Mix design	Slump values
M0	85
M1	76
M2	75
M3	74
M4	70
M5	68

Note-M0 means GGBS 0% & cement 100% and M1 means GGBS 10% & Cement 90% in same wayM2 M3 M4 M5.



Graph 1.slump values

Compressive strength

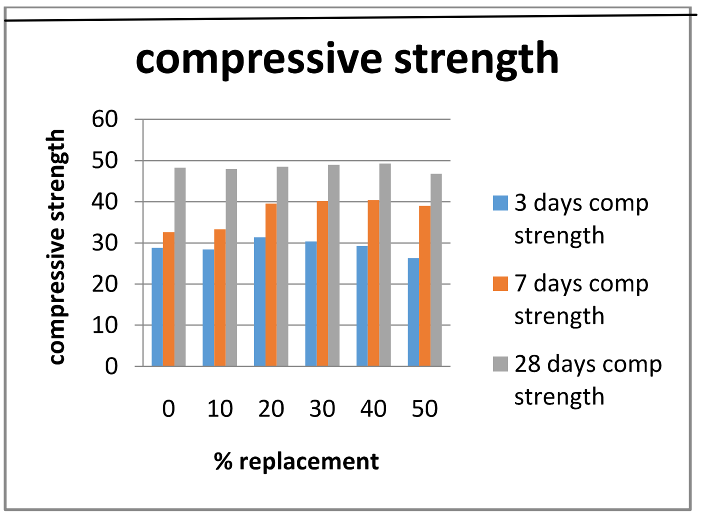
The mixes were mixed manually in a laboratory pan to ram mixture. Fresh mortar mixture was ~~ca~~st in cube moulds (150 mm x 150 mm x 150 mm). The moulds were filled in two layers and each layer was compacted on a vibrating table. The specimen are cured And Tested At 3days7days 28 Day There was slow increment in compressive strength with time beyond 28 days for the samples without GGBS the strength trends were likely to change over time. Three specimens for each series were crushed on a U T M machine and the average is reported.

Compressive strength obtained for the specimens are presented in table no.5.

Table 5: compressive strength of concrete

Mix	3days	7days	28days
M0	28.77	32.63	48.22
M1	28.39	33.33	47.95
M2	31.4	39.55	48.52
M3	30.34	40.12	48.93
M4	29.27	40.37	49.23
M5	26.32	38.96	46.78

Note-M0 means GGBS 0% & cement 100% and M1 means GGBS 10% & Cement 90% in same wayM2 M3 M4 M5.



Graph 2 Compressive Strength

Image 4: Variation of Compressive Strength % of GGBS

Flexural - Strength

Flexural strength test on the150x150x700mm were casted and cured for 28 days. The flexural strength is determined by the

$$fcr = P_f L / bd^2$$

Where,

fcr = Flexural strength, MPa

P_f = Central load through two point loading system, N

L = Span of beam, mm

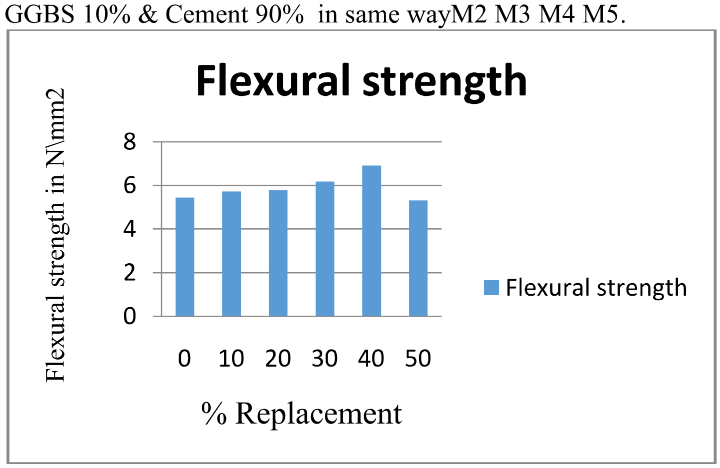
b = Width of beam, mm

d = Depth of beam, mm .

Table 6: Flexural strength-

Mix design	Flexural strength
M0	5.45
M1	5.72
M2	5.79
M3	6.18
M4	6.92
M5	5.32

Note-M0 means GGBS 0% & cement 100% and M1 means GGBS 10% & Cement 90% in same wayM2 M3 M4 M5.



