A STUDY ON THE EFFECT OF GGBS ON CLAY BRICKS

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Abstract -Bricks are one of the primeval construction components that has been utilized since the initial development. With the extended emerging requirement for bricks within the country, the reservoir of clay soils suitable for creating bricks are depleting day by day. A replacing practice to scale back the number of clays is by addition of waste materials. Ground Granulated furnace Slag (GGBS) is an outgrowth obtained from the industries making steel and iron. during this study, GGBS is added in various percentages of 0%, 2%, 4%, 8% and 10% alongside clay to enhance the properties of clay bricks. For the scrutiny of the study, Compression Strength test, thermal conductivity test, Water Absorption test and efflorescence test were conducted. The strength of the improved bricks is higher than that on the virgin specimen. Water absorption rises with inclusion of materials and thermal conductivity shows a declining pattern with rise in material inclusion.

Key Words:Clay, GGBS, Compressive strength, Thermal conductivity, Water absorption, Efflorescence.

1.INTRODUCTION

The wide use of clay and cement sand bricks as building materials has given rise to depleting and dwindling of natural resources, thus gradually degrading the environment within the end of the day thanks to heat of firing, high utilization of energy, and high emission of CO_2 (CO_2). Hence, the utilization of commercial byproducts as alternative materials and binder for fabrication of bricks was found significant to beat this problem. Industrial by-product that's available worldwide in massive amounts and constantly produced is coal ash which constitutes of mainly ash and bottom ash. the mixture use of ash and bottom ash as raw materials for fabrication of bricks is a perfect solution to maximize the use of coal ash since most studies elsewhere focused on the use of ash or bottom ash alone. Moreover, ground granulated furnace slag (GGBS), an industrial by-product from iron making might be used as alternative binder to hydraulic cement when unfired method is employed for hardening process. The pozzolanic behavior and cementitious properties of GGBS is analogous thereupon of high-calcium Class C ash but much weaker in comparison to the hydraulic cement. Therefore, GGBS is usually mentioned as alkali activated binder. the utilization of GGBS as binder for brick fabrication has not been widely explored. However, there's paucity of published work on the addition of GGBS in clay bricks.

In this study, clay bricks were made with GGBS alongside clay. GGBS were added in 2%, 4%, 8%, and 10%. The Compression Strength, thermal conductivity, Water Absorption and efflorescence.

2. LITERATURE REVIEW

Mohamad Nidzam Rahmat et.al [2016] carried out an experiment on Strength and environmental evaluation of stabilized Clay- Pulverized ash eco-friendly bricks. during this research Lower Oxford Clay (LOC) was combined with Pulverized ash (PFA) as target materials were stabilized with Lime, hydraulic cement (PC) and blended binders comprising of Lime and PC blended with Ground Granulated Blast-furnace Slag. This research illustrated that each one the key parameters of compressive strength, and environmental properties were within the suitable engineering standards for masonry units. For LOC-PFA bricks, the UCS value raised as rise in the quantity of dose of stabilizers unlike when only lime was used. When LOC-PFA bricks were stabilized along with lime, there was 20-22% of absorption capacity up to soaking for 56 days. Whereas when lime:GGBS was used, it showed16-18%. The PC-GGBS blend ultimately showed very little absorption but later in it increased after soaking for 10 days.The general absorption for both PC stabilizers was between 7% and 10% with low energy used and no kiln firing required during production, this reduces the value of the top products. the sensible implications of this experimental programmed is that unfired bricks are often used for community-based development and may be applied to internal wall construction, with the general target of improving the standard, cost effectiveness and most significantly, it is often considered as a part of sustainable building materials.

Gaurav and Ajay conducted a study on aninvestigation on use of factory sludge in brick manufacturing [2017]. during this study an eco-friendly light weight bricks were produced with a binary mixture of factory sludge and soil. Here both laterite and soil types were used and bricks madeon these two soil types alongside factory sludge. the combination ratio was varied from 0%, 5%, 10%, 15% and 20%. the combination was tested by evaluating properties like linear shrinkage, compressive strength, water absorption, mass loss on ignition, and bulk density of bricks as recommended by the relevant Indian and ASTM standard codes. X ray diffraction results confirmed that the addition of PMS doesn't show any phase transformation and only enhances the porosity thereby resulting in weight reduction and therefore the fluxing agents which aids in reducing firing temperature and possible energy saving. An optimum mixture of 10% PMS with both soil types was found suitable for brick production at a firing temperature of 9000C. Maximum compressive strength and lower water absorption shows on control bricks. Water absorption is said to durability thus firing at heat decreases water absorption and thus improves the sturdiness.

Malhotra and Tehri (1995) investigated the event of bricks from granulated furnace slag, a byproduct of the iron and industry. The slag was first mixed with calcium hydroxide then the lime–slag mixture with Badarpur sand thoroughly. Brick specimens were made by pressing the mixture during a hydraulic machine at a pressure of 4.9MPa then curing the molded specimens at 270– 2720°C and 95% humidity over a period of 28 days. The cured bricks were tested for compressive strength (in saturated conditions), bulk density and water absorption properties. The study revealed that good quality bricks might be produced from a slag–lime mixture and sand.

