International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

Determination of strength of concrete by using Ground-granulated blast-furnace slag (GGBS)

Usha Lodhi[1], Kamlesh Kumar Choudhary[2], Narendra Ghritkaushik[3]
[1] *Student, SIET Jabalpur*
[2] *Assistant Professor, SIET Jabalpur*
[3] *Student*

Submitted: 15-10-2021 Revised: 26-10-2021 Accepted: 28-10-2021

ABSTRACT
Cement is widely most used in the recent construction industry because of its easily availability and cheap in the market. The demand for concrete as a construction material is on the increase. However, the manufacture and consumption of cement causes pollution to the environment and reduction of raw material (limestone). Use of GGBS(Ground Granulated Blast Furnace Slag) as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. In this experiment specimen for testing were prepared, the cube, cylinders are cured for 7& 28. Then properties are determined by performing different tests like split tensile strength, flexural strength and compressive strength and. The aggregates are substituted by GGBS by 20%,40%,60%,80% and then compared with that of cement and the ideal percentage of GGBS is obtained. It was observed that there is no change in fresh or hardened features of concrete in presence of GGBS. The maximum strength for the concrete specimen is obtained when 40% of GGBS is replaced with cement.
Keywords: GGBS, GGBFS, Flexure strength test, splitting tensile strength test, compressive strength test.

I. INTRODUCTION

Concrete plays a very critical role in the design and construction of the nation's infrastructure The most expansively used construction matter in the world is probably Concrete with about six billion tones being produced every year.

1.1 GENERAL

In terms of per capita consumption, it is only next to water. The most enormous individual material element in the built environment is concrete. Significant environmental and economic benefits may be realized if the embodied energy of concrete can be reduced without decreasing the performance or increasing the cost. The cement clinker production is highly expensive and harmful in view of economically and environmentally due to hazardous emissions of CO_2, NOx and SOx, which are the significant contributors to the "greenhouse gas (GHG) effect". To reduce greenhouse effect, different types of pozzolanic and cementitious materials, for example ground granulated blast furnace slag (GGBS), Silica Fume (SF) and Fly Ash (FA) are commonly used in production of concrete. These pozzolanic and cementitious materials not only reduce the greenhouse effect but also progress durability, reduce porous nature and improve the interlocking with the aggregate and also provides better building and execution properties.

1.2 Overview of GGBS

Ground Granulated Blast Furnace Slag (GGBS) is a mineral admixture given in IS 456: 2000, produced by grinding of blast furnace slag available in iron industries. Ground granulated blast furnace slag (GGBS) is a byproduct of iron industry. Iron ore, coke and limestone are fed into the furnace to produce iron, and the resulting flowing slag floats above the molten iron at a temperature of about 1500°C to 1600°C. The melted slag has content 30-40% silicon dioxide (SiOa) and approximately 40% calcium oxide (CaO), which is close to the chemical configuration of OPC. After the molten iron is tapped off the remaining melted slag which mainly contains siliceous and aluminous residues is then quickly water- quenched. GGBS is gotten by quenching molten iron slag from a blast furnace in water or steams to produce a glassy granulate slag. Rapid cooling or quenching is done to get glassy granular slag. This glassy granulated slag is dried and ground into a fine powder to produce ground granulated blast fumace slag. GGBS is an amorphous powdery material having oxide composition (CaO, FeiOs, Si02, AI2O3 etc) similar to Portland cement, but the actual content of these oxides would differ. Blast furnace slag when ground to a size less than 45-micron meter, can have a specific area of about 400 to 600 m^2/kg. GGBS has particle sizes almost similar to Portland cement. GGBS is widely accepted for use in Portland cement concrete to achieve improved workability, higher strength and durability, superior resistances to chloride penetration, sulphate attack, and alkali-silica reaction.

1.3 CONCRETE

It is a material which is composed and formed by mixing of granular materials called aggregates or filler surrounded together and mixing with that of the cement or binding material which fills the voids among the aggregates particles, glues them together. Aggregates are usually obtained from weathering of natural rocks, either crushed stones or natural gravels. Cement binds the aggregates together. Natural coarse aggregates are generally crushed stones and gravels which are retained on the 4.75mm sieve. Other material like fly ash or ground blast furnace slag may also be used as binding material. Aggregates are divided into two parts: fine aggregates and coarse aggregates. Fine aggregates are considered to be the material passing through 4.75mm sieve and are predominately retained on 75micron sieve. Finally, water is added to commence the binding process. This makes the mix stiffer and forms the material called concrete, which can be castoff in construction and forms a basis of our modern society.

