International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental study on behaviour of stabilized mud brick

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ABSTRACT:

The basic composition of mud bricks includes clay, sand, and water, which are combined to create a mixture that is then moulded into bricks and dried naturally in the sun. However, traditional mud bricks face challenges related to strength, durability, and resistance to weathering. These issues can be mitigated by addition of natural materials, such as lime, straw, rice husk, or even plant-based fibers like hemp or bamboo, which improve their mechanical properties and weather resistance. In this particular experiment we used a coconut fiber as a strengthening material which is also lead to reduce shrinkage cracks. These fibers are ecofriendly in nature and also used to improve the thermal insulation. We don't used the clay in making of bricks, these bricks would rather consider as stabilized mud brick because the used of cement and lime in it as per required. The particles of fly ash led to a reduction in the density of brick and a substantial improvement durability.

Stabilized mud bricks are