EXPERIMENTAL STUDY ON THE BEHAVIOUR OF GEOPOLYMER BRICKS

Pavithra N
Assistant Professors, Civil Engineering, VELTECH, Chennai, Tamilnadu, India

Divya G
Assistant Professors, Department of Civil engineering, Veltech RR & Dr.SR R&D Institute of science and Technology, Chennai, India

Suganthi M
Assistant Professors, Civil Engineering, VELTECH, Chennai, Tamilnadu, India

Omprakash S
Assistant Professors, Department of Civil Engineering, Veltech RR & Dr.SR R&D Institute of science and Technology, Chennai, India

ABSTRACT

The bricks are manufactured from natural clay, which is obtained from agricultural land the geo polymer bricks are an alternative for the conventional bricks which can be used effectively to replace the conventional bricks. Various properties of these bricks were studied by different researchers and they understood these bricks can be used for construction of low cost houses. This paper is an attempt to study the durability and strength aspect of bricks prepared using class F fly ash, slag, metakaolin and quarry dust. The experiment is conducted to observe the properties i.e. compressive strength and water absorption of geopolymer brick. In this slag (10%) and quarry dust (35%, 30%) are kept constant and class f fly ash (55% to 35%, 60% to 40%) is replaced with white metakaolin up to 20 percentage and chemicals (sodium hydroxide and sodium silicate). The geo polymer bricks are tested after 7 days, 14 days and 28 days curing in advanced concrete research laboratory of the institute.

Key words: Slag, Compressive strength, Metakaolin, Quarry dust, chemicals, Water absorption


http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=2
1. INTRODUCTION
Burnt clay bricks are being used extensively almost throughout India and are perhaps the most important building construction material. But the unlimited use of clay is harmful to society as all the bricks kilns in India depend on good quality clay available from agricultural fields and presuming a weight of 3 kg. per brick.

So, the use of industrial waste products such as fly ash, for making bricks is ecologically and economically advantageous since apart from saving precious top agricultural soil, it meets the social objective of disposing industrial waste i.e. fly ash which otherwise is a pollutant and a nuisance. The ever increasing volume of fly ash quantities in the world has not been remotely matched by its utilization.

Use of fly ash in concrete is to the extent of maximum of 25% replacement of Portland cement. This conservatism can be understood in the context of concrete where the ash is mixed raw, and the effects of high volume replacement are still subject to research. It is however not quite justifiable that the brick industry should take similar conservative attitude.

Environmental concerns have been raised in some parts of the world where coal is the main power generating resource and where bricks are also the main building material. Such concerns have resulted in legislation to oblige the brick industry to incorporate at least 25% by weight of fly ash and or bottom or pond ash in the brick making mixture if the industry is within 50 km from a coal power generation plant. Some successful ventures have been reported where fly ash was incorporated in the mixture at the rate of 20% to 50%. Nevertheless, there is only little evidence that incorporation of fly ash in the brick mixture has exceeded the 30% by volume, even when the legislation was obeyed. Fly ash is finely divided residue resulting from combustion of powdered coal.

2. LITERATURE REVIEWS
Alkali Activated Eco-friendly Metakaolin/Slag Geopolymer Building Bricks H. M. Khater et.al This study explores the physico-mechanical characteristics of geopolymer bricks using eco-friendly slag/metakaolin binder. Alkaline activation of slag – metakaolin binder of geopolymer brick results in formation of C-A-S-H as well as N-A-S-H gel, which adopts different structures depending on the nature of the alkaline activator. Activators used are 10% NaOH solution in addition to 5% liquid sodium silicate both used from the total binder weight), Geopolymer bricks prepared by partial binder substitution of metakaolin (fired kaolin) by water cooled slag in the ratio from 0 up to 10%.

Experimental Studies on Fly Ash Based Lime Bricks Arati Shetkar et.al This paper addresses the technology of making FaL-G mortar compressed bricks with low-calcium (Class F) dry fly ash as the base material. The FaL-G bricks were prepared without the use of conventional cement. Quarry dust and sand were used as fine aggregates as sustainable materials. The properties of FaL-G masonry hollow blocks were determined for different parameters.

Experimental Study On Class F Fly Ash Cement Bricks Using Partial Replacement Of Fly Ash By Metakaolin K. Muhammad Nisha et.al The experiment are conducted in two phases to observe the properties i.e. compressive strength and water absorption of fly ash cement brick. In both phase the cement (10%) and quarry dust (35%, 30%) are kept constant and class f fly ash (55% to 35%, 60% to 40%) is replaced with white metakaolin up to 20 percentage.
Experimental Study on the Behaviour of Geopolymer Bricks

The fly ash based cement bricks are tested after 7 days, 14 days and 28 days curing in advanced concrete research laboratory of the institute.

**Fly Ash Brick: Glass Fibre The Innovative Concept For Getting Higher Strength Brick Nutan C. Patel (Gujarat)** Experiments have been carried out by several materials like Fly ash, lime, sand, Kheda dust, Glass fibre for the manufacturing of the brick. The fly ash of ‘F’ category was used as a raw material for making fly ash bricks. The combination of fibre fly ashbrick have different percentage of the Glass fibre adding like 0.2%, 0.4%, 0.6%, 0.8%, 1.0%. In the testing of the fibre fly ash brick there are main two type of the testing is done compressive strength test and water absorption test after 7, 14, 21 days. With Changing (increasing) in the percentage of the Glass fibre of compressive strength of the fibre fly ash brick is increase and water absorption is decrease.

3. **EXPERIMENTAL ANALYSIS**

**MATERIALS USED**

**Flyash Class F**
Fly ash clay bricks are manufactured with clay and fly ash, at about 1,000 degrees C. Some have shown that these bricks tend to fail poor produce pop-outs, when bricks come into contact with moisture and water, causing the bricks to expand studies.

**Metakaolin** is a dehydroxylated form of the clay mineral kaolinite, metakaolin is a valuable admixture for concrete/cement applications. Replacing portland cement with 8–20% (by weight) metakaolin produces a concrete mix, which exhibits favorable engineering properties

**Composition of metakaolin**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Wt%</th>
<th>At%</th>
</tr>
</thead>
<tbody>
<tr>
<td>OK</td>
<td>41.15</td>
<td>54.60</td>
</tr>
<tr>
<td>MgK</td>
<td>1.06</td>
<td>0.93</td>
</tr>
<tr>
<td>AlK</td>
<td>25.57</td>
<td>20.12</td>
</tr>
<tr>
<td>SiK</td>
<td>32.22</td>
<td>24.35</td>
</tr>
<tr>
<td>Matrix</td>
<td>Correction</td>
<td>ZAF</td>
</tr>
</tbody>
</table>

**Granulated Blast Furnace Slag (GGBS)** is a useful by-product recovered from the blast-furnaces used in the production of iron. It can be used un-ground as a coarse aggregate or as a supplementary cementitious material. It is obtained by quenching molten iron slag from a blast furnace in water or stream, to produce a glassy, granular product that is then dried and ground into a fine powder

**Quarry dust**
It is residue taken from granite quarry. Also creates environmental problems of large-scale depletion of these sources. The properties of the quarry dust are in conformation with IS 2386:1963. Quarry dust was tested was various properties like specific gravity, sieve analysis and are conforming to IS standards

**Alkaline Liquid**
A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M.
**Water**
Ordinary clean portable water free from suspended particles was used both for mixing and curing the brick specimen. And also there is no IS provision for taking water amount.

**Process of Manufacturing**
Fly ash, lime, sand and gypsum are manually fed into a pan mixer where water is added in the required proportion for intimate mixing.

The proportion of the raw material is generally in the ratio 35-55% of fly ash 0-20% metakaolin, 10% Ground granulated blast furnace slag and 35% quarry dust, depending upon the quality of raw materials.

The materials are mixed in pan mixture. After mixing, the mixture is conveyed through belt conveyor to the hydraulic/mechanical presses. The homogenised mortar taken out of roller mixer is put into the mould boxes. Depending on the type of machine, the product is compacted under vibration/hydraulic compression etc.

The green bricks are dried up under sun from 24 to 48 hours, depending whether lime route or cement route; the dried up bricks are stacked and subjected for water spray curing once or twice a day, for 7-21 days, depending on ambience.

Fly Ash,+metakaolin,+GGBS+Quarrydust+chemicals

↓ ↓ ↓

Weighing

↓

Fly Ash Brick Making Machine (Hydraulic (or) Power Press)

↓

Pan Mixer

↓

Conveyor

↓

Kept as it is for two to four days for setting

↓

Dispatch

The work size of a standard brick is: **75 mm high x 230 mm long x 110 mm wide**. Some bricks are made with different work sizes.

**Compressive strength test**
The crushing strength of a brick is found out by placing it in a compression testing machine. It is pressed till it breaks. As per IS 3495(PART 1),
Experimental Study on the Behaviour of Geopolymer Bricks

Mix Proportion
Aggregate (combined) = 1848 kg/m³
Coarse aggregate = 1293.6 kg/m³
Fine aggregate = 554.5 kg/m³
Fly ash = 394.28 kg/m³
Sodium Hydroxide = 45.06 kg/m³
Sodium silicate = 112.64 kg/m³
Volume of brick = 0.230*1.10*.075 = 1.89X10⁻³ m³

4. EXPERIMENTAL TESTS

**Water Absorption**

It should not exceed 20 per cent of weight of dry brick.

\[
\text{Water absorption} = \frac{M_2 - M_1}{M_1} \times 100
\]

28th day testing result

Water absorption 28th day result
Days of testing | 7th day | 14th day | 28th day
--- | --- | --- | ---
Water absorption results at 15% metakaolin | 4.50% | 3.820% | 3.710%

Presence of Soluble Salt (Efflorescence Test)
Geopolymer bricks 5 number each were selected at random out of the samples of red and fly ash bricks. Then each bricks was placed on edge in dish containing distilled water, the depth of immersion of the brick was not less than 2.5 cm.

The whole arrangement was placed to in a ventilated room at 20 to 30 C until whole of water in the dish evaporated .when the water has been absorbed and bricks appeared to be dried, a similar quantity of distilled water was put in the dish and same was allowed to evaporate as before. At the end of this period, the brick was examined for efflorescence.

Efflorescence test

If the white deposits cover **about 10 per cent surface, the efflorescence is said to be slight** and it is considered as **moderate**, when the white deposits cover about 50 per cent of surface.

If grey or white deposits are found on more than 50 per cent of surface, the efflorescence becomes **heavy** and it is treated as serious, when such deposits are converted into powdery mass.

5. SHAPE AND SIZE OF THE BRICK

In this test, a brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges. For this purpose, 20 bricks of standard size (**230 mm x 110 mm x 75 mm**) are selected at random and they are stacked lengthwise, along the width and along the height.
Size and shape of brick

<table>
<thead>
<tr>
<th>TYPE OF BRICKS</th>
<th>Overall dimension</th>
<th>Size (mm)</th>
<th>Average dimension (mm)</th>
<th>Variation</th>
<th>Codal provision IS 1077:1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOPOLYMER BRICKS</td>
<td>length</td>
<td>230</td>
<td>232.85</td>
<td>+2.85</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>breadth</td>
<td>110</td>
<td>110.75</td>
<td>+0.75</td>
<td>+3</td>
</tr>
<tr>
<td></td>
<td>height</td>
<td>75</td>
<td>75.50</td>
<td>+0.50</td>
<td>+3</td>
</tr>
</tbody>
</table>

Structure of the Brick

A brick is broken and its structure is examined. It should be homogeneous, compact and free from any defects such as holes, lumps, etc. On a whole of 20 bricks have conducted test to determine the accuracy of structure and to determine the absence and presence of holes inside the bricks.

SEM-EDAX RESULT
COLOR TEST
Color throughout. A good brick should be of proper shape and standard specified size, the edges of it should be sharp, there should not be any cracks and fissures on the brick. The colour of a geopolymer brick is found to be grey in colour.

6. CONCLUSIONS

- Geopolymer bricks can be manufactured with low calcium fly ash with molarities of NaOH. It is found that the geopolymer bricks with 16M molality gives good strength compared to ordinary clay bricks and flyash bricks.
- Adequate curing temperature and adequate curing time (minimum 24 hrs) can give better results.
- From observation it is found that the usage of metakaolin at 15% gives higher compressive strength at 7th day of testing i.e 10.11N/mm².
- The 14th day and 28th day results of compressive strength shows that the maximum strength of compressive at 15% of metakaolin i.e 15.405 N/mm² and 23.66N/mm².
- The water absorption of geo polymer brick of various mixes have been observed and determined that the minimum water absorption was found at 15% usage of metakaolin at 28th day is 3.71%.
- The reason for the improvement in compressive Bricks are closely viewed to check if its edges are sharp and straight and uniform in shape. A good quality brick should have bright and uniform strength of geopolymer concrete is the chemical reaction due to the speedy polymerization process and aging of the alkaline liquid.
- Thus by using the proportion of 40% flyash, 35% of quarry dust, 10% of ground granulated blast furnace slag and 15% of metakaolin gives best results in both water absorption and compressive strength.
- The presence of soluble salt tests have been done to the bricks and it is found that the appearance of soluble salt is less than 10% of whole area and the condition is SLIGHT.
REFERENCES


