

Experimental Analysis of Lime Stabilized Compressed Earth Bricks as A Sustainable Alternative to Fired Clay Bricks

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Abstract—The environmental impact associated with conventional fired clay bricks, particularly in terms of high energy consumption and carbon emissions, has necessitated the exploration of sustainable alternatives in the construction industry. This study presents a comprehensive experimental investigation on lime-stabilized compressed earth bricks (LSCEBs) produced using clay soil. It is applicable in various types of soil, there are other studies that showing lime-stabilized compressed earth bricks (LSCEBs) can be also manufactures in Black cotton and alluvial soil. soil was stabilized with hydrated lime at proportions of 3%, 6%, 9%, and 12% by weight and compacted under a pressure of 10 Ton. In most of the region where Cost and Transporting of building materials is not applicable. Then the Compressed brick can be mould at the construction site itself. The bricks were manufactured without kiln firing and compacted using a mechanical press applying a load of 10 tons within a mould of dimensions 150 × 150 × 150 mm. Detailed material characterization was performed through sieve analysis, Atterberg limits, pH testing, and litmus tests to evaluate the suitability of the soil and the effectiveness of lime stabilization. Compressive strength, density, and overall performance were evaluated. To ensure standard testing accuracy, compressive strength was determined using smaller specimens. The results demonstrate that lime stabilization significantly improves the engineering properties of clay soil through pozzolanic reactions, resulting in durable and eco-friendly construction units. The study concludes that LSCEBs provide a technically viable, economically feasible, and environmentally sustainable alternative for modern construction.

Index Terms—Compressed Earth Bricks, Lime Stabilization, Clay Soil, Sustainable Construction, Compressive Strength, Pozzolanic Reaction

I. INTRODUCTION

The rapid growth of the construction industry has significantly increased the demand for building materials, particularly fired clay bricks. However, the manufacturing process of these bricks involves high-temperature kiln firing, which consumes large amounts of energy and contributes substantially to greenhouse gas emissions. This has led to an urgent need for sustainable and energy-efficient alternatives. Compressed earth bricks (CEBs) have emerged as a promising solution due to their low environmental impact, cost-effectiveness, and utilization of locally available materials. Unlike conventional bricks, CEBs do not require firing, thereby reducing energy consumption and emissions. However, natural soil often lacks adequate strength and durability for structural applications. Stabilization techniques are therefore essential to improve its engineering properties.

Lime stabilization is one of the most widely used methods for enhancing soil performance. When lime is added to soil, it reacts with silica and alumina to form cementitious compounds, improving strength and durability. Despite extensive research, there remains a need to optimize lime content and compaction conditions for different soil types. This study aims to evaluate the effect of varying lime content on the strength characteristics of compressed earth bricks prepared under controlled compaction conditions.

II. LITERATURE REVIEW

Previous studies have established that lime stabilization significantly improves soil strength and durability. Bell (1996) demonstrated that lime reduces plasticity and enhances strength through pozzolanic reactions. Walker (2004) reported improved compressive strength in stabilized earth blocks. Houben and Guillaud (1994) provided a comprehensive overview of earth construction techniques, emphasizing the importance of proper soil grading and stabilization for achieving durable structures. Several researchers have also highlighted that the optimum lime content typically ranges between 5% and 10%, depending on soil composition. Z. Field implementations, particularly by the Auroville Earth Institute, confirm that compressed earth blocks can achieve performance comparable to conventional bricks. However, limited research exists on large mould compaction combined with standardized strength testing, which this study addresses.

III. METHODOLOGY

The experimental program was designed to prepare and test lime-stabilized compressed earth bricks using a systematic and controlled procedure. Locally available soil was collected, air-dried, and sieved to remove oversized particles and impurities. Hydrated lime was added to the soil in proportions of 3%, 6%, 9%, and 12% by dry weight.

The preparation procedure involved thorough dry mixing of soil and lime to achieve uniform distribution. Water was then gradually added to reach the optimum moisture content of approximately 14%. The mixture was continuously mixed to ensure homogeneity.

