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# Fabrication and Mechanical Testing of Eco-friendly bricks using Fly Ash and Marble Dust as a Partial Cement Replacements

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***Abstract: This study focuses on the fabrication and testing of eco-friendly bricks using fly ash and marble dust as partial replacements for cement. These industrial waste materials were used in varying proportions (10%, 20%, and 30%) to evaluate their effects on the strength and durability of the bricks. A control mix with 100% cement was also prepared for comparison. All brick samples were cast, cured, and tested for compressive strength, water absorption, and density. The results showed that up to 20% replacement achieved comparable or better strength than conventional bricks while improving sustainability and reducing cost. This study highlights the potential of using fly ash and marble dust in construction as a step toward greener and more efficient building practices.***
***Keywords: Eco Friendly bricks, Mechanical, Fly ash, Marble dust, Cement replacement, Compressive strength, Sustainable construction, Density, Compressive strength, Water absorption, Green building materials, Industrial waste utilization.***

## I. INTRODUCTION

The construction industry significantly contributes to environmental pollution, primarily because of the high usage of cement in bricks and concrete. A large quantity of Co2 is emitted by cement production which arises concerns about sustainability and climate impact. This has led to increased interest in using industrial waste materials as partial replacements in construction to reduce environmental harm and material cost. Fly ash, a fine powder generated by coal combustion in thermal power plants, exhibits pozzolanic properties that can enhance the strength and durability of cement-based products. Marble dust,which is obtained as a byproduct of marble cutting and polishing is rich in calcium carbonate, it helps to improve density and workability in mixes.

This study aimed to fabricate eco-friendly bricks by partially replacing cement with fly ash and marble dust in varying proportions (10%, 20%, and 30%). A conventional brick using 100% cement was used as the control. The fabricated bricks were tested for compressive strength, water absorption, and density to assess their mechanical performance and suitability for construction. The objective is of this study was to determine whether these alternative materials can produce sustainable, cost-effective bricks that meet performance standards.

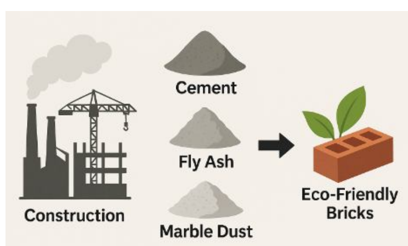


Figure 1.1

## II. LITERATURE REVIEW

To achieve a cost effective and Sustainable development. Incorporation of industrial waste materials as construction product has become an effective and popular strategy. Among these materials, fly ash and marble dust have gained significant attention owing to their availability and cementitious or filler properties, making them suitable alternatives for partial cement replacement in bricks.

Fly ash, a fine powder generated as a byproduct of coal combustion in thermal power plants, possesses pozzolanic characteristics that can improve the strength and durability of cementitious composites. Sharma et al. (2022) reported in the *Materials* journal that replacing up to 30% of cement with fly ash yielded bricks with comparable compressive strength and improved workability.

Marble dust, another abundant industrial byproduct of the marble processing industry, is rich in calcium carbonate. According to Khan et al. (2021) in *ACS Omega*, partial replacement of clay with 10–20% marble dust improved brick strength, although higher contents resulted in increased porosity and reduced performance.

Kumar et al. (2023) further demonstrated that geopolymer bricks combining fly ash, rice husk ash, and marble dust exhibited enhanced strength and curing characteristics when marble dust was used at up to 30%. Prasad et al. (2019), in the *South Asian Journal of Engineering and Technology*, demonstrated that even small additions of marble dust (4%) in fly ash-based bricks improved strength and water absorption behavior. Joshi et al. (2020) emphasized the importance of consistent mixing and quality control in achieving reliable compressive strength in fly ash bricks, as published in the *Journal of Materials in Civil Engineering*.

While prior research supports the use of fly ash and marble dust individually, limited studies have investigated their combined effects on cement-based bricks. Most existing studies focus on clay or geopolymer systems rather than conventional cement bricks. This study aims to fill this gap by analyzing the combined use of fly ash and marble dust as partial cement replacements (10%, 20%, and 30%) and evaluating the resulting bricks for compressive strength, water absorption, and density. The goal is to determine whether these materials can produce bricks that meet construction standards while also promoting sustainability and cost efficiency.

