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A Sustainable Alternative in Brick Manufacturing

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ABSTRACT

A new approach to brick manufacturing was explored by incorporating industrial byproducts such as class F fly ash, quarry dust, and sludge lime as primary materials. In India, thermal power plants and quarry industries produce large amounts of fly ash and quarry dust. These industrial byproducts are hazardous and pose significant disposal challenges. Recycling these wastes into construction materials offers a sustainable solution to pollution concerns. This approach also emphasizes energy conservation and cost efficiency. The paper outlines an effort to develop and implement this alternative method for brick production.

Keywords: class F fly ash, quarry dust, sludge lime

1. Introduction

Housing is a fundamental need, yet for a large portion of India's population, owning a home remains a significant challenge due to the high costs associated with construction. Around 60-70% of households fall within the low-income group, making housing affordability a critical issue. This has led to the need for cost-effective housing solutions that can accommodate India's growing population. One approach to address this problem is by exploring alternative building materials, particularly those derived from industrial by-products, which are more readily available. In some areas, locally produced clay bricks suffer from quality issues, such as low compressive strength, high water absorption, and uneven surfaces. These challenges have driven the search for more efficient and affordable materials that can improve construction quality while reducing costs.

1.1 Need for the study

1. To enhance engineering properties like workability, plasticity, and water resistance.
2. To increase compressive strength for better stability and durability of the bricks.
3. To ensure consistent size and shape of fly ash bricks, thereby minimizing the need for plastering thickness.

2. Materials and its properties

2.1 Flyash (Class F)

Class 'F' fly ash is a fine, powdery by-product produced from the combustion of coal in thermal power plants. Also referred to as flue ash, it is a well-graded mixture primarily composed of silica, alumina, and unburned carbon. This type of fly ash is pozzolanic, containing less than 10% lime. Chemical composition of class F flyash is shown in table 1.

Table 1 – Chemical Composition of Class F Flyash.

Sl. No	Chemical Compound	Percentage
1	SiO_2	57
2	Al_2O_3	29
3	Fe_2O_3	6.34
4	CaO & K_2O	3.7
5	MgO	0.7

2.2 Quarry Dust

The ornamental stone processing industry generates large amounts of fine powder waste during the sawing and polishing processes. Approximately 30% of the quarry material is lost as dust during cutting. Chemical Composition of quarry dust is given in table 2

Table 2 – Chemical Composition of Quarry Dust

Sl. No	Chemical Compound	Percentage
1	SiO_2	74
2	Al_2O_3	12
3	Fe_2O_3	2.5
4	CaO & K_2O	4
5	MgO	1

2.3 Sludge Lime

Naturally occurring limestone, when calcined, produces both lime and lime sludge. The lime sludge is a by-product formed during the hydration process of lime. Table 3 indicates the chemical composition of sludge lime.

Table 3 – Chemical Composition of Sludge Lime

Sl. No	Chemical Compound	Percentage
1	SiO_2	28.22
2	Al_2O_3	0.14
3	Fe_2O_3	3.8
4	CaO & K_2O	37.7
5	MgO	1.8

2.4 Sand

Sand is a naturally occurring granular substance made up of tiny rock and mineral particles. Its primary component is silica, although the exact composition can vary based on the local rock sources and environmental conditions.

3. Design Mix

The mix design is carried out by varying the percentages of fly ash and the water-to-cement ratio. The specific details are presented in Tables 4 and 5.

Table 4 – Deign Mix

Brick Samples	Flyash (%)	Quarry Dust (%)	Sludge Lime (%)	Cement (%)	Sand (%)
S0	70	0	10	10	10
S1	60	10	10	10	10
S2	50	20	10	10	10
S3	40	30	10	10	10
S4	30	20	10	10	10

Table 5 – Water to Cement ratio

Brick Samples	W/C (%)
S0	0.65
S1	0.52
S2	0.41
S3	0.32
S4	0.25

4. Methodology

The primary ingredients used include three industrial by-products: fly ash, quarry dust, and sludge lime, combined with sand. Ordinary Portland Cement served as the binding agent. In the control brick mix, fly ash was partially replaced with quarry dust at varying levels of 10%, 20%, 30%, and 40%. Six different proportions were prepared, with materials measured accordingly. The materials were thoroughly mixed in a dry state, and water was added as needed.

The mould used had dimensions of 240 mm × 110 mm × 90 mm and was a column box type with welded joints on both sides. The bricks were hand-moulded by layering the mix into the mould, compacting it in three to four layers until the mould was full. The surface of the bricks was neatly finished. After casting, the bricks were left to dry for 24 hours and then cured through immersion in water.

5. Result and Discussion

5.1 Compressive Strength

The compressive strength of the bricks was evaluated after 7, 14, 21, and 28 days of curing. During testing, two iron plates, each 6 mm thick, were placed—one beneath and one above the brick—to ensure even load distribution throughout the testing process.

Table 6 – Compressive strength of bricks

Brick Samples	7 Days N/mm^2	14 Days N/mm^2	21 Days N/mm^2	28 Days N/mm^2
S0	2.69	3.26	4.10	4.72
S1	3.69	4.05	4.98	5.94
S2	5.80	7.35	8.18	10.33
S3	5.07	6.80	7.73	8.96
S4	3.69	4.75	5.40	6.77

5.2 Water Absorption

The bricks intended for testing must first be oven-dried at a temperature between 105°C and 115°C until a constant weight is achieved. Once dried, the bricks are cooled to room temperature and weighed .The dried bricks are then fully submerged in clean water for 24 hours at a temperature of 27 ± 2°C. After 24 hours, the bricks are removed, wiped to eliminate any surface water, and immediately weighed, following the guidelines specified in IS 12894:2002.

Table 7 – Water absorption values

Brick Samples	Water absorption value (%)
S0	5.00
S1	1.70
S2	2.80
S3	3.60
S4	3.50

6. Conclusion

- The highest compressive strength was achieved when the proportions of fly ash and quarry dust were 50% and 20%, respectively, for both methods of immersion curing.
- These bricks exhibited a significantly lower water absorption capacity compared to traditional clay bricks.
- Fly ash-quarry dust bricks are cost-effective, energy-efficient, and promote the development of "eco-friendly green bricks" for sustainable construction.
- This study contributes to minimizing the harmful impacts and disposal challenges associated with industrial waste materials.

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