Graph 3 Flexural strength

Spilt Tensile Strength

The split tensile strength test is carried on diameter 150 mm and length 300 mm was casted and cured for 28 days. The split tensile strength of cylinder is calculated by the following formula:

$$f_{cys} = 2P_{sp} / \pi D L$$

Where,

f_{cys} = split Tensile strength, Mpa

P_{sp} = Load at failure, N

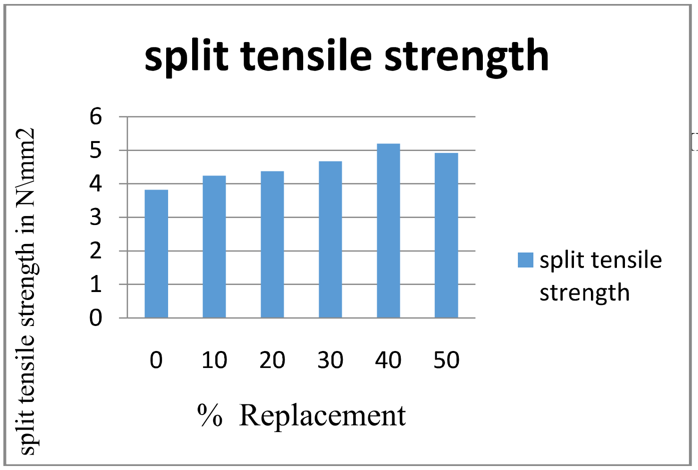
L = Length of cylinder, mm

D = Dia. Of cylinder, mm

Table 7: Spilt tensile test result

Mix design	Spilt tensile strength
M0	3.82
M1	4.24
M2	4.38
M3	4.67
M4	5.20
M5	4.92

Note-M0 means GGBS 0% & cement 100% and M1 means GGBS 10% & Cement 90% in same wayM2 M3 M4 M5.



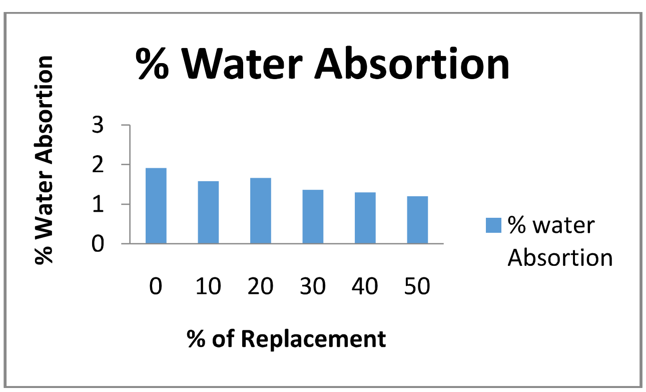
I. Graph 4. Spilt tensile strength

Water Absorption Test:

Water absorption test or the porosity test was carried to find out the percentage water absorption. 3 cubes of each variation were casted for the conduction of test. The test results obtained are as follows:

Table 8: Experimental test results for water absorption test

Sr.No.	Mix Notation	% Replacement of Cement by GGBS	Wet weight (gm)	Dry weight (gm)	Water absorbed (gm)	% Water Absorption
1	M0	0 %	9063	8892	171	1.92
2	M1	10%	9008	8851	157	1.77
3	M2	20 %	8894	8748	146	1.67
4	M3	30 %	9069	8930	139	1.56
5	M4	40 %	8919	8785	134	1.52
6	M5	50 %	8837	8715	122	1.40



Graph 5: Comparative water absorption of concrete with Cement replacement with GGBS for 28 days

A decrease of 1.77%, 1.67% and 1.67% water absorption was observed for 10%, 20% and 30% replacement of GGBS respectively.

I. CONCLUSION:

1 Early strength of concrete is compared with GGBS blended cement is slightly lower than conventional concrete.

2 The compressive strength result of GGBS blended cement concrete replace up to 40% is more than conventional concrete at the end of 28 days

3 GGBS allows for water reduction of 3 to 5% as compare to OPC cement concrete without any loss in workability

4 This concrete maximum increase in compressive strength at 40% GGBS replaced by cement for this grade

5 It is also found that by increasing percentage of GGBS workability increases and strength decreases

6 The maximum 28 days split tensile strength obtained with 40% replaced with cement

7 .The maximum 28 days flexural strength obtained with 40% replaced GGBS with cement

8. Use of GGBS effectively fills the voids and gives dense concrete microstructures, which reduces the water absorption.

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