

Effect of Partial Replacement of Marble Powder and Rice Husk Ash in Sustainable Brick Production

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ABSTRACT

The construction industry faces increasing challenges related to environmental sustainability and resource depletion. This study explores the feasibility of using marble powder (MP) and rice husk ash (RHA) as partial replacements for natural soil in brick production. Bricks were manufactured with varying replacement levels ranging from 0% to 30% and were air-cured for 28 days without firing, promoting an energy-efficient process.

Experimental investigations were conducted to evaluate compressive strength, density, and water absorption. Results indicate that bricks with 5–15% replacement of MP and RHA exhibit satisfactory mechanical properties, achieving compressive strength comparable to conventional bricks, while maintaining acceptable density and durability. However, higher replacement percentages led to reduced strength and increased water absorption.

The study demonstrates that incorporating industrial and agricultural waste materials not only reduces dependency on natural soil but also supports sustainable waste management and cost-effective construction. The developed bricks are suitable for eco-friendly and non-structural building applications, contributing to greener construction practices.

KEYWORDS: Sustainable bricks, Marble powder, Rice husk ash, Partial replacement, Compressive strength, Eco-friendly materials

INTRODUCTION

The construction sector is a major consumer of natural resources, especially in the production of conventional building materials like clay bricks. However, traditional brick manufacturing has notable environmental drawbacks. The extraction of clay leads to the depletion of fertile topsoil, causing ecological imbalance, soil erosion, and loss of agricultural productivity. In addition, the firing process involved in brick production emits large quantities of carbon dioxide, contributing to air pollution and global warming. With the growing demand for infrastructure and housing, it has become essential to identify sustainable alternatives that reduce environmental impact while maintaining material performance.

One promising approach is the utilization of industrial and agricultural waste materials as partial replacements for natural soil in brick production. Among these, marble powder and rice husk ash have gained attention due to their availability and beneficial characteristics. Marble powder is a waste by-product generated during marble cutting and processing, while rice husk ash is obtained from the combustion of rice husks in mills. Both materials exhibit pozzolanic properties, enabling them to enhance the strength and durability of construction materials when used appropriately.

This study focuses on evaluating the feasibility of incorporating marble powder and rice husk ash as partial substitutes in brick manufacturing. The investigation includes assessing key properties such as compressive strength, water absorption, durability, and thermal performance of the produced bricks. Furthermore, the study examines environmental advantages, including reduced dependence on natural resources and lower carbon emissions.

In addition to environmental benefits, the use of these waste materials offers economic advantages by reducing raw material costs and promoting resource efficiency. Their incorporation also supports circular economy principles by

converting waste into valuable construction inputs. Moreover, these materials can improve brick quality by enhancing compaction, reducing porosity, and increasing resistance to cracking. Overall, this approach contributes to the development of sustainable, cost-effective, and high-performance building materials suitable for modern construction needs

LITERATURE REVIEW

- Singh and Bhattacharjee studied rice husk ash (RHA) in fired bricks with 0–15% replacement. An optimum of 10% RHA increased compressive strength by ~12% and reduced water absorption by ~18%. Improved bonding due to pozzolanic reaction and reduced shrinkage led to fewer cracks and better durability.
- Raut et al. evaluated marble powder and rice husk ash (RHA) as partial replacements in bricks. Up to 15% RHA improved strength, reduced porosity, and enhanced thermal insulation due to its fine, silica-rich nature. Marble powder improved bonding and surface finish. The study highlighted that optimal use of these materials enhances performance and supports sustainable waste utilization.
- Deepika and Kaur studied marble dust as a partial soil replacement (5–25%) in bricks. Optimum content of 15–20% showed comparable or slightly improved strength with reduced weight. Strength gain was due to filler effect and calcium carbonate bonding, while 25% replacement reduced strength. The study concluded that marble dust bricks are suitable for non-load-bearing applications and help in waste utilization.
- Ghosh and Mandal investigated RHA (0–20%) in fired bricks at 900 °C. An optimum of 10% RHA provided the best strength, durability, and water resistance due to formation of calcium silicate compounds. Higher RHA improved insulation but reduced strength. The study highlighted RHA bricks as suitable for energy-efficient construction, especially in tropical regions.

OBJECTIVES

- To explore the feasibility of partially replacing soil with marble powder and rice husk ash in bricks.
- To evaluate the mechanical behaviour of the bricks through tests such as compressive strength, density, hardness, and soundness.
- To determine how different replacement percentages influence the mechanical and physical properties of the bricks.
- To identify the optimal replacement percentage that yields durable, eco-friendly bricks.

MATERIALS AND METHODOLOGY

Materials:

A. Red Soil

Red soil was used as the primary base material due to its availability, fine texture, and good workability in brick production. It contains a balanced mix of sand, silt, and clay, providing adequate plasticity for moulding and shaping. The presence of iron oxide enhances bonding and strength during drying and curing. It also ensures good compaction and stability when mixed with marble powder and rice husk ash. The red soil used in this study was procured from Anaji Village, Davangere, at a depth of 2 m below ground level (GL).