The prepared mix was placed into a steel mould of dimensions $150 \times 150 \times 150$ mm. Compaction was carried out using a hydraulic press under a load of 10 tons (approximately 98 kN). The compaction pressure applied was calculated as:

$$P = \frac{F}{A} = \frac{98,000}{0.0225} = 4.36 \text{ MPa}$$

compaction, the specimens were carefully demoulded and cured under moist conditions using a controlled environment to maintain humidity. The curing periods considered were 7, 14, and 28 days. Following curing, the specimens were tested for compressive strength using a standard compression testing machine.

IV. MATERIAL IDENTIFICATION

• Soil Identification based on Properties

Organic matter: < 1%

Clay content: 25–30%

Sand content: 40–50%

Silt content: 15–30%

Combined silt + clay: 45–50%

Soil should be non-expansive



• Lime

Lime used is, Calcium Hydroxide which is made from Neettukakka which is collected from shell. Chemical name of Neettukakka is CaO. Neettukakka is hydrated to form calcium Hydroxide which is used in block moulding.



- Water

Water used in manufacture of brick having a PH of 7.

V. TEST DETAILS

1. Sieve Analysis

Sieve analysis was conducted using a 1000 g soil sample. The results indicated a well-graded soil with approximately 22% fines passing the 0.075 mm sieve, providing adequate binding characteristics while maintaining strength.

Sieve Size (mm)	Weight Retained (g)	% Retained	% Passing
4.75	0	0	100
2.36	50	5	95
1.18	120	12	83
0.600	180	18	65
0.300	220	22	43
0.150	210	21	22
0.075	140	14	8
Pan	80	8	0

2. Atterberg Limits

The soil exhibited a liquid limit of 42%, plastic limit of 24%, and plasticity index of 18%, indicating medium plasticity suitable for lime stabilization.

3. Compressive Strength Calculation

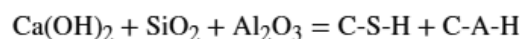
Compressive strength was calculated using:

$$\sigma = \frac{F}{A}$$

(Using standard test specimens for accuracy) Typical result

Average Value: $\sigma = 5.95$ MPa

4. Chemical Reaction



C-S-H, C-A-H, are the Cementitious compound.

VI. MOLD DESIGN



VII. RESULTS AND CONCLUSION

Property	Value Obtained	Standard/Typical Range
CLAY SOIL		
Liquid Limit (LL)	52%	35–60%
Plastic Limit (PL)	30%	20–30%
Plasticity Index (PI)	22%	10–25%
Soil pH	6.5	5.5–7.5
% Passing 0.150 mm	30%	20–40%
Soil Type	Clayey Soil	—
Dry Density	1800 kg/m ³	1600–2000 kg/m ³
LIME		
Type	Hydrated Lime (Ca(OH) ₂)	—
Specific Gravity	2.4	2.2–2.5
pH (in solution)	11–12	>10
Reactivity	High	—
Lime Content Used	5–10%	4–10%
WATER		
pH	7	6–8
Quality	Potable	Free from impurities
Role	Hydration medium	—

The results indicate that compressive strength increases with lime content and curing duration. The applied compaction pressure improved density and reduced voids, while lime stabilization enhanced bonding through pozzolanic reactions.



Mix Ratios and Compressive Strength Table

Mix	7 Days	14 Days	28 Days
L3	2.5 MPa	3.1 MPa	3.8 MPa
L6	3.6 MPa	4.8 MPa	5.9 MPa
L9	4.5 MPa	6.2 MPa	6.9 MPa
L12	4.8 MPa	6.5 MPa	7.2 MPa

Compressive Strength Comparison

Brick Type	Strength (MPa)
Burned Brick	3.5 – 10
LSCEB	3.8-7.2

VIII. CONCLUSION

Overall, the findings of this study strongly support the adoption of lime-stabilized compressed earth bricks in low- to medium-load-bearing applications. With proper mix design, compaction, and curing, LSCEBs can serve as an environmentally friendly, technically sound, and economically efficient alternative in modern construction

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