IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

AN EXPERIMENTAL STUDY ON GEOPOLYMER BRICKS WITH RICE HUSK ASH AS REPLACEMENT TO FLYASH

[1]SupriyaC.L, [2]Manjunath H.S, [3]Harshith H.J, [4]Chetan K.M

[1]Assistant Professor, [2]Assistant Professor, [3]Assistant Professor
[1]Department of Civil Engineering,
[1]Rajeev Institute of Technology, Hassan, India

Abstract : Brick is the oldest building material. It is a standard sized weight bearing unit. The earliest bricks were formed from clay or mud and sun dried. During 2007 the new flyash bricks were created using by-products from coal plants. Recently, due to the ever-increasing demands of the construction industry, clay extraction is posing a serious environmental problem. As engineers, it is our responsibility to look for an alternate solution which is both efficient and environmentally sustainable. One such alternative is to substitute clay in bricks with pozzolanic industrial by-products. Pozzolona ns are inert cementitious materials rich in clay and alumina. Use of an alkaline activator solution promotes the reactions in the pozzoloanic material and activates the cementitious property. In the present work, geopolymer bricks containing fly ash (70 percent by weight), ground granulated blast furnace slag (30 percent by weight), natural sand and alkaline activator, have been manufactured. The alkaline activator used was a combination of sodium hydroxide and sodium silicate solutions. Further, the suitability of rice husk ash (RHA) as a puzzolonic material has been tried by casting bricks with different percentages of fly ash and RHA. Fly ash has been replaced with RHA at increments of 20 percent by weight of binder in bricks. The bricks were cured under ambient conditions for 28 days and laboratory tests have been conducted to ascertain the physical and mechanical properties of the bricks. Based on the test results, a suitable percentage of RHA in geopolymer bricks has been suggested

***IndexTerms* – Flyash, Geopolymer bricks, Rice husk ash**

I. INTRODUCTION

1.1INTRODUCTION

Brick is the most commonly used building material in India for more than 1000 years. Fired clay bricks are most commonly used in India. But nowadays fly ash bricks have been tremendously being used due to the reduction in cost as well as its light weight. Geopolymer bricks are the latest innovation in the brick industry which consist of supplementary cementitious materials such as fly ash or GGBS activated by an alkaline activator. The application of geopolymer technology gained importance due to the reduction of the CO2 emissions by utilizing the supplementary cementitious materials in place of cement.

1.2 OBJECTIVES

To manufacture geopolymer bricks using fly ash and GGBS, To study the physical and mechanical properties of geopolymer bricks, To present a comparative study b/w brick with various percentages of RHA and FA, To replace fly ash by rice husk ash at increment of 20 percent by weight of fly ash in geopolymer bricks.

2.1 Materials & Methodology

Fly Ash: Locally available fly ash from a nearby brick manufacturing plant was procured. It was sieved through IS 75-micron sieve and used in the mix. The properties of fly ash are as furnished below

Following are the results of tests conducted on Fly Ash Bricks samples in favour of M/s. Lakshman Bricks Industries, Plot No.245, KIADB, Hassan Industrial Growth Centre, H.N.Pura Road, Hassan. lt.dt.14.09.2018.

1. Water Absorption

Sl	Dry Weight (gms)	Wet Weight (gms)	Water Absorption (%)
1	2970	3261	9.798
2	2780	3039	9.316
3	3060	3360	9.800

2. Compressive Strength

Sl	Size (cm)	Crushing Load (t)	Compressive Strength (Kg/cm^2)
1	22.0 x 10.5	35.2	145.76
2	22.0 x 10.5	34.8	144.10
3	22.0 x 10.5	35.0	144.92

3. Dimension Analysis

Dimension	% Variation
Length	0.12
Breadth	0.11
Depth	0.11

Tested by
Dr.Mohan Kumar Chavan, Ph.D.,

CHAIRMAN
MCE CONSULTANCY CENTRE

GGBS : Ground granulated blast furnace slag (GGBS) was procured from a vendor in 50 kg bags .The properties of GGBS are as Furnished below:

IS-16714
CM/L-6200131683
ISO 9001,ISO 14001,ISO 50001 & OHSAS 18001 Certified by IRQS
JSW CEMENT LTD.,
Vijayanagar works

TEST CERTIFICATE FOR GROUND GRANULATED BLAST FURNACE SLAG

SL NO	Characteristics	Reference to Requirement as Per IS 16714:2018	Test Result
	CHEMICAL REQUIREMENTS		
1	Manganese Oxide (MnO) %	5.5 % (Max)	0.10
2	Magnesium Oxide (MgO) %	17.0 % (Max)	7.55
3	Sulphide Sulphur (S) %	2.0 % (Max)	0.38
4	Sulphate (as SO3) %	3.0 % (Max)	0.20
5	Insoluble Residue (I.R) %	3.0 % (Max)	0.40
6	Chloride Content (Cl) %	0.1 % (Max)	0.007
7	Glass Content %	85 % (Min)	92
8	Loss On Ignition (L.O.I) %	3.0 % (max)	0.19
9	Moistur Content %	1.0 % (max)	0.02
10	(CaO+MgO+1/3 Al2O3) / (SiO2+2/3 Al2O3)	1.0 % (Min)	1.08
11	(CaO+MgO+ Al2O3) / SiO2	1.0 % (Min)	1.91
	PHYSICAL REQUIREMENTS	Reference to Requirement as Per IS 16714:2018	Test Result
1	Specific Gravity		2.91
2	Fineness, M2/Kg	320 (Min)	360
3	Slag Activity Index		
	a) 7 Days	60 % (Min)*	71.59
	b) 28 Days	75 % (Min)**	Awaited

Week No -08
(19.02.2022-25.02.2022)
For the production of GGBS granulated blast furnace slag confirming to the IS 12089:1987 has been used.
Note:- * Not Less than 60 % of control OPC 43 Grade Cement Mortar Cube
** Not Less than 75 % of control OPC 43 Grade Cement Mortar Cube
Slag Activity index (SAI) shall be determined using blend of 50 % GGBS & 50 % Control OPC 43 Conforming to IS 269.

Authorized Signatory

Alkaline Activators: The alkaline liquid used was a combination of sodium silicate solution (Na_2SiO_3) and sodium hydroxide solution (NaOH). The NaOH pellets were dissolved in water to make the solution. The mass of NaOH solids in a solution depends on the concentration of the solution and is expressed in terms of Molar (M). NaOH solution with a concentration of 10 M consists of 10x 40 = 400 grams of NaOH solids (in flake or pellet form) per litre of the solution, where 40 is the molecular weight of NaOH. Sodium silicate was used in the liquid form. A binder to alkali activator ratio of 0.4 was adopted. The ratio of Sodium Silicate to Sodium Hydroxide was taken as 2.5.

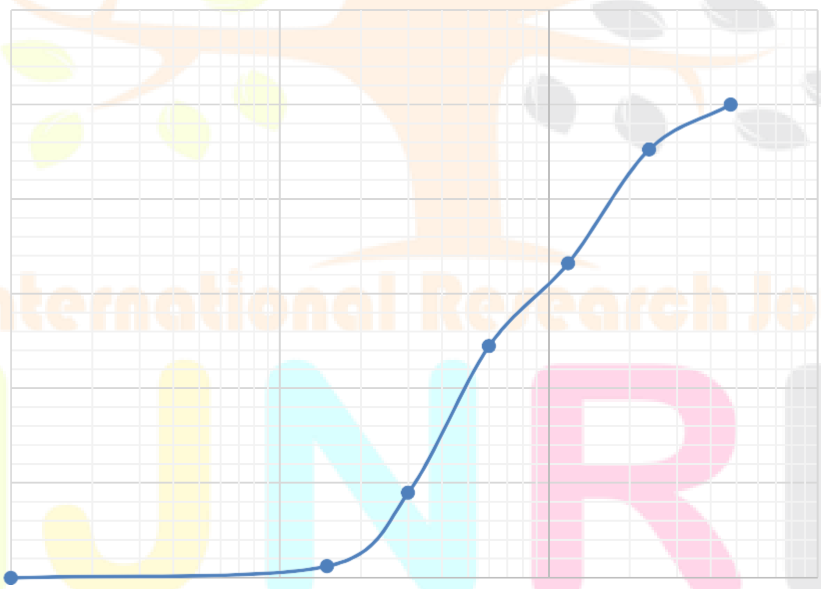
$$0.5 = \frac{\text{Na2sio3 Solution}}{\text{Binder}}$$