1.4 PROPERTIES OF (GGBS or GGBFS)

It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, and hydrates like Portland cement. By replacing the Portland cement with GGBFS will results in reduction of carbon dioxide gas emission. It is therefore an environmentally friendly construction material. GGBFS from modern thermal power plants generally does not require processing prior to being incorporated into concrete and is therefore considered to be an environmentally free input material. The production of GGBFS requires more energy as compared with the energy needed for the production of Portland Cement. We can replace about 80% of the Portland cement by using GGBFS in concrete. GGBFS has characteristics of better water impermeability as well as improved resistance to corrosion and sulphate attack. Due to lower heat hydration it reduces the risk of thermal cracking. It has higher durability, workability, reduces permeability to external agencies, which helps in making, placing and compaction easier. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

Table 1.1 Typical physical features of GGBS

Property	**Value**
Specific Gravity	2.8
Bulk density, kg/m^3	1200
Fineness	350 m2/kg
Colour	off white

II. METHODOLOGY

In this project the study of usage of GGBS in concrete in place of cement is done. First of all, cement and river sand was collected and the test are conducted for physical properties like gradation, specific gravity, fineness, etc. GGBS was collected from Laxmi steel factory JABALPUR. The water contents must be considered because they are different in different samples. Then mix was designed for M30 concrete. Fresh concrete properties were determined by mixing concrete. The waste product GGBS at the proportions of 0%, 20%, 40% ,60%,80% was partially replaced for cement for the curing period of 7 and 28 days.

The performance of concrete in which the cements are replaced by GGBS by 20%, 40%, 60%, 80%, are compared to that of predictable concrete and the most favorable percentage of GGBS is found.

III. RESULTS AND DISCUSSIONS

In this chapter, the results obtained from the experimental study of the GGBS concrete have been presented and discussed. This chapter contains the result of fresh concrete test (slump

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

test) and mechanical properties such as compressive strength, flexural strength and split tensile test of various concrete mixes with variation in the percentage of GGBS. The variation of mechanical properties with the variation in the proportion of GGBS and age of curing has been discussed in detail. The cubes, beams, cylinder specimens have undergone the process of testing using standard equipment to determine compressive, flexural and split tensile strengths at the age of 7, and 28 days.

3.1 Compressive Strength

Out of many tests applied to the concrete, this is the outmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. For cube test two types of specimens either cubes of 15cm x 15cm x 15cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

Table 3.1 Comparison of strength at 7days and 28 days for different percentages of ggbs

Percentage replaced	7 day compressive strength for cube(N/mm^2)	28 day compressive strength for cube(N/mm^2)
0	24.53	45.33
20	26.055	44.88
40	29.53	50.33
60	23.95	42.58
80	24.65	41.26

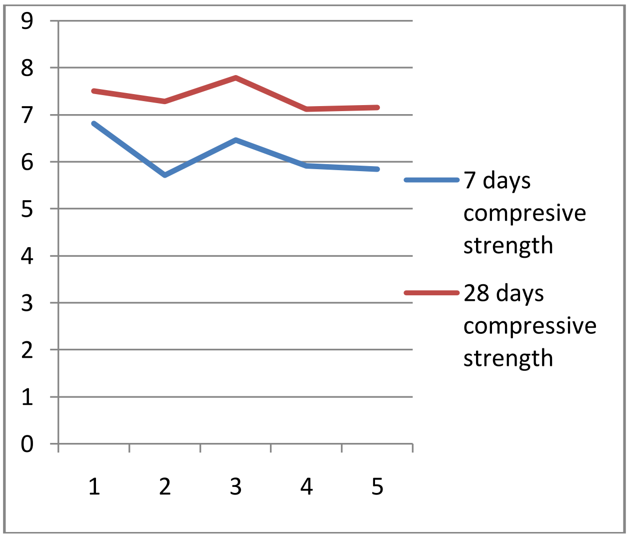

Fig 3.1 7 & 28 day compressive strength of concrete

3.2 Spilt tensile strength

The Spilt tensile strength of concrete obtained using cylinder specimens of size 150mm*300mm. Calculation of splitting tensile strength of each sample was calculated by the given equation.

$$T = 2P/\pi LD$$

Where

T = split tensile strength in psi.

P= maximum load applied in pounds.

L= average sample length in inches.

D = sample diameter in inches

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence. it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength.

Table 5.2 7days and 28 days split tensile strength of cylinder

Percentage replaced	Spilt tensile strength (N/mm2) 7 days	Spilt tensile strength (N/mm2) 28 days
0	4.300	4.526
20	3.945	4.492
40	4.210	4.610
60	4.021	4.427
80	4.012	4.324