Fig 1.1 : Red Soil

B. Rice Husk Ash (RHA)

Rice husk ash (RHA) was used as a partial replacement for soil due to its high silica content and pozzolanic properties. It enhances bonding within the brick matrix, leading to improved strength, reduced density, and better thermal insulation. Its porous nature also helps in lowering water absorption and refining the internal structure of bricks. The use of RHA reduces dependence on natural soil and promotes effective utilization of agricultural waste. The RHA used in this study was procured from a local rice mill near Anaekonda, Davangere.



Fig 1.2 : Rice Husk Ash

C. Marble Powder (MP)

Marble powder (MP) was used as a partial replacement for soil due to its fine particle size and high calcium carbonate (CaCO_3) content. It acts as a filler, improving the compactness and density of the brick matrix while reducing the need for natural soil. The presence of CaCO_3 also helps in lowering the firing temperature by acting as a fluxing agent. The inclusion of MP results in smoother surface finish, reduced shrinkage during drying, and comparatively lighter bricks. Additionally, its use supports sustainable construction by utilizing waste generated from marble processing. The marble powder used in this study was procured from local marble cutting and polishing units in Davangere.



Fig 1.3 : Marble Powder

METHODOLOGY



A. Material Preparation

All raw materials were prepared to ensure uniformity and consistency. Soil was air-dried, manually crushed, and sieved through a 4.75 mm sieve to remove impurities. Marble powder and rice husk ash were dried and sieved through

a 75-micron sieve to obtain fine particles. This preparation improves material dispersion, enhances bonding, and ensures reliable results.



Fig 1.4 : Material Preparation

B. Mix Proportion

A control mix with 100% soil was used as a reference. Experimental mixes were prepared by partially replacing soil with marble powder and rice husk ash in the range of 10% to 30%. All materials were measured by weight and mixed uniformly. Water was added to achieve a workable consistency for moulding. This approach helps evaluate the effect of different replacement levels on brick properties.

Table 1.1 : Mix Proportion

Sl. No	Rice Husk Ash	Marble Powder	Soil	No of samples
MIX1	0.00%	0.00%	100%	3
MIX2	2.50%	2.50%	95%	3
MIX3	5.00%	5.00%	90%	3
MIX4	7.50%	7.50%	85%	3
MIX5	10.00%	10.00%	80%	3
MIX6	12.50%	12.50%	75%	3
MIX7	15.00%	15.00%	70%	3

C. Mixing and Moulding

Dry materials were mixed uniformly, and water was added to obtain a plastic, workable mix. The mixture was placed in standard moulds (190 mm × 90 mm × 90 mm) and compacted manually to remove air voids. Bricks were then demoulded carefully. Proper mixing and compaction ensure strength, durability, and dimensional accuracy.



Fig 1.5: Mixing & Moulding

D. Drying / Curing

After moulding, bricks were shade-dried for 1–3 days to prevent cracking, then air-cured in an open area for 28 days. This gradual drying ensured uniform moisture removal and adequate strength. The study used unfired, fully air-dried bricks for testing.



Fig 1.6: Moulds Kept for Curing

TEST RESULTS AND DISCUSSIONS

Test Results on Soil

Table 1.2: Basic Test Results of Red Soil

Sl. NO	Properties	Results
1	Grain size analysis	SM
2	Specific gravity of soil sample	2.22
3	Moisture content test	28.92%
4	Liquid limit of soil	24.17%
5	Plastic limit of soil	19.17%
6	Light compaction test	
	a) Maximum dry density soil sample	1.442
	b) Optimum moisture content of soil sample	13.70%
7	Specific gravity of rice husk ash	1.62

Test Results on Bricks

A. Compressive Strength Test

Table 1.3 : Compressive Strength of Bricks

Sl. No	Load (KN)		Average (KN)	Area of C/S (mm)	Compressive strength (N/mm ²)
	Trial 1	Trial 2			
Mix 1	53	51	52	8100	6.42
Mix 2	50	50	50	8100	6.17
Mix 3	47	50	48.5	8100	5.99
Mix 4	48	50	49	8100	6.05
Mix 5	38	40	39	8100	4.81
Mix 6	41	40	40.5	8100	5.00
Mix 7	34	28	31	8100	3.83

