MANUFACTURING OF ELLIPTICAL SHAPE CONCRETE HOLLOW BRICKS USING GRANULATED BLAST FURNACE SLAG AS A FINE AGGREGATE

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ABSTRACT: By using GBFS which is a by-product of steel industry as a fine aggregate, we can save the natural resources and environment. The GBFS provides durability and better engineering properties and the elliptical shape which helps in enhanced thermal properties. The experiment helps in find out the economical and technical features of the product by conducting different tests like economical mix proportions, compressive strength, to meet the standards and to develop eco-friendly building block. Since, it is designated as Green Building Material it would help to get GRIHA (Green Rating for Integrated Habitat Assessment) as well as the LEED (Leadership in Energy and Environmental Design) certification. Systematic laboratory tests were carried out with different proportions of cement, river sand and slag sand to compare the quality, durability and technical feasibility.

Key words: Concrete Bricks, Ordinary Portland Cement **(**OPC), Ground Granulated Blast furnace Slag (GGBS), Granulated Blast furnace Slag (GBS).

INTRODUCTION

Shelter is one of the three basic requirements of human being. Initially ancient man started living in caves excavated below ground level on near the hill ends. Thereafter, they started constructing walls from mud, and in due course of time, they developed the techniques of burnt clay brick masonry to form the structural part of the shelter. The desire for search of new structural materials paved the way for hollow concrete blocks due to the following advantages

1. Adequate strength and structural stability.
2. Superior thermal insulation and acoustic characteristics.
3. Resistance to fire.
4. Light weight.
5. Speedy work.
6. Economy

Building construction is a multi disciplined technology. It involves an exchange of thoughts, experience and ideas among those engaged in the various disciplines of the construction activity in order to achieve overall economy and proper serviceability of the construction project at hand. It should also make use of innovative methods in the field of material technology by use of new/improved materials resulting in the production of economical, aesthetically acceptable and durable structure. The resistance to any change comes not only from the artisans and makers but even from engineers, contractors, owners and public in general. It is a human attitude of unwillingness to come out of a well established route. The modern recommended practice is to dispense with several 'on the spot' operations and replace them with the manufactured materials. That site operation is often left to workers who do not have the skills to the desirable extent and cannot adequately supervised, resulting in such work often being shoddy and expensive. Economical and efficient construction techniques demand excellent micro-planning, determining as to which of the building materials should be manufactured on a mass scale, setting out and promoting such manufacturing facilities and popularizing their use. The development of construction technology is closely related to the development of adequate mechanization and handling technology, the latter involves both the provisions of equipment as well as the handling dexterity.

Hollow concrete block is an important addition to the types of masonry units available to the builders and its use for masonry is consistently increasing, some of the advantages of hollow concrete block construction resulted in reduced mortar consumption, light weight and greater speed of masonry work compared to traditional brick masonry. Since many builders are yet to become familiar with the use of hollow concrete blocks, this will help them to appreciate the essential constructional details and adopt hollow concrete block masonry in a large scale wherever it is economical.

We did an experiment on concrete hollow bricks of size **24×12×6 - inch** by introducing an elliptical shaped hollow portion to reduce the material and to get more load bearing capacity and also to improve all engineering properties by using Granulated Blast Furnace Slag (GBS/Slag sand) & Ground Granulated Blast Furnace Slag (GGBS/Slag Cement). This project work carried out by following the instructions given in **"IS: 2185 (Part 1) – 1979 (Reaffirmed 2003), Edition 3.1 (1984-05): SPECIFICATION FOR CONCRETE MASONRY UNITS; HOLLOW AND SOLID CONCRETE BLOCKS (Second Revision)"**

MATERIALS USED

Type 1: Ordinary Portland Cement 53 Grade, Stone dust, Granulated Blast furnace Slag (GBS), 6mm Aggregate
Type 2: OPC of 53 grade, Ground Granulated Blast furnace Slag (GGBS), Stone dust,

Natural sand, 6mm Aggregate

Slag: "Slag" is a non-metallic product consisting essentially of glass containing silicates and Alumino Silicates of lime. It is the by -product obtained in the manufacture of pig Iron in blast furnaces at around 1400° to 1500°C in the molten form.The granulated slag is obtained by rapidly chilling (Quenching) the molten ash from the furnace by means of water or steam and air.

Granulated Blast furnace Slag

Granulated Blast furnace Slag is an alternative for river sand. The natural sand being successfully obtained from river bed thought to be everlasting supply, now the sand resources are getting depleted and exhausted. The physical properties of the slag was evaluated in a reputed testing Lab of **National council for Cement and Building materials (NCCBM), Hyderabad** and the test results shown that the Slag is meeting the requirements of IS 383-1973(reaffirmed) for sand.

