

# A Experimental Study on Cement-Free Block Using Perlite and Bentonite Clay

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**Abstract** - This study investigates the mechanical and physical properties of cement-free masonry blocks developed using a alkali-activated binder system composed of perlite and bentonite. As the construction industry seeks sustainable alternatives to Ordinary Portland Cement (OPC) a major contributor to global CO<sub>2</sub> emissions this research explores the Energy between the high silica content of expanded perlite and the binding capabilities of calcium bentonite clay.

The experimental program focused on varying the ratios of perlite to bentonite to optimize compressive strength, thermal conductivity, and water absorption. Sodium hydroxide (NaOH) and sodium silicate (Na<sub>2</sub>SiO<sub>3</sub>) were employed as alkaline activators to trigger the geopolymerization process. Test specimens were subjected to different curing process, it includes a ambient air curing, to evaluate the rate of strength gain.

**Key Words:** Cement free block, perlite, bentonite, GGBS.

## 1. INTRODUCTION

The rapid growth of the construction industry has led to an increased demand for conventional building

materials, particularly cement. However, the production of cement is associated with high energy consumption and significant carbon dioxide emissions, which contribute to environmental pollution and global warming. This has created a need to develop sustainable and eco-friendly alternative materials that can reduce the dependency on cement in construction.

In recent years, industrial by-products such as Ground Granulated Blast Furnace Slag (GGBS) have gained attention as potential substitutes for cement due to their pozzolanic properties. When combined with suitable activators, GGBS can contribute to strength development through the formation of binding compounds. While conventional geopolymer concrete uses alkaline activators such as sodium hydroxide and sodium silicate, these chemicals are often expensive, hazardous to handle, and not always suitable for small-scale or field applications.

This project focuses on the development of cement-free blocks using GGBS, lime, bentonite, and perlite without the use of alkaline activators. In this system, lime acts as a mild activator that reacts with GGBS to form calcium silicate hydrate (C-S-H) gel, which is responsible for strength development. Bentonite is incorporated to improve cohesion and water retention, while perlite is used to reduce the density and enhance thermal insulation properties of the blocks.

## 2. Body of Paper

This project focuses on the development of a cement-free construction block using materials such as Ground Granulated Blast Furnace Slag (GGBS), lime, perlite, and bentonite without the use of alkaline activators. The main objective is to produce an eco-friendly and sustainable building material by eliminating cement, which is a major source of carbon dioxide emissions. In this system, GGBS acts as the primary binding material due to its rich content of calcium, silica, and alumina. Lime provides the necessary alkaline environment to activate GGBS and initiate the reaction process. Perlite is incorporated to reduce the density of the block and improve thermal insulation properties, while bentonite enhances the cohesion, water retention, and overall workability of the mix.

The strength development in this project is mainly based on the pozzolanic reaction between lime and the silica present in GGBS. When water is added, lime dissociates to release calcium ions, which react with silica and alumina to form cementitious compounds such as Calcium Silicate Hydrate (C-S-H) gel. This gel is responsible for binding the particles together and providing strength and durability to the block. Unlike geopolymer concrete, this method does not require hazardous chemical activators like sodium hydroxide or sodium silicate, making it safer, economical, and suitable for practical applications. Over time, continuous reactions lead to a denser microstructure, reduced porosity, and improved mechanical properties, resulting in a durable and environmentally friendly construction material.

The chemical reaction occurs as follows:

### Pozzolanic reaction

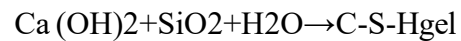


**Table 1 cement-free cube**

| SAMPLES    | Time interval<br>Days | Average<br>KN | Strength<br>of cube<br>N/mm <sup>2</sup> |
|------------|-----------------------|---------------|------------------------------------------|
| <b>C 1</b> | 7                     | 165.33        | 7.35                                     |
|            | 14                    | 229.33        | 10.19                                    |
|            | 28                    | 343.33        | <b>15.26</b>                             |
| <b>C2</b>  | 7                     | 570.67        | 25.36                                    |
|            | 14                    | 823.33        | 36.59                                    |
|            | 28                    | 957.33        | <b>42.5</b>                              |
| <b>C 3</b> | 7                     | 446           | 19.8                                     |
|            | 14                    | 568.33        | 25.26                                    |
|            | 28                    | 6255          | <b>27.7</b>                              |

