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Experimental Investigation on Geopolymer Bricks by Partial Replacement of Fly Ash with Dolomite Powder

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ABSTRACT: This experimental study investigates the feasibility of enhancing the mechanical properties of geopolymer bricks by incorporating dolomite powder as replacement material with fly ash. The replacement percentage of dolomite powder with the weight of 5%, 10%, 15% and 20% of Fly ash. The study systematically examines the effects of varying dolomite powder content on the compressive strength, water absorption and efflorescence of geopolymer bricks through a series of laboratory experiments. Results reveal that the addition of dolomite powder improves compressive strength at certain percentage and the absorption rate also drops and the efflorescence gradually increases by the higher addition in dolomite powder. The Optimal proportions of 10% dolomite powder is identified for enhanced mechanical properties, balancing cost- effectiveness and performance

KEYWORDS: Geopolymer Brick, Fly ash, Dolomite Powder, Alternative Material.

I. INTRODUCTION

Geopolymer bricks are a type of construction material made from geo polymerization, a chemical process that binds together materials like fly ash, slag, or clay. These bricks offer several advantages over traditional clay bricks, including reduced carbon emissions, higher strength, and resistance to chemicals and fire. They are an eco-friendly alternative in construction, contributing to sustainable building practices. Geopolymer bricks are formed through the reaction of calcium materials with an alkaline activator, typically sodium hydroxide and sodium silicate. This process creates a strong, durable bond between the particles, resulting in bricks with excellent strength and low absorption rates.

II. SCOPE

- The aim of study in project preparation is to promote sustainable construction practices by utilizing industrial by-products such as fly ash and inorganic materials like dolomite.
- Geopolymer bricks offer benefits like lower carbon footprint, reduced waste, and energy savings compared to traditional bricks.
- To reduce the environmental pollution because generally it requires lower energy inputs compared to conventional fired clay bricks, reducing carbon emissions.

III. PROPERTIES OF MATERIALS

MATERIALS USED

The materials that are used for making geopolymer bricks,

- Fly ash
- Quarry Dust
- Cement
- Dolomite powder
- Lime



FLY ASH

Fly Ash is a fine powder material which is produced from the electric power generating plants. It is byproduct from burning coal, which is classified into two types, class F and class C. It is mainly used as the replacement material, which also good in strength, workability and durability.

Table 1- Properties of Fly ash

| S. No | Types of test | Result |
|-------|-----------------------------|--------|
| 1. | Fineness test of Fly ash | 20% |
| 2. | Specific gravity of Fly ash | 2.42 |
| 3. | Water absorption | 10.9% |

QUARRY DUST

Quarry dust is a Residue of the extraction process which is a used as fine aggregate for brick making purpose. Quarry dust is used for different activities in the construction application such as earth fill material, alternate material for sand materials, aggregates and bricks.

Table 2- Properties of Quarry Dust

| S. No | Types of test | Result |
|-------|--------------------------------|--------|
| 1. | Fineness | 20% |
| 2. | Specific gravity of Quarrydust | 2.1 |
| 3. | Water Absorption | 4.2% |

CEMENT

Cement is a binding material which is used in construction application. In this project we have used Ordinary Portland cement grade of 53. The cement is varied by their types and purpose of operation, and also change in strength, setting time and workability.

Table 3- Properties of Cement

| S. No | Types of test | Result |
|-------|----------------------------|----------|
| 1. | Fineness test on cement | 10 % |
| 2. | Specific gravity of cement | 3.14 |
| 3. | Initial setting time | 28 Min |
| 4. | Final setting time | 10 Hours |

DOLOMITE POWDER

Dolomite powder is obtained by powdering the dolostone can be used as replacement for Fly ash in bricks up to certain percentage. Dolostone can be converted into powder through a process called pulverization or grinding. Dolomite powder can be added to brick manufacturing processes to enhance the quality of bricks. It contributes to the compressive strength and resistance to weathering.



Table 4 - Properties of Dolomite powder

| S.No | Types of test | Result |
|------|------------------------------|--------|
| 1. | Specific gravity of Dolomite | 3 |
| 2. | Fineness | 10% |
| 3. | Water Absorption | 2 % |

LIME

Lime powder is obtained from limestone by grinding process. Lime is also a binder material which used from ancient times. Lime has the higher heat of hydration compared to other materials. It is also used in other industries like water treatment and agriculture.