## III. MATERIALS AND METHODOLOGY

### *A. Materials used :*

To select the materials for this study criteria's guided by mechanical considerations came into play like strength, density and material behavior under load. All materials were chosen to evaluate their mechanical suitability in sustainable brick fabrication:

- Cement: Ordinary Portland Cement (OPC) of grade 43 was used as the binding material. It conforms to IS: 8112–1989 standards and provides the basic strength to bricks.
- Fly Ash: Class F fly ash, obtained from a local thermal power plant, was used for its pozzolanic behavior and particle fineness, which contributing to improved mechanical-performance.
- Marble Dust: Finely powdered marble waste was collected from local marble-cutting units. The high calcium carbonate from marble dust enhances brick density and reduces voids
- Fine Aggregate (sand): River sand, passed through a 4.75 mm sieve, was used to ensure good compaction and packing.
- Water: Clean potable water was used in all mixes to maintain consistency and to aid cement hydration.

### *B. Mix Design :*

Four mixes were prepared: one control mix (M0) and three experimental mixes (M10, M20, and M30) with increasing replacement levels of cement with equal parts of fly ash and MD. Each mix was designed to study the mechanical response of bricks to varying binder compositions.

| Mix ID | Cement (%) | Fly Ash (%) | Marble Dust (%) | Sand (%) | Water-Cement Ratio |
|---|---|---|---|---|---|
| M0 (Control) | 100 | 0 | 0 | 100 | 0.45 |
| M10 | 80 | 10 | 10 | 100 | 0.45 |
| M20 | 60 | 20 | 20 | 100 | 0.45 |
| M30 | 40 | 30 | 30 | 100 | 0.45 |

Table 1

### *C. Fabrication Procedure*

In a mechanical pan mixer the dry materials are weighed and mixed to ensure uniformity. Water was added gradually to achieve the desired workability. The fresh mix was then placed into standard cast iron molds of size 190 mm × 90 mm × 90 mm and compacted. The bricks were allowed to set in the shade for 24h before being demoded. Subsequently, they were cured in clean water for 7 days to allow proper hydration and strength development.

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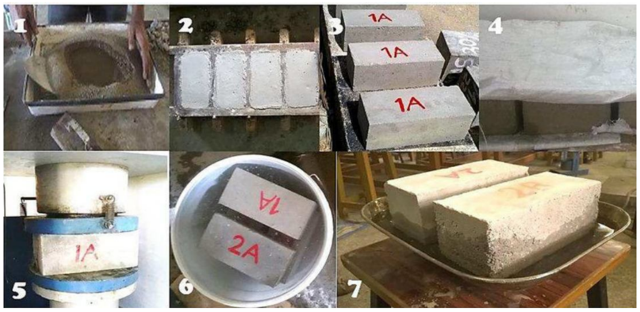


Figure 3.3

### D. *Testing of Bricks*

After the curing period, the bricks were tested to evaluate their mechanical performance:

- Compressive Strength: Tested using a Compression Testing Machine (CTM) as per IS 3495 (Part 1): 1992. The load at failure was recorded and compressive stress was calculated.
- Water Absorption: Determined by immersing oven-dried bricks in water for 24 hours and measuring the weight gain, as per IS 3495 (Part 2): 1992
- Density: Calculated by dividing The dry mass of each brick was divided by its volume to assess its compactness and structural integrity.

## IV. RESULT AND DISCUSSIONS

### A. *Compressive Strength*

The compressive strength is inversely proportional to the cement replacement percentage .The strength decreases gradually as there is an increase in the cement replacement percentage.. The control mix (M0) achieved the highest strength, as expected, owing to the presence of 100% cement. However, the bricks with 10% and 20% replacement (M10 and M20) exhibited strength values within acceptable limits for non-load-bearing applications. At 30% replacement (M30), a noticeable drop in strength was observed, but the bricks still maintained structural integrity.

This indicates that up to 20% replacement of cement with fly ash and marble dust can be considered effective without significantly compromising the mechanical performance

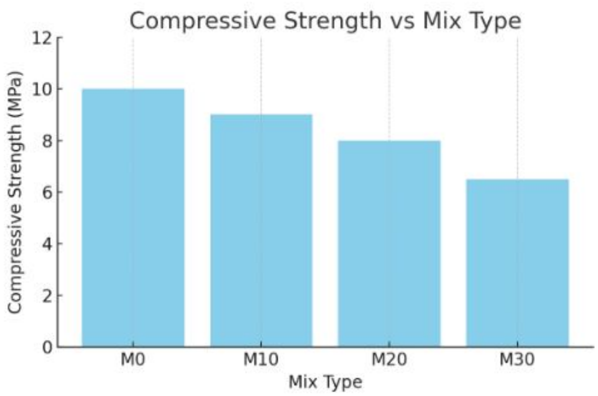


Figure 4.1

### B. *Water absorption*

Water absorption increase slightly with higher replacement levels. This is attributed to the increased porosity caused by the partial replacement of cement. The control brick (M0) exhibited the lowest water absorption, whereas M30 exhibited the highest. Despite this trend, all bricks remained within acceptable limits according to the IS standards. The results suggest that the mixes maintained reasonable resistance to moisture penetration, especially at 10% and 20% replacement levels.

