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Geopolymer Brick

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Abstract

The objective of this experiment study is to construct an energy saving building material which is economically good and ecofriendly. The fly ash which is a coal combustion product, is made of fine particles of burnt fuels and fuel gas emitted from coal. This brick is prepared using waste reusable materials such as fly ash, GGBS which is iron waste and waste brick powder. Clay as main ingredient and addition of chemical solution along with the above materials gives geopolymer nature to the prepared new brick. The brick has less weight compared to the standard brick as the brick is made of using waste reusable materials such as fly ash, GGBS, waste brick powder and chemical solution mix of sodium silicate and sodium hydroxide in a fixed ratio. The brick is cured in an oven in order to avoid the pollution created by burning of brick at a brick kiln. The compressive strength and water absorption tests are conducted and results are obtained. The best Geopolymer brick sample is obtained by adding clay and fly ash in the ratio 2:1 and chemical solution (Na_2SiO_3+NaOH) with a ratio to clay as 0.27. For a sample of brick GGBS is taken 0.25 times of fly ash and waste brick power is approximately taken as 0.1kg. The results of experiment are compared with the standard brick.

Keywords: *Clay soil, Ecofriendly, Geopolymer, Light weight bricks,*

INTRODUCTION

India is a country having a total geographical area of 328.73 million hectares (MH), of which approximately 32% (105 MH) of its facing land degradation. With a whopping 82.6 million hectares as its gross irrigated crop area, India stands at the top of the world in agriculture, defeating countries such as The United States and China. At present, in India about 250 billion bricks are made annually for which the net consumption is over 10000 hectares of land with a high adverse impact on soil erosion and also India has about 100000 brick kilns, employing about 15 million workers.

Concrete is still one of the most popular construction materials on earth. The cement manufacturing industries usually use fly ash as a partial or complete replacement to make Portland cement. Ordinary Portland cement (OPC) typically produces a large amount of carbon dioxide (CO_2) in the nature that significantly contributes to greenhouse gas emissions.

Geopolymer solid brick is an innovative building material, normally produced by the chemical reaction of inorganic particles which has a more potential to deplete the greenhouse emission by 80%. This study is to present the technology behind the producing of geopolymer solid bricks using low-calcium (Class-F) dry fly ash as its main source material and to discover and evaluate of the physical and durable properties of it. The brick is one of the most widely used masonry units for building construction. Common building materials, such as bricks and cement, are responsible for a number of sensitive issues linked to the social and environmental impacts.

Conventional bricks are made from raw materials, clay, sand, and non-plastic materials, then fired in a kiln at a temperature ranging from 850 to 950 °C. The use of fossil fuels induces large energy consumptions that are responsible for economic, energy, environmental and ecological issues. As an example, the production of one ton of cement requires the consumption of 1.7 tons of raw materials and involves the emission of 0.8 tons of CO_2 into the atmosphere. However, during the industrial production phase, a significant percentage of waste such as fly ash (FA), waste bricks (WB), ground granulated blast furnace slag (GGBS) is obtained. These wastes result in environmental challenges.

The process of recycling and recovering a large amount of waste bricks has become necessary to ensure environmental protection. The Reuse of this industrial waste by recycling it into new building materials is considered a practical solution for reducing many environmental problems related to pollution.

Geopolymers are alkaline aluminosilicate binders, which can be a substitute for building materials. The main characteristic of geopolymers is their ability to provide an important reduction in CO_2 emissions and less energy requirements for production compared with Ordinary Portland Cement products thanks to the low curing temperature used.

Geopolymers can be considered a green concrete. The main objective of this research is to develop a new geopolymer for the building construction sector by using waste bricks as a solid precursor. In addition to waste bricks, other minerals are used for alkaline activation such as blast furnace slag and sand. Three properties were considered: the ratio of clay/fly ash, the ratio of GGBS/WB, the molarity of sodium hydroxide and the silicate to hydroxide

ratio. The optimal value of each parameter was determined in this study.

OBJECTIVE

The main objective of this experimental study is:

- To make a brick which is economical and ecofriendly.
- To study and develop important properties of Geopolymer brick.
- To implement the use of this kind of bricks in construction field.
- To investigate a process of casting and curing which don't require more amount of water.

MATERIALS

In this study, Fly ash, Ground Granulated Blast furnace Slag (GGBS), Sodium hydroxide (NaOH) pellets, Sodium silicate (Na_2SiO_3) solution commercially available in market, Clay soil, Waste bricks which are collected at brick kiln.

The Fly ash was obtained from National Thermal Power Plant, NTPC, Ramagundam, Telangana. This fly ash is of class F. Ground Granulated Blast Furnace Slag (GGBS) is by product of iron manufacturing which when added to concrete improves its properties such as workability, strength and durability.

The previous on Geopolymer Brick used a mix proportion of **Clay : Fly Ash** as **1 : 1**with a solution (NaOH & Na_2SiO_3 combined together) to clay ratio of 0.25. The trial mix is arrived by slightly modifying the

The Clay soil and waste bricks was collected from a local supplier brick kiln at Gaddipotharam village, near Bowrampet, Hyderabad, Telangana, India.

Sodium Hydroxide (NaOH) and Sodium Silicate (Na_2SiO_3) are purchased in the approved chemical industry as pellet form and commercial form respectively at Balanagar, near Bowenpally, Hyderabad, Telangana, India.