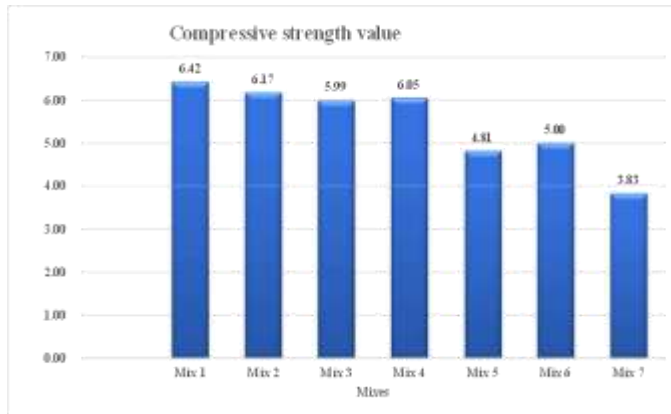


Fig 1.7 : Variation of Compressive Strength of Bricks

B. Density Test

Table 1.4 : Density of Cured Bricks

Sl. No	Volume (cm ³)	Weight of Brick (gm)		Average Weight (gm)	Density (gm/cc)
		Trial 1	Trial 2		
Mix 1	1539	2540	2480	2510	1.650
Mix 2	1539	2664	2596	2630	1.709
Mix 3	1539	2410	2368	2389	1.552
Mix 4	1539	2204	2310	2257	1.467
Mix 5	1539	2160	2212	2186	1.420
Mix 6	1539	2200	2206	2203	1.431
Mix 7	1539	2240	2172	2206	1.433

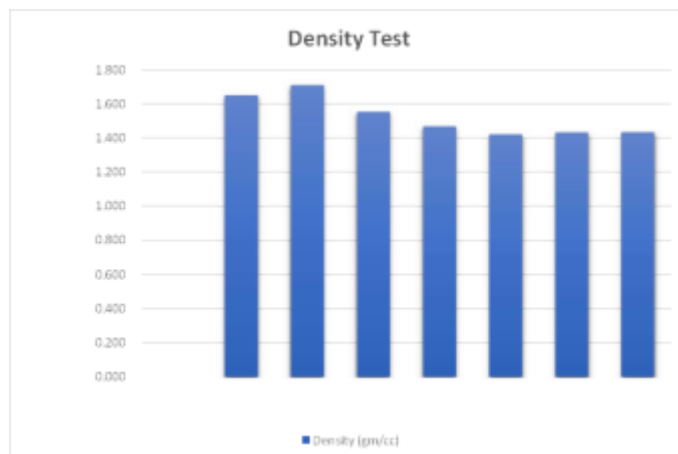


Fig. 1.8 : Density Variation of Cured Bricks

C. Water Absorption Test

Table 1.5 : Water Absorption of Cured Bricks

Sl. No	Dry Weight (kg)	Wet Weight (kg)	Water Absorption (%)
MIX 1	2.56	2.78	8.59%
MIX 2	2.664	2.915	9.42%

MIX 3	2.41	2.675	10.99%
MIX 4	2.204	2.505	13.65%
MIX 5	2.16	2.495	15.50%
MIX 6	2.2	2.58	17.27%
MIX 7	2.24	2.65	18.30%

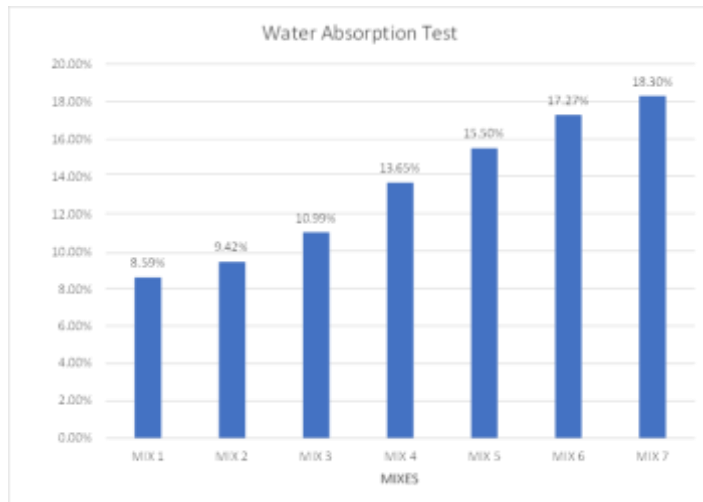


Fig 1.9: Water Absorption of Cured Bricks

CONCLUSIONS

- Partial replacement of clay with marble powder (MP) and rice husk ash (RHA) reduces dependence on natural soil and supports effective waste utilization, contributing to sustainable brick production.
- Bricks containing 5–15% replacement exhibited adequate compressive strength and overall satisfactory performance comparable to conventional bricks.
- Replacement levels beyond 15–20% resulted in a noticeable reduction in strength, indicating that higher proportions are not suitable for structural use.
- The air-drying technique adopted in this study proved effective in producing usable bricks without firing, thereby lowering energy requirements and production costs.
- Overall, the controlled incorporation of MP and RHA can lead to the development of eco-friendly, cost-effective bricks with acceptable strength and performance characteristics.

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