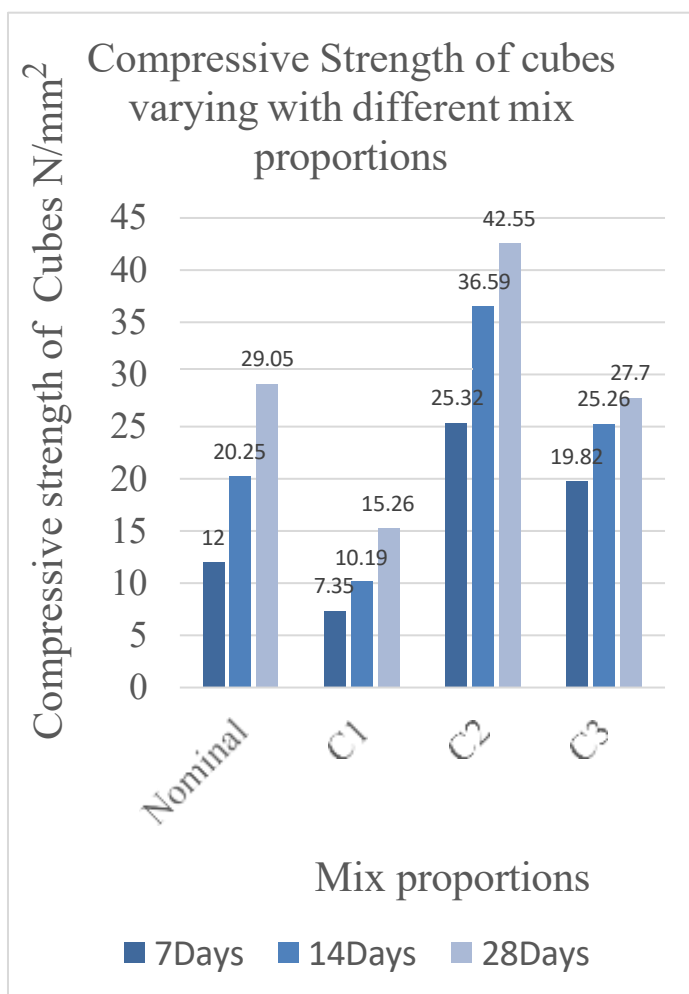


**FIG 1 Comparison with conventional & cement - free blocks on compression test**

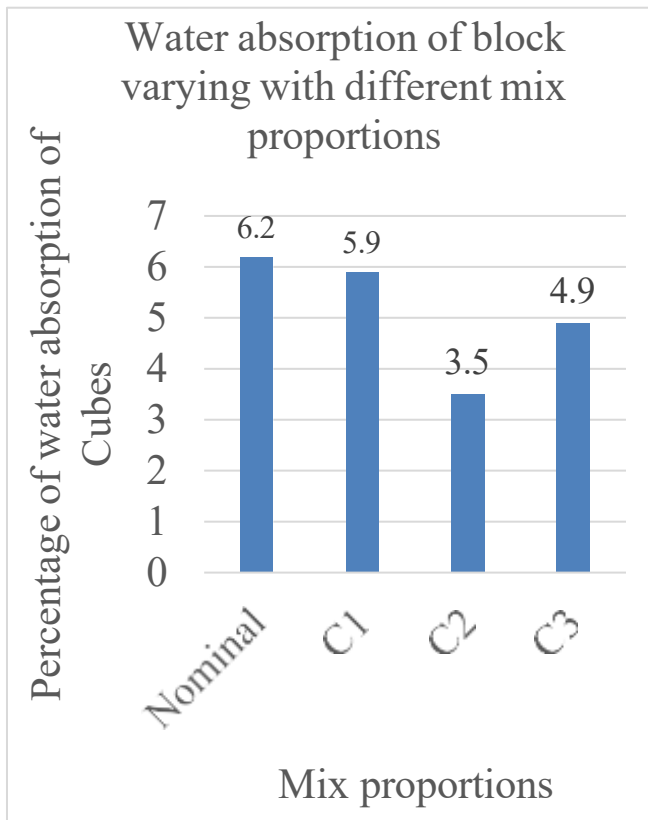
### WATER ABSORPTION TEST OF CUBE SPECIMENS