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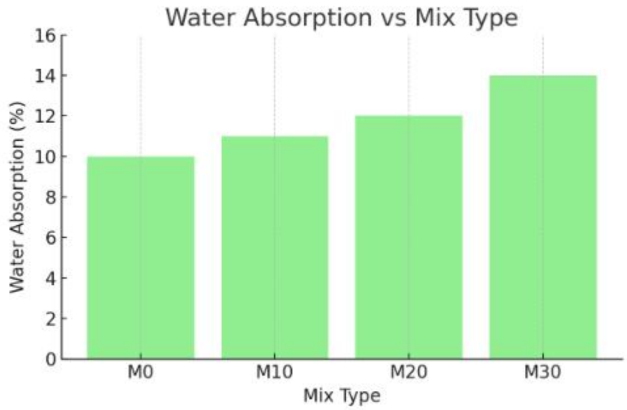



Figure 4.2

### C. *Density*

The density results showed a gradual decrease as the percentages of fly ash and marble dust increased. This can be attributed to the lower specific gravity of the replacement materials compared to cement. Although the control mix had the highest density, M10 and M20 exhibited values consistent with standard construction materials. Low density bricks can be a beneficiary option for thermal insulation , reduced dead load in structures adding advantage for certain applications.

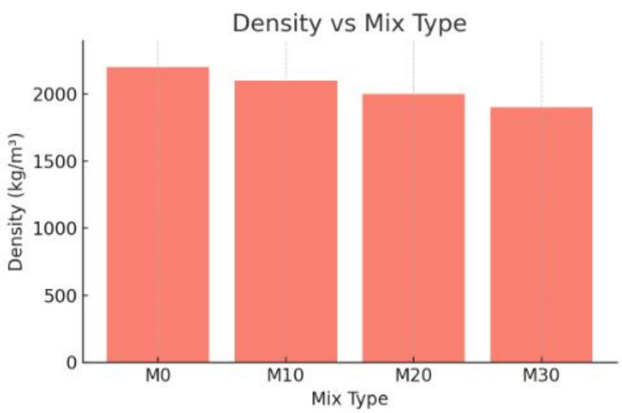



Figure 4.3

### D. *Summary of Findings*

From a mechanical perspective, bricks with up to 20% cement replacement with fly ash and marble dust demonstrated a balanced combination of strength, durability, and sustainability. Although the compressive strength decreased slightly compared to that of control, the performance remained within permissible limits. The water absorption and density trends also aligned with expectations, showing that the proposed eco-bricks are suitable for general construction purposes where light weight and moderate load-bearing capacity are acceptable.