Table 5 - Properties of Lime

| S.No | Types of test | Result |
|------|------------------------------|--------|
| 1. | Specific gravity of Dolomite | 2.45 |
| 2. | Fineness | 13.2% |
| 3. | Water Absorption | 11.7% |

IV. EXPERIMENTAL INVESTIGATION

Investigating the effects of adding dolomite powder to geopolymer bricks sounds like an intriguing experiment. Dolomite is often used as a filler or additive in various materials due to its properties like hardness and resistance to heat. Adding it to geopolymer bricks could potentially alter their properties like strength durability, or thermal conductivity. The experiment would likely involve testing different proportions of dolomite powder mixed into the geopolymer mixture by partial replacement with fly ash and evaluating the resulting bricks through various tests like compression strength, Absorption of water , and Efflorescence.

Table 7 – Mix proportion

| Mix | Fly Ash % | Quarry Dust% | Cement % | Lime% | Dolomite Powder % |
|-----|-----------|--------------|----------|-------|-------------------|
| 1 | 35 | 55 | 5 | 5 | - |
| 2 | 33.3 | 55 | 5 | 5 | 1.7 |
| 3 | 31.6 | 55 | 5 | 5 | 3.4 |
| 4 | 29.8 | 55 | 5 | 5 | 5.2 |
| 5 | 29.1 | 55 | 5 | 5 | 6.9 |



Table 8 – Quantity of Materials

| Materials | Weight for one Brick | Weight for 15 Bricks (10% wastage) |
|-------------|----------------------|------------------------------------|
| Fly ash | 0.885kg | 14.102kg |
| Quarry dust | 1.363kg | 22.48kg |
| Cement | 0.127kg | 2.09kg |
| Lime | 0.216kg | 3.56kg |
| Dolomite | 7.05kg | |

CASTING AND CURING

The raw materials for brick in the planned proportion are mixed in wet form. In this mix proportion Dolomite powder is replaced partially with Fly ash added at the percentage of 5%, 10%, 15% and 20% by weight of Fly ash. The size of brick is 230mm x 110mm x 70mm is non modular size which is described in the IS 12894 (2002). The materials required for the bricks are stored in the hopper and the materials with the planned mix were fed into the mixer machine. The mixed materials were feeded into the conveyor of the mould machine. The wet blended materials are transfered into the mould machine. The machine is shaken for the proper mixing of materials then the mould is again filled. Then the mould is pressed by the machine. The mould is removed from the bricks and the bricks are kept in the air platform for 2 days, after 2 days curing was done for 15 days continuously for two times a day. The bricks were shifted for drying process for a week. The bricks are dispatched after 22 days.

COMPRESSIVE STRENGTH

The compressive strength is tested for the geopolymer bricks by the procedure described in IS 3495(Part1). The compressive strength is tested at 7,14 and 28 days from the casing date of specimens. A total of 15 bricks were tested for evaluation of compressive strength.

$$\text{Compressive Strength} = \text{Load/Area}$$

Table 9 – Compressive Strength

| Mix | 7 Days | 14 Days | 28 Days |
|-----|--------|---------|---------|
| 1 | 5.200 | 7.870 | 9.56 |
| 2 | 5.556 | 7.911 | 10.01 |
| 3 | 5.780 | 8.206 | 13.32 |
| 4 | 5.400 | 7.620 | 12.79 |
| 5 | 5.300 | 7.500 | 12.58 |