The water absorption test of concrete cubes is carried out to determine the amount of water absorbed by the specimen, which indirectly indicates the porosity and durability of the material. In this test, concrete cubes (usually of size 150 mm × 150 mm × 150 mm) are first cured properly, typically for 28 days. After curing, the cubes are taken out and dried in a hot air oven at a temperature of about 100–110°C until a constant weight is achieved. This dry weight is recorded as W1

Next, the cubes are immersed in clean water for a period of 24 hours at room temperature. After immersion, the cubes are removed, surface water is wiped off with a damp cloth, and the saturated weight is recorded as W2.

**Table 2 Water absorption of cubes**

| S.no | Samples | Wet weight of cube (W1) g | Dry weight of cube (W2) g | %water absorption of cube | Average |
|------|---------|---------------------------|---------------------------|---------------------------|---------|
| 1.   | Nominal | 9.059                     | 9.004                     | 6.1%                      | 6.2%    |
|      |         | 9.089                     | 9.036                     | 5.9%                      |         |
|      |         | 8.824                     | 8.766                     | 6.6%                      |         |
| 2.   | C1      | 8.213                     | 8.163                     | 6.1%                      | 5.9%    |
|      |         | 8.744                     | 8.686                     | 6.7%                      |         |
|      |         | 8.182                     | 8.142                     | 4.9%                      |         |
| 3.   | C2      | 8.201                     | 8.175                     | 3.2%                      | 3.5%    |
|      |         | 8.783                     | 8.759                     | 2.7%                      |         |
|      |         | 8.803                     | 8.761                     | 4.8%                      |         |
| 4.   | C3      | 8.665                     | 8.163                     | 6.7%                      | 4.9%    |
|      |         | 8.285                     | 8.686                     | 4.5%                      |         |
|      |         | 8.587                     | 8.142                     | 4.8%                      |         |



### Comparison with conventional & cement - free blocks after 28 days on water absorption test

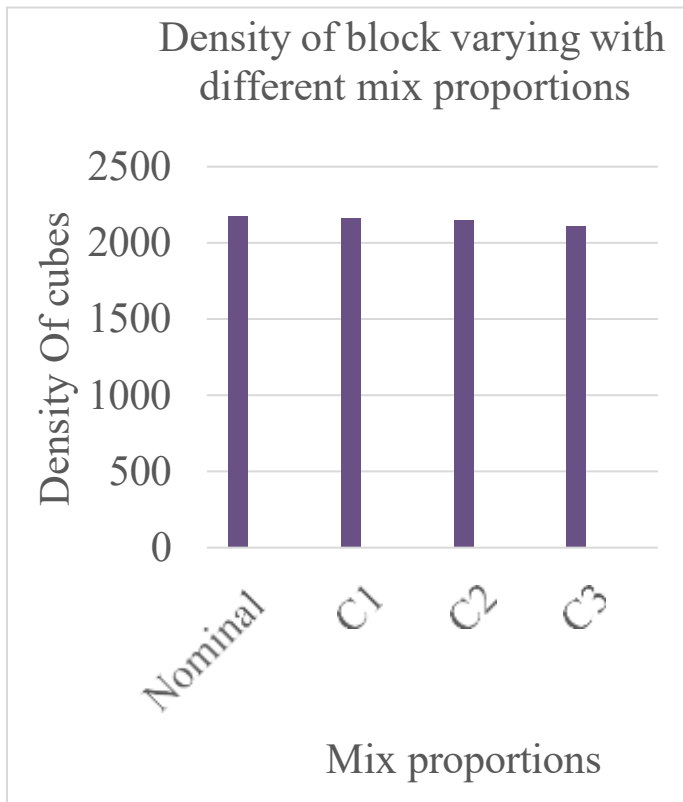
### DENSITY TEST OF CUBE SPECIMENS

The density test of cubes is carried out to determine the mass per unit volume of a hardened concrete or geopolymer cube. It is an important parameter because density reflects the degree of compaction, uniformity, and overall quality of the material. In this test, the cube specimen (usually of standard size such as 150 mm × 150 mm × 150 mm) is first cured properly and then taken out for testing. The surface of the cube is cleaned to remove any loose particles and moisture. The weight of the cube is measured using a digital weighing balance, giving the mass (W) in kilograms. The dimensions of the cube are measured accurately using a scale or caliper to determine its volume (V). The result is expressed in kg/m<sup>3</sup>. For normal concrete, the density typically

ranges between 2200 to 2500 kg/m<sup>3</sup>, while geopolymer or lightweight blocks (such as those containing perlite) may show lower density values depending on the materials used. This test helps in assessing the compactness and quality of the cube. A higher density generally indicates better compaction and fewer voids, whereas a lower density may indicate the presence of pores or lightweight aggregates.

Table3 Density test of cubes

| S.NO | SAMPLES | Density of cubes<br>Kg/m <sup>3</sup> | Average density of cubes<br>Kg/m <sup>3</sup> |
|------|---------|---------------------------------------|-----------------------------------------------|
| 1.   | Nominal | 2247.47                               | 2175.92                                       |
|      |         | 2146.46                               |                                               |
|      |         | 2133.84                               |                                               |
| 2.   | C1      | 2184.34                               | 2163.29                                       |
|      |         | 2121.21                               |                                               |
|      |         | 2184.34                               |                                               |
| 3.   | C2      | 2196.97                               | 2146.46                                       |
|      |         | 2146.46                               |                                               |
|      |         | 2095.96                               |                                               |
| 4.   | C3      | 2159.09                               | 2112.79                                       |
|      |         | 2108.59                               |                                               |
|      |         | 2070.71                               |                                               |



#### Comparison with conventional & cement – free cube after 28 days on Density test

### 3. CONCLUSIONS

The experimental investigation on GGBS–lime–bentonite–perlite based cement-free blocks demonstrates that the material system is capable of producing structurally efficient and durable masonry units under ambient curing conditions. The compressive strength results reveal that strength increases with curing age for all mixes. The optimum performance was achieved by Sample 3, attaining a maximum strength of about 24 N/mm<sup>2</sup> at 28 days, which is significantly higher than the nominal mix. This indicates efficient geopolymer/pozzolanic reaction and strong binder formation. In contrast, Sample 1 showed lower strength, while Sample 2 showed higher strength.

The water absorption test indicates that all mixes satisfy durability requirements, with values generally below 7%. Notably, Sample 3 (GGBS 70%, Lime 20%, Bentonite 4%, Perlite 3%) showed the lowest average water absorption (~4.9%), reflecting a denser microstructure, reduced porosity, and improved particle packing.

From the density test, all the samples exhibited densities within the permissible range of 1800–2400 kg/m<sup>3</sup> (IS 2185:2008), confirming that the developed blocks qualify as normal-weight structural blocks. Among the mixes, the nominal mix showed slightly higher density, while increasing perlite content reduced density due to its lightweight and porous nature.

Overall, Sample 3 is identified as the optimum mix, providing the best balance between strength, durability, and density. The study confirms that GGBS-based cement-free blocks can successfully replace conventional concrete blocks, offering a sustainable, eco-friendly, and high-performance alternative for construction applications.

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