MATERIALS AND METHODS

Slag Sand (GBS) and Slag Cement (GGBS) used for this study were provided by JSW CEMENT LIMITED, Secunderabad. Other locally available materials 53grade Ordinary Portland Cement, Fine aggregate (Natural Sand), Quarry dust and Coarse Aggregate (6mm chips) were obtained for this study. Potable water available in the campus conforming to the requirements of water for concreting and curing was used throughout the project.

PROPERTIES OF GBS

Chemical composition

The primary components of iron and steel slag are:

a) Lime (CaO) and

b) Silica (SiO_2)

The other components include alumina ($Al2O_3$) and magnesium oxide (MgO), as well as a small amount of sulfur (S).

Physical properties

Reliable Quality:

Blast furnace slag fine aggregate is a product for industrial use manufactured under suitable, quality-controlled conditions.

No deleterious materials:

Blast furnace slag fine aggregate does not contain materials that may affect the strength and durability of concrete, such as chlorides, organic impurities, clay and shells.

Increased long term Strength:

The compressive strength of the mortar and concretes achieved with BF slag as sand is similar to that of natural sand at a material age of 7days and 28 days.It also helps in the continuous strength gain beyond 28 days.

Alkali-aggregate Reactions:

Since no siliceous and clayey materials are present in BF Slag it doesn't generate Alkali-Silica Reaction, and the concrete made with slag sand is more durable

PROPERTIES OF GGBS

Concrete Properties:

Slag cement is a more uniform product as a result concrete made with slag cement will generally have more uniform properties.

Plastic Properties:

Water reduction:

The use of either material should result in a reduction of the required water content to reach a given consistency. This effect with slag cement is due to its influence on paste characteristics and absorption.

Air Entrainment:

Slag cement does not contain carbon and does not cause instability in the entrained air content.

Time of Set:

Time of initial set is influenced by the use of slag cement. Concrete made with slag cement can have faster set times than concrete made with other cementitious materials.

Pumpability and Finishability:

Pumpability with slag cement is generally improved largely due to the addition of fines to the matrix. Finishability is also improved.

Hardened Properties:

Strength:

At 28 days, slag cement will achieve higher strength than straight Portland cement in concrete mixtures.

Permeability:

At normally specified replacement levels, concrete made with slag cement will have lower permeability than concrete when tested according to ASTM 1206 (rapid chloride permeability test).

Sulfate Attack and Alkali-Silica Reaction (ASR): Slag cement provides protection against sulfate attack and ASR.

Time of Set: Time of initial set is influenced by the use of slag cement. Concrete made with slag cement can have faster set times than concrete made with other cementitious materials.

Chemical composition: The ternary diagram, shown in Table1 shows that slag cement is more closely related to Portland cement than other cementitious materials.

Parameter	GGBS	As per IS: 12089- 1987 (Reaffirmed 2008)
Cao	37.34%	---
Al_2O_3	14.42%	---
Fe_2O_3	1.11%	---
SiO_2	37.73%	---
MgO	8.71%	Max. 17.0%
MnO	0.02%	Max. 5.5%
Sulphide sulphur	0.39%	Max. 2.0%
Loss On Ignition	1.41%	---
Insoluble Residue	1.59%	Max. 5%
Glass Content	92%	Min. 85%
Chemical Moduli: 1. $\frac{CaO+MgO+1/3Al_2O_3}{SiO_2+2/3Al_2O_3}$ 2. $\frac{CaO+MgO+Al_2O_3}{SiO_2}$	$1.07 \geq 1.0$ $1.60 \geq 1.0$	The presence of major oxides with granulated slag shall satisfy at least one of the equation

Chemical composition of slag cement

Physical properties:

The following are the physical properties of GGBS,

Blaine fineness, m^2/ kg - 400

Specific gravity - 2.94

Good quality GGBS

1. Fineness : Typically about 300 M^2/Kg
2. Manganese Oxide : Max. 5.5%
3. Magnesium Oxide : Max. 17.0%
4. Sulphide sulphur : Max. 2.0%
5. Glass content : Min. 85%
6. Insoluble Residue : Max. 5%

MIX DESIGN AND PRODUCTION OF THE BLOCK SAMPLES

There is no proper mix design for concrete bricks, the nominal mix proportion used is, cement, fine aggregate, coarse aggregate; 1: 4: 8.

Mix

Mixing was done by following IS: 2185 (Part 1). Mix proportion taken for both the types is, cement, fine aggregate, stone dust, coarse aggregate 1: 3: 3: 6. Constant water cement ratio is applied which is 0.8 in every mix.

Type 1: In this investigates 53grade OPC, GBS as fine aggregate, stone dust and 6mm chips as coarse aggregate were used.