3. MATERIALS AND METHODOLOGY

3.1 Materials

The raw materials used for the study are:

a. Clay.
b. Ground Granulated Blast Furnace Slag (GGBS).

a. Clay

The soil sample is collected from Margao, Goa. This clay is chiefly worn for production of bricks as shown in Figure 1.

Fig -1:Clay

The various properties obtained after performing basic tests as per Indian Standards are tabulated in Table I.

Table -1: Typical Properties of Clay

Sr. No.	Properties		Symbol	Values
1	Specific gravity		G	2.65
2	Hydrometer	Silt	M	75%
		Clay	C	25%
3	Soil classification		CH	Organic clay of high plasticity
4	Water content		w	21%
5	Dry density		γ_d	1.5g/cc
6	Liquid limit		W_L	55%
7	Plastic limit		W_P	22%
8	Plasticity Index		I_P	40%
9	Optimum moisture content		OMC	25%

b. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is obtained from Panaji, Goa by suppressing iron slag from steam blast furnace as shown in the figure.

Fig -2: GGBS

The physical properties of GGBS are listed in Table 2.

Table -2: Typical Physical Properties of GGBS

Sr. No.	Parameter	Description
1	Color	off-white
2	Specific gravity	2.5-3.5
3	Bulk density	1000-1400 kg/m^3
4	Fineness	>350m^2/kg

The major Chemical components of GGBS are listed inTable 3.

Table -3: Typical Chemical Compositions of GGBS

Sr. No.	Chemical	%
1	Calcium Oxide (CaO)	30-50
2	Silica (SiO_2)	28-38
3	Alumina ($Al2O_3$)	08-24
4	Magnesia (MgO)	01-18

3.2 Methodology

Preliminary tests were conducted on the materials as per IS standards & Specifications for its physical and chemical properties. Bricks were casted in the non-modular molds as per IS code 1077(1992) to obtain the required size of specimen. The molds were cleaned initially before the mix was poured in to the mold. The sample was compacted using a vibrating table for a small period of 1-2 minutes. The mix was poured into the mold and was kept for drying for 14 days. After that, the bricks were transferred to Kiln. The bricks were burnt at a temperature range of 900°C to 1350°C. After cooling, the bricks were removed from the kiln and tested after 28 days.

The main aim of the methodology is:

- To find the optimum dosage of GGBS to attain highest Compressive Strength, lower Thermal Conductivity, Water Absorption and nil or negligible Efflorescence.

Tests conducted on Ground Granulated Blast Furnace Slag GGBS (Size 90μ)

The values obtained after performing the following tests are tabulated in Table 4 and 5.

- Specific Gravity and Water Absorption Test
- Chemical properties

Table -4: Physical Tests of GGBS

Sr. No.	Test	Method of Test	Average Result	Permissible Value
1	Specific Gravity	IS:2720 (Part 3)	2.9	-----
2	Water Absorption	IS:2386 (Part 3)	0.09%	-----

Table -5: Chemical Property Tests of GGBS

Sr.No.	Characteristics	Requirements as per BS: 6699	Test Result
1	Fineness(M^2/Kg)	275 (Min.)	441
2	Insoluble Residue (%)	1.5 (Max.)	0.36
3	Magnesia Content (%)	14.0 (Max.)	6.82
4	Sulphide Sulphur (%)	2.00 (Max.)	0.26
5	Sulphite Content (%)	2.50 (Max.)	0.36
6	Loss on Ignition (%)	3.00 (Max.)	-0.26
7	Manganese Content (%)	2.00 (Max.)	0.16
8	Chloride Content (%)	0.10 (Max.)	0.028
9	Glass Content (%)	67 (Min.)	94.5
10	Chemical Modulus		
a	$CaO+MgO+SiO_2$	66.66 (Min.)	78.29
b	$CaO+MgO/SiO_2$	>1.00	1.23
c	CaO /SiO_2	<1.40	1.03

4. EXPERIMENTAL DETAILS

4.1 Casting of bricks

Clay bricks are made prepared by mixing GGBS in various percentages. They are molded by hands and are burnt in kiln. GGBS were added in 2%, 4%, 8% and 10%. The water content achieved to be the optimum was determined and added. The size of the bricks was selected as 230×110×70mm non-modular bricks.

4.2 Test methods

The prepared bricks were cured for 28 days and then the tests were carried out. Compression Strength test, thermal conductivity test, Water Absorption test and efflorescence test were conducted as per IS 3495 (PART 1-3) and as per IS 3346:1980.

5. RESULTS AND DISCUSSION

Clay bricks made with GGBS were tested for analyzing the physical properties of bricks such as Compression Strength, thermal conductivity, Water Absorption and efflorescence.

5.1 Compressive strength

The compressive strength test was determined as per IS 3495 (Part 1) - 1992 as shown in figure 3. Clay bricks were made by adding GGBS in varying percentages of 2%, 4%, 8% and 10%. The bricks were tested in the compressive testing machine and the following results were obtained. It is one of the important tests and its result gives the strength of the brick. The test results are listed in Table 6.