$$2.5 = \frac{\text{Na2sio3 Solution}}{\text{Na0H}}$$

Chemical Composition	Percent %
Na2O	7.5 – 8.5
Sio2	25-28
PH	Neutral

Fine Aggregate: Locally available Natural Sand in 50 kg bag was procured and used for the present Work. It conformed to zone II as per IS 383-1970.

Property	Values
Specific Gravity	2.51
Bulking	1.49 kg/m3



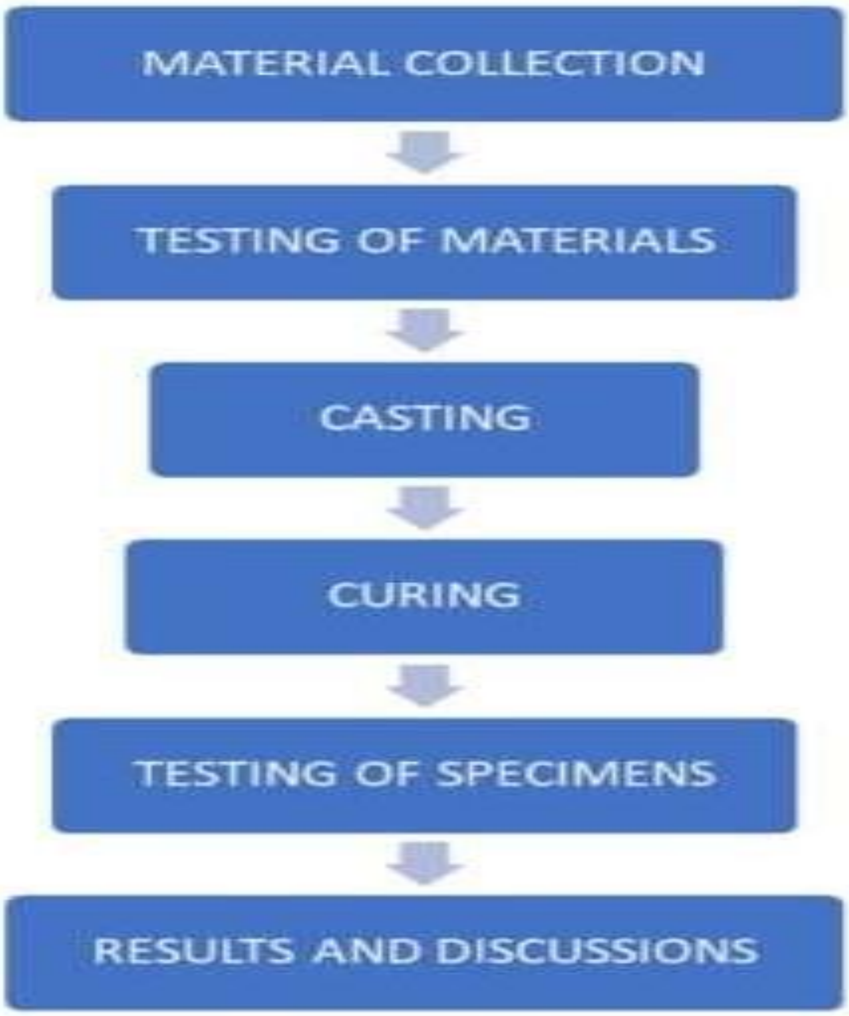
3.2 Methodology

Manufacturing of Bricks

- The Size of the brick mould was 230*110*90 mm.
- The mixes were Prepared in the proportion of 1:3 binder to aggregate ratio and with binder to solution ratio of 0.5.
- The binder consisted of 70% fly ash and 30% GGBS.
- Several mixes were Prepared with varying fly ash with replacement to rice husk ash and bricks were machine-cast in a local casting yard. The details are presented below.

Mix Designation	Fly-Ash (gms.)	GGBS (gms.)	RHA (gms.)	Sand (gms.)	Alkaline Activator in (gms.)	
					NaOH	Na_2SiO_3
GPB-1	700	300	-	3000	142.5	357.5
GPB-2	560	300	140	3000	142.5	357.5
GPB-3	420	300	280	3000	142.5	357.5
GPB-4	280	300	420	3000	142.5	357.5
GPB-5	140	300	560	3000	142.5	357.5
GPB-6	-	300	700	3000	142.5	357.5

3.3 Methodology



4.1 Tests on Geopolmer Bricks

- Mass Density of Bricks.
- Compressive Strength.
- Dimension Analysis.
- Initial Rate of Absorption.
- Water Absorption Test

4.1.1 Mass Density of Bricks.

The mass and volume of an oven dried brick were measured. The bulk density was determined by dividing its mass by volume. Mass Density = Mass of brick/ Volume of brick.

4.1.2 Compressive Strength

Compression strength is the capacity of a material or structure to withstand loads tending to reduce the size. Three dry bricks on each proportion were tested for compressive strength. In this test a brick specimen was placed in the compression testing machine and the pressure was applied till the failure point. The value of ultimate load was noted down and the crushing strength value of brick was calculated. As per IS1702-1992 the minimum crushing strength of brick is 3.50 N/mm2.If it is less than 3.50 N/mm2, then it is not useful for construction purpose.

4.1.3 Dimension Analysis

Twenty bricks were selected at random to check the length, width and height. These dimensions were measured in one or two lots of ten each. Variation in dimensions are allowed only within narrow limits i.e., ±3% for class one and ±8% for other classes.

4.1.4 Initial Rate of Absorption

There is a need to understand the rate at which moisture is absorbed by the masonry unit. This rate is specified through a parameter known as the Initial Rate of Absorption (IRA).This is determined by dipping dry masonry unit in a 3 mm layer of water for one minute (ASTM C67). The IRA is then specified in terms of $kg/m^2/min$. typical values for Indian bricks vary over a range of 1.17 $kg/m^2/min$. to 9.33 $kg/m^2/min$.

4.1.5 Water Absorption Test

Absorption test was conducted on bricks to find out the amount of moisture content absorbed by the bricks under extreme conditions. In this test, three dry bricks were taken and weighed. After weighing, these bricks were immersed in water for a period of 24 hours. Then the bricks were again weighed. The difference of weight between wet and dry brick will give the amount of water absorption. For a good quality brick, the amount of water absorption should not exceed 20% of weight of dry brick.

Water Absorption= [(W2- W1) / W1] X 100

Where W1 - Wet weight specimen

W2 - Dry weight specimen

5. RESULT AND DISCUSSIONS

5.1 Mass Density of Bricks

Mix Designation	Average Dry Density of Bricks (Kg/m^3)
GPB-1	1820.32
GPB-2	1828.25
GPB-3	1744.44
GPB-4	1766.37
GPB-5	1787.60
GPB-6	1841.02

Table 5.1 Mass Density Test

Remarks: The mass density of bricks of all proportions varied between 1700 to 1850Kg/m^3.

5.2 COMPRESSIVE STRENGTH

Mix Designation	Average Compressive Strength (N/mm^2)
GPB-1	3.56
GPB-2	3.81
GPB-3	4.01
GPB-4	4.89
GPB-5	5.68
GPB-6	6.26

Table 5.2 Compressive Strength Test

Remarks: The strength of bricks exhibited at an increasing trend with increase in the percentage of RHA. The highest compressive strength was observed at 100% replacement level.

5.3 DIMENSION ANALYSIS

Dimension	Average % Variation
Length	0.23
Breadth	0.11
Depth	0.18

Remarks: The results revealed that the variation in length, breadth and depth did notexceed the specified limit of 3 percent.

5.4 Initial Rate of Absorption

Mix Designation	Average Compressive Strength (N/mm^2)
GPB-1	11.95
GPB-2	15.29
GPB-3	6.93
GPB-4	7.30
GPB-5	5.01
GPB-6	6.85

Table 5.4 Initial Rate of Absorption

Remarks: The results obtained from the IRA test have been satisfactory and are in thenormal range compared to that of clay bricks.

5.5 Water Absorption Test

Mix Designation	Average Water Absorption (%)
GPB-1	13.26
GPB-2	12.42
GPB-3	14.23
GPB-4	13.78
GPB-5	11.83
GPB-6	8.76

Table 5.5 Water Absorption Test

Remarks: The water absorption showed a decreasing trend beyond 60 percent of RHA.Least absorption was observed in the brick specimens with 100 percent RHA.

6 Conclusion:

- Geopolymer bricks have been manufactured using 70 percent fly ash, 30 PercentGGBS, Natural sand and alkaline activator.
- Alkaline activator has been prepared with the combination of sodium Hydroxidesolution and sodium silicate solution.
- Various mixes were prepared by replacing fly ash with RHA at increments of 20%by weight of fly ash.
- Bricks were cast in a casting machine and cured under ambient conditions for 28 days.
- The bricks were tested for physical and mechanical properties.
- The results obtained were comparable to that of clay bricks
- From the strength point of view, geopolymer bricks with 100% of RHA issuggested.

II. Acknowledgment

Brick is the oldest building material. It is a standard sized weight bearing unit. The earliest bricks were formed from clay or mud and sun dried. During 2007 the new flyash bricks were created using by-products from coal plants.

Recently, due to the ever-increasing demands of the construction industry, clay extraction is posing a serious environmental problem. As engineers, it is our responsibility to look for an alternate solution which is both efficient and environmentally sustainable. One such alternative is to substitute clay in bricks with pozzolanic industrial by-products. Pozzolans are inert cementitious materials rich in clay and alumina. Use of an alkaline activator solution promotes the reactions in the pozzolanic material and activates the cementitious property.

In the present work, geopolymer bricks containing fly ash (70 percent by weight), ground granulated blast furnace slag (30 percent by weight), natural sand and alkaline activator, have been manufactured. The alkaline activator used was a combination of sodium hydroxide and sodium silicate solutions. Further, the suitability of rice husk ash (RHA) as a pozzolanic material has been tried by casting bricks with different percentages of fly ash and RHA. Fly ash has been replaced with RHA at increments of 20 percent by weight of binder in bricks. The bricks were cured under ambient conditions for 28 days and laboratory tests have been conducted to ascertain the physical and mechanical properties of the bricks. Based on the test results, a suitable percentage ofRHA in geopolymer bricks has been suggested.

References

[1] Lavanya B, Preet D Kuriya, Suganesh S, Indrajith R and Ramesh Babu Chokkalingam, "Properties of geopolymer bricks made with flyash and GGBS", IOP Conf. Series: Materials Science and Engineering 872 (2020) 012141.

[2] M. M. Abdhulla, 'A Review of Fly Ash-Based Geopolymer Lightweight Bricks', Applied Mechanics and Materials Vols. 754-755 (2015) pp 452-456.

[3] Sumathi, 'Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust', Int.J. Chem Tech Res.2014-15, 07(01), pp 28-36.

[4] P. Sakthivel, 'Experimental Investigation on Fly ash Based Geopolymer Bricks', International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 5, Page 216-227.

[5] Gurdarshan Singh Brar, 'Experimental Investigation of Clay Fly Ash Bricks fo Gamma-Ray Shielding', Nuclear Engineering and Technology (2016).

[6] "Alternative Building Materials and Technologies", K.S. Jagadeesh, B. V Venkatarama Reddy and K. S. Nanjunda Rao, New Age International (P) Ltd., 2014.