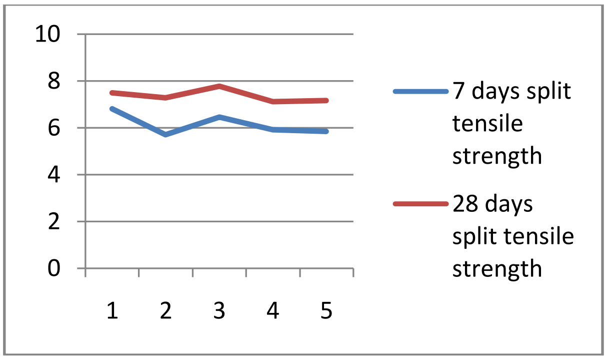

Fig 5.2 7 & 28 days split tensile strength of concrete

3.3 Flexural strength test

Flexural strength is a measure of tensile strength of concrete prisms of size 750mm*100mm*100mm were used. It is 12-20 % of compressive strength. The flexural strength testing conducts on the prism for 7 days and 28 days respectively and the comparison of the results are shown in the Fig. From the results it is observed that the result 15% increments in mix when replaced by 40% of GGBS when compared with control mix.

Table 5.3 7days and 28 days' Flexural strength of cylinder

Percentage replaced	Flexural strength (N/mm^2) 7 days	Flexural strength (N/mm^2) 28 days
0	6.81	7.51
20	5.72	7.29
40	6.46	7.79
60	5.92	7.12
80	5.85	7.16

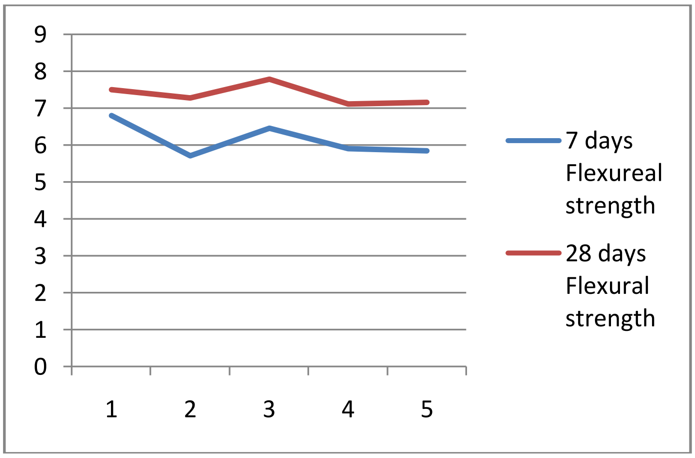

Fig 5.3 7 & 28 days flexural strength of concrete

IV. CONCLUSIONS

The following conclusions can be drawn from the experimental investigations conducted on the behavior of concretes with GGBS as partial replacements for cement.As GGBS is partially replaced with the cement, the consumption of the cement is reduced and also the cost of construction is reduced.

- Thus the workability is improved by the partial replacement of the GGBS with cement.
- The use of GGBS as a replacement of cement helps to reduce the Energy consumption in the manufacturing of cement.
- We find that there is increase in the strength of concrete that compressive strength is 50.33N/mm^2 ,split tensile strength is 4.610N/mm^2 and flexural strength is 7.79 N/mm2
- We get the maximum strength at 40% replacement of GGBS with cement.

REFERENCE

[1]. **P.K. Prasanna (2019**) “Compressive Strength Assessment using GGBS and Randomly Distributed Fibers in Concrete” International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019

[2]. **S.k.Sirajuddin (2019)** “Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Quarry Dust” International Conference on Advances in Civil Engineering (ICACE-2019) | 21-23 March 2019

[3]. **Pratap Singh (2019)** “An Experimental Study on Effect of Concrete Performance in Addition of GGBS and Partial Replacement of Cement by Glass Fiber” International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 7 Issue: 5

[4]. **Anas (2018)** “A Review on Ground Granulated Blast-Furnace Slag as a Cement replacing material” International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018

[5]. Shetty M.S. “Concrete Technology” Chand S. and Co. Ltd.,India (2004).

[6]. IS:456-2000, “Plain and Reinforced Concrete -Code of Practice “Bureau of Indian Standards.

[7]. IS: 2386-1963 (Part I to Part III), “Indian Standards Method of Test for Aggregate for Concrete”, Bureau of Indian Standards, New Delhi, India

[8]. IS: 383-1970, “Indian Standard Specification for coarse and fine aggregates from Natural Source for Concrete”, Bureau of Indian Standards, New Delhi, India.

[9]. IS: 8112-1989, “Specifications for 43-Grade Portland Cement”, Bureau of Indian Standards, New Delhi, India.

[10]. IS: 10262-1982,“ Guidelines for Concrete Mix Design”,Bureau of Indian Standards, New Delhi, India

[11]. IS: 516-1959, “Indian Standard Code of Practice-Methods of Test for Strength of Concrete”, Bureau of Indian Standards, New Delhi, India.

[12]. IS: 5816-1999, “Method of Test Splitting Tensile Strength of Concrete”, Bureau of Indian Standards, New Delhi, India.

[13]. IS: 9103-1999, “Specification for Concrete Admixtures” Bureau of Indian Standards, New Delhi.