MIX DESIGN

For this study, Geopolymer Brick was developed through preliminary tests based on the existing mix proportions of Geopolymer brick by replacing the water in full version by chemical solution and adding the additional materials together such as Fly ash, GGBS and Waste Brick powder.

Sodium Hydroxide (NaOH) is available in the local market in pellet form. 10 Molar solution was used. Since the molecular weight of Sodium Hydroxide is 40, and in order to prepare 10 molar solution 10 x 40 = 400 grams of Sodium Hydroxide was dissolved in 1000 ml of water.

quantities of clay soil and fly ash. Hence the proposed Trial Mix is **Clay : Fly Ash** is **2 : 1**. The ratio of solution to clay is 0.27. The quantities required for a single brick are presented in Table 1. In this study the sodium

silicate and the sodium hydroxide solution were prepared separately one day prior to the use in preparing the geopolymer brick. The ratio of sodium silicate solution to sodium hydroxide solution was fixed as 0.5%.

S. No.	Materials	Quantity
1.	Clay	2.2 kg
2.	Fly ash	1.1 kg
3.	Ground granulated blast slag furnace	0.275 kg
4.	Waste Brick Powder	0.1 kg
5.	Sodium Silicate solution	200 ml
6.	Sodium Hydroxide Solution	400 ml

Table 1 - Mix for single Geopolymer brick sample

PROCEDURE

We have collected all the materials like Fly ash, Ground granulated blast slag furnace, Clay, Waste Bricks, sodium silicate (Na_2SiO_3), and also along with these materials, we have prepared 10M solution of sodium hydroxide (NaOH) by adding 400g of sodium hydroxide pellets to 1000ml distilled water.

Rectangular moulds with a cross section of 20 cm x 10 cm x10 cm were prepared. Then, specimens were prepared based on ISSN: 0974- 6846, the methods for making and curing test specimens for strength tests.

On a flat surface, a tray is placed. Alternate layers of clay, fly ash, GGBS, waste brick powder are placed. Mix these materials until a proper mix occurs. Now take a bowl and add both the chemical solutions of required quantity and mix it well. Now add this chemical solution gradually to the uniform mix placed in tray.

Mixing was done again until a visually acceptable mix was obtained. Hand mixing was employed throughout the entire specimen preparations. Gloves are used while adding the chemical solution and mixing it. Now take the brick mould and apply fly ash to all the sides in order to unmould the brick sample as soon as it is casted.

After getting a uniform mix, place the sample in the mould at once and compact it using the hands gently until the sample obtains the shape of the mould.

Now invert the mould on the ground level and gently apply load over the mould using a compaction rod or gently tap the mould to the ground level until the sample comes out of the mould. Remove the excess fly ash on the

sample and place it in the room temperature or outside for 2 days.

CURING

After casting the specimens, they were kept outside for 2 or 3 days to get adjusted with the surrounding conditions.

Later the samples are kept in an oven for 6 days @ 80° C. After that the temperature is increased up to 110°C for 12 hours.

The specimens which are cured in both room temperature and oven are kept ready for compressive strength test which is done in laboratory.

Figure 2 Geopolymer Bricks

Figure 3 Oven Curing

Figure 4 Compressive Strength Testing Machine

TESTING OF SAMPLES

A) Compressive Strength Test: The brick samples were tested in a compressive testing machine having 2000kN, and loaded at a constant rate of loading at 200kg/cm2/min as per Indian standard procedure for clay bricks and fly ash bricks (IS: 1077-1992 and IS: 12894-2002). The Compression test results for three samples of oven curing for 9 days are tabulated in Table 2.

B) Water Absorption Test:

Water absorption test is conducted to check the durability property (such as degree of burning, quality and behavior under weathering action etc.) of the bricks (IS: 3495, Part-II). When specimen after cooling down attains the room temperature, its weight is noted (W_1). The dry sample then immersed in clean water at a temperature (27+2)°C for 24 hours. Finally, the specimen was removed from the water and wiped with damp cloth to remove the surface water. The final weight of water absorbed brick is noted (W_2). The formula for calculating water absorption (% by mass) is as follows

$$\text{Water Absorption} = \frac{W2 - W1}{W1} \times 100$$

The test results are tabulated in Table 3.

Material Ratio (Soil : Fly ash ratio)	**Weight of the Brick (Kg)**	**Compressive Strength (N/mm^2)**
2:1	2.70	3.40
2:1	2.75	3.28
2:1	2.73	3.10

Table 2 - Compressive Strength of Geo Polymer Bricks (N/mm^2)

Material Ratio (Soil : Fly ash)	Initial Dry Weight (W1) in Kg	Final Weight after water absorption (W2) in kg	% of Water Absorption
2:1	2.75	3.10	12.72%
2:1	2.73	3.08	12.82%
2:1	2.70	3.02	11.85%

Table 3 - Water Absorption of Geo Polymer Bricks (%)

CONCLUSION

Based on the above experimental studies carried out on Geopolymer Brick, we can conclude that

- The weight of Geopolymer Brick is comparatively less than regular clay brick.
- Through compressive strength test it is observed that the strength of this ecofriendly bricks is more than that of conventional ones.
- From water absorption test it is clearly observed that water absorption and penetration is less for Geopolymer Brick than regular clay brick.
- As we adapted geopolymerization, a huge amount of water is not wasted and also, we used oven curing in order to avoid the pollution created by burning bricks at a brick kiln.

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