Table -6: Thermal Conductivity Test Results

Sr. No.	GGBS content (%)	Compressive strength (N/mm^2)
1	0	9.8
2	2	9.95
3	4	10.5
4	8	10.09
5	10	9.4

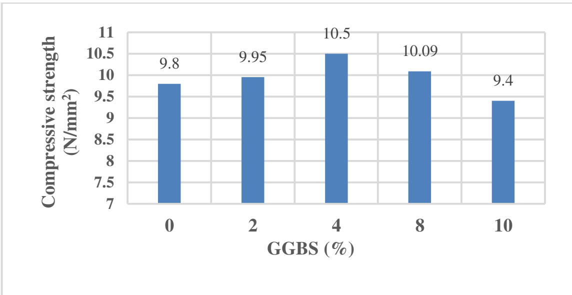

Fig -3: Variation of compressive strength result of clay bricks with GGBS

8% addition of GGBS to clay bricks shows higher compressive strength compared to that control bricks. Beyond 8% the compressive strength decreases with increase in GGBS content.

5.2 Thermal Conductivity

Thermal conductivity test is performed based on the concept of steady state condition and as per IS 3346: 1980. The whole arrangement is kept in a closed room to avoid air flow which causes delay in formation of steady state condition.

Clay bricks were made of GGBS with different percentages of 2%, 4%, 8% and 10%. Then it was tested for thermal conductivity as shown in Figure 4 and the results are tabulated in Table 7.

Table -7: Thermal Conductivity Test Results

Sr. No.	GGBS content (%)	Thermal Conductivity (W/m ^{0}C)
1	0	1.2
2	2	0.92
3	4	0.89
4	8	0.86
5	10	0.82

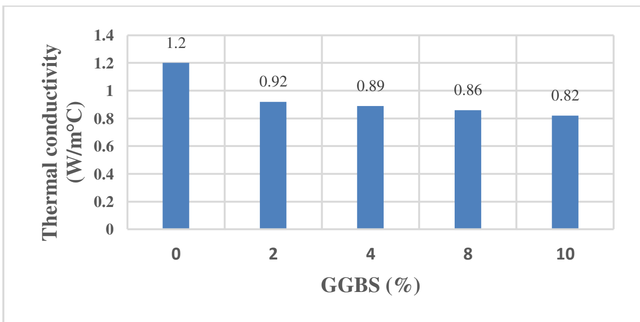

Fig -4:Variation of thermal conductivity result of clay bricks with GGBS

It was observed that, the thermal conductivity of the brick decreases with increase in GGBS content.

5.3 Water Absorption

Clay bricks made with GGBS in 2%, 4%, 8% and 10%. The water absorption test was conducted by immersing the bricks in cold water for 24 hrs. The results are tabulated in Table 8 and represented in Figure 5.

Table -8: Water Absorption Test Results of Clay Bricks With GGBS

Sr. No.	GGBS content (%)	Water absorption (%)
1	0	15.5
2	2	16.8
3	4	17.7
4	8	18.4
5	10	20.6

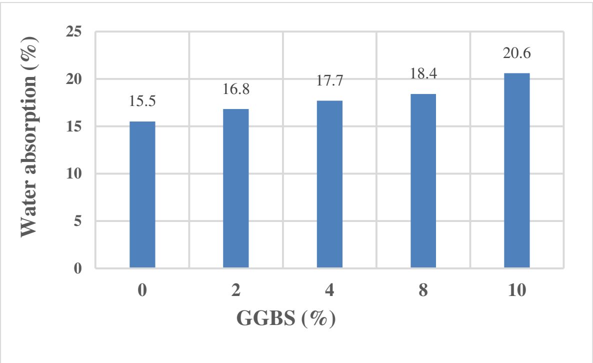

Fig -5: Variation of water absorption result of clay bricks with GGBS

Clay bricks made with GGBS show that the percentage of water absorption increases with increase in GGBS content.

5.4 Efflorescence

Efflorescence was determined for find the alkaline salt content in bricks. The test was conducted as per IS 3495 (part III) – 1992 shown in figure 6. In this experimental work, no perceptible deposit is observed on majority of samples but there is a very thin deposit of salts observed on some samples.

Fig -6:Efflorescence test

6. CONCLUSION

This study shows the feasibility of GGBS for brick making. Based on the aforementioned experimental results, following conclusions can be made:

- Modified clay bricks show increase in compressive strength up to an 8%, beyond that point compressive strength decreases. This is due to the porous nature and density of the modified bricks.
- The thermal conductivity of bricks was less for all the percentages of GGBS addition compared to the control bricks. Thermal conductivity is closely related to the porosity of bricks. Porous structure of bricks is due to CaO rich particles in GGBS and paper sludge. Good bricks should have low thermal conductivity so that houses keep cool in summer and warm in winter.
- Water absorption increases with increase percentage addition of materials. Increase in water absorption is due to the porous nature of the bricks. This is due to the lesser soil particles in bricks and it became coarser; this results in higher water absorption.
- All the bricks have nil or slight efflorescence content. This shows the alkaline salt content in those bricks are less.

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