Type 2: In investigates 53grade OPC was replaced with 50% GGBS, natural sand as fine aggregate, stone dust and 6mm aggregate

Materials	Type 1	Type 2
OPC	35	17.5
GGBS	---	17.5
Stone dust	105	105
Natural Sand	---	105
GBS	105	---
6mm Chips	210	210

Mix proportions of concrete brick

Preparation of test specimen

The experimental investigation has been carried out on the test specimens to study the strength properties as a result using GBS as fine aggregate. The test specimens were cast in steel molds and wooden elliptical shaped hollow making part. The inside of the mold was applied with oil to facilitate the easy removal of specimens. The raw materials were weighed accurately. The concrete was mixed thoroughly in dry condition. Initially, 75% of water was added to the dry mix, and they were mixed thoroughly. Then the remaining 25% of water was added to the mix. The mixing was continued until a uniform color was obtained. Fresh concrete was placed in the mold in three layers, and each layer was compacted using tamping rod. The concrete specimen cast is a 24 × 12 × 6-inch hollow brick. After (before initial setting (5-10 minutes) the elliptical portion should be removed to make easy work) 24 hrs from casting, the test specimens were taken out and placed in a curing tank, until the age of the specimens. The prepared specimens were analyzed for workability and compressive strength as per IS standards.

COMPRESSIVE STRENGTH

The compressive strength of the brick samples was determined in accordance with the standard procedure for concrete masonry units (IS 2185 Part 1). Samples were taken from curing tank before testing. Nine sample bricks were crushed each at 7, 14 and 28 days after casting of type 1 and type 2 using the compressive testing machine in the concrete laboratory of Civil Engineering Department, JNTU Hyderabad.

WATER ABSORPTION

The test specimens were completely immersed in water at room temperature for 24 hours. The specimens were then be weighed, while suspended by a metal wire and completely submerged in water. Then removed from the water and allowed to drain for one minute by placing them on a coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed. Then all specimens dried in a ventilated oven at 100 to 115^0C for not less than 24 hours and weighed. The difference between two weights then determined and percentage of water absorption calculated.

BLOCK DENSITY

Three blocks taken and dried to constant mass in suitable oven heated to 100^0C. After cooling the blocks to room temperature, the dimensions of each block were measured volume was computed. Block then weighed in Kilograms and the density of each block calculated.

RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH TEST

The specified minimum required compressive strength of hollow blocks for both Type 1 and Type 2 is 3.5 N/mm^2 as per IS 2185 (Part 1). The test results have shown increase of strength by replacing OPC with GGBS compared to blocks made with only OPC. The average data for strength against curing age is shown in **Table 4**. The results clearly indicated that strength increased with time. Further it is observed that GGBS and GBS reach the optimum values of strength at 60 days. Partial replacement of cement with GGBS has better commercial viability due to reduced cost. Strength development of blocks containing GBS and GGBS can perform well in gaining ultimate strength and durability.

Days	Type 1 brick	Type 2 brick
7	3.63	3.57
14	4.13	5.35
28	4.69	5.98

Compressive strength N/mm^2

WATER ABSORPTION TEST

The water absorption tests were conducted as per IS 2185 (Part 1). After 28 days of curing, the average value of the water absorption of Type 1 and Type 2 are 5.32% and 2.55% respectively. The maximum allowable water absorption is 10% by mass and result obtained was well within the limits.

DENSITY TEST

Test conducted by following procedure given in IS 2185 (Part 1). As per standards, density should not be less than 1500 Kg/m^3 for Grade A hollow load bearing unit. Our test results for type 1 and type 2 are 1848.15 Kg/m^3 and 1870.37 Kg/m^{3}respectively. So, these blocks meeting the requirement of Grade A.

CONCLUSION

This project work concluded that,

1) The use of Blast Furnace Slag in concrete works makes environmental friendly constructions. The lower specific gravity of slag helps in reduction of weight of concrete and improves the strength and durability.
2) The study shows that the concrete bricks prepared using slag sand (GBS) as fine aggregate comes under **Grade A(4.5)** and 50% of cement replaced with GGBS comes under **Grade A(5.5)** as per IS 2185-1979 (Part1) hollow load bearing units.
3) The manufacturing of Red bricks consumes lot of fertile alluvial soil and energy causing environment pollution. The hollow blocks made with Slag (GBS & GGBS) are environment friendly and helps in conserving the natural resources.

4) This elliptical hollow portion reduces the material quantity and improves load bearing capacity which is economically feasible with better engineering properties.
5) These building blocks can be used in place of beams and columns in non- engineering buildings.
6) These bricks have high heat resistance and eco-friendly properties. Finally these units can be recommended for low cost building.

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