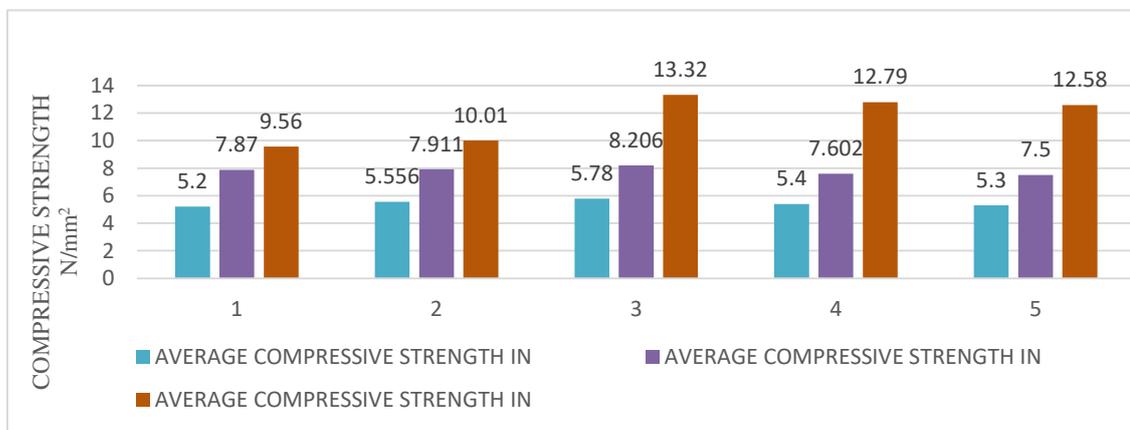


Chart 1: Compressive strength of Bricks



WATER ABSORPTION TEST

The water absorption of bricks isn't solely determined by their porosity due to the diverse nature of pores. The bricks are tested by the procedure in IS 3495 (Part 2), The bricks are immersed in cold water for 24 hours, the absorption rate does not exceed 20%.

$$\% \text{ of Water Absorption} = ((W2-W1)/W1) \times 100$$

Table 10 – Water Absorption

| S. No | % of Replacement | Water absorption % |
|-------|------------------|--------------------|
| 1. | - | 6.41 |
| 2. | 15 | 6.64 |
| 3. | 30 | 5.98 |
| 4. | 45 | 4.68 |
| 5. | 20 | 4.55 |

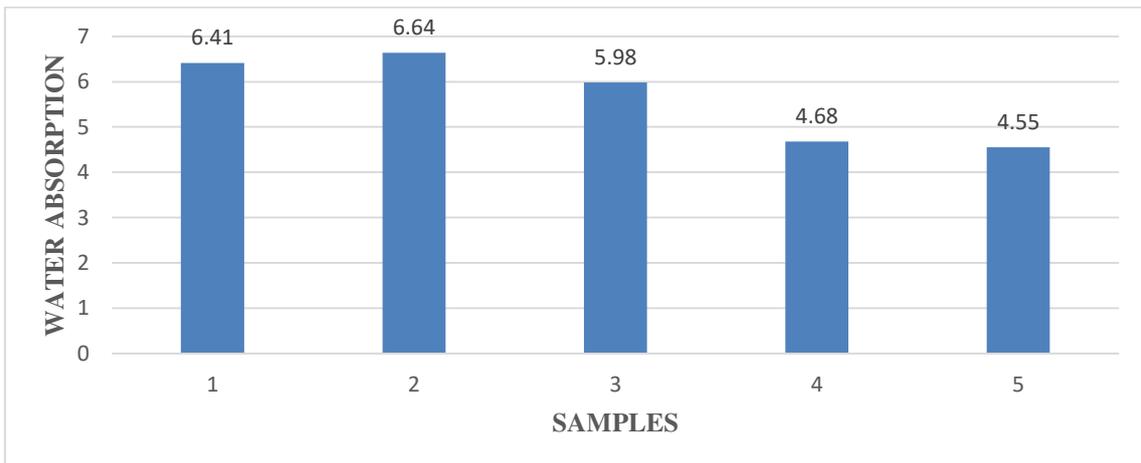


Chart 2: Water Absorption of Bricks

EFFLORESCENCE TEST

The bricks are tested to check the efflorescence defectives. The test is carried out by the procedure in IS 3495 (Part 3), The efflorescence shall not be higher than moderate.

Table 11: Efflorescence Defectives

| Sample | Efflorescence Defectives |
|--------|--------------------------|
| 1 | Slight |
| 2 | Slight |
| 3 | Moderate |
| 4 | Moderate |
| 5 | Moderate |

IV. CONCLUSION

- In this experimental study, the addition of 10% dolomite powder in geopolymer bricks resulted in the highest strength of 13.38 N/mm² after 28 days.
- The increase in the amount of dolomite powder in geopolymer bricks decreases the compressive strength.
- An increase in the compressive strength of bricks lowers the rate of water absorption.

- In the efflorescence test we have noticed that the increase in dolomite powder results the precipitation of salt layer on the brick surface because of the high calcium content.

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