## V. CONCLUSION

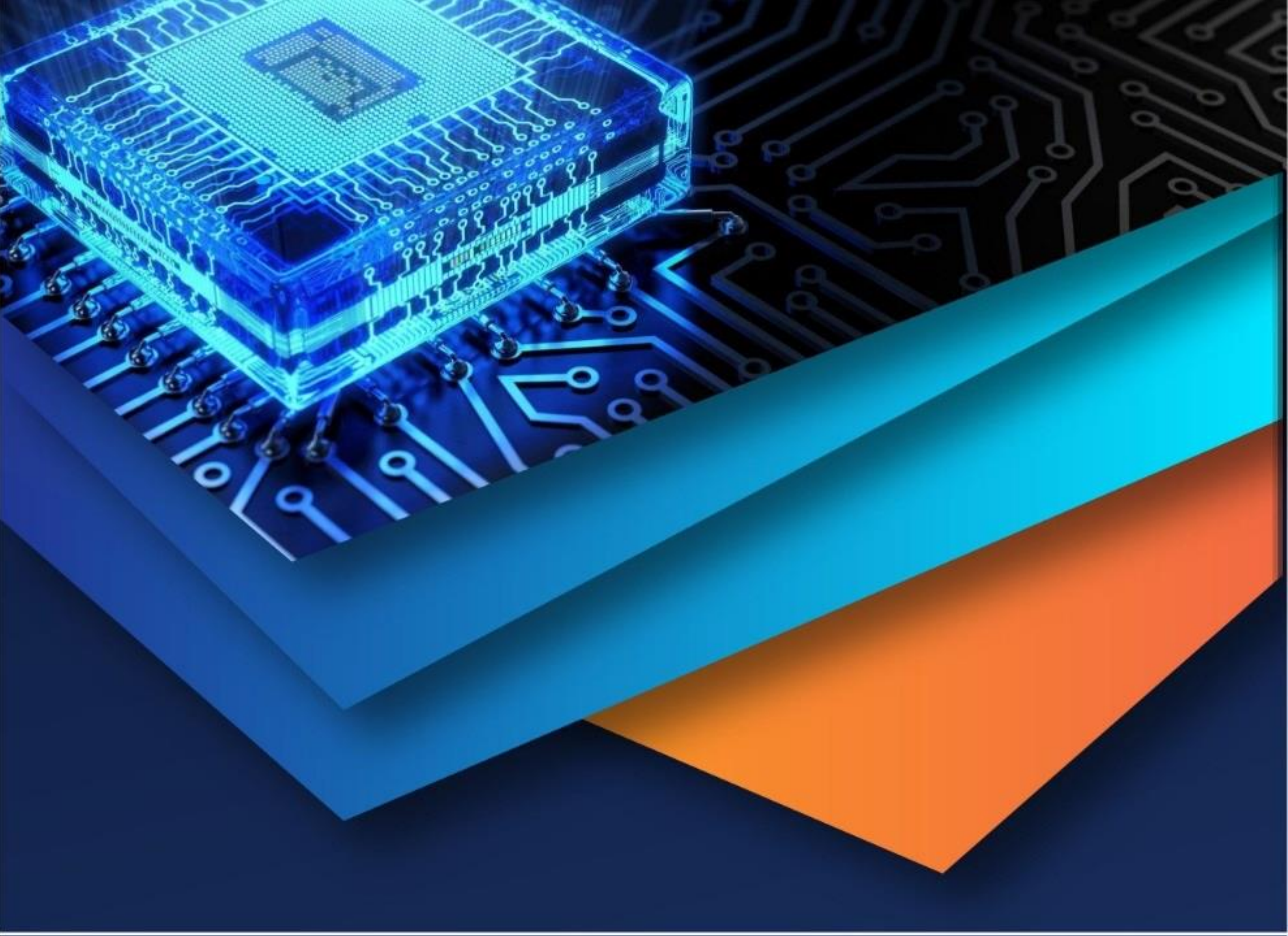
This study successfully demonstrated the feasibility of fabricating eco-friendly bricks using fly ash and marble dust as partial cement replacements. Mechanical testing revealed that bricks with up to 20% replacement exhibits compressive strength and durability characteristics comparable to those of conventional cement bricks. Although higher replacement levels led to slight reductions in strength and density, the overall performance remained within acceptable limits for general-purpose construction applications.

From a mechanical engineering perspective, the experimental results confirmed that the inclusion of industrial waste materials can yield bricks with adequate load-bearing capacity, reduced density, and acceptable water absorption. These properties make these bricks suitable for lightweight and non-load-bearing structures. Furthermore, the reuse of waste materials promotes environmental sustainability, reduces construction costs, and aligns with the principles of green engineering

The findings of this study support the broader adoption of industrial byproducts in building materials, particularly in the development of sustainable construction solutions. Future work can explore the long-term durability, thermal insulation, and lifecycle analysis of such bricks under different environmental conditions.

## REFERENCES

[1] R. Sharma and D. Dutta, "Performance of Bricks Using Fly Ash and Marble Dust as Partial Replacements for Cement," Materials, vol. 15, no. 3, p. 1157, 2022
[2] M. Khan, A. Rehman, and F. Khan, "Utilization of Marble Dust and Fly Ash in the Manufacturing of Bricks: A Sustainable Approach," ACS Omega, vol. 6, no. 12, pp. 8504–8511, 2021.
[3] V. Kumar and S. Yadav, "Development of Geopolymer Bricks Using Fly Ash and Marble Dust," Preprints, 2023.
[4] A. Prasad, P. Mishra, and R. Singh, "Mechanical Properties of Bricks Using Fly Ash, Marble Dust and Lime Sludge," South Asian Journal of Engineering and Technology, vol. 5, no. 3, pp. 12–18, 2019.
[5] A. Joshi and N. Verma, "Statistical Analysis of Strength Variation in Fly Ash Bricks," Journal of Materials in Civil Engineering, vol. 32, no. 9, p. 04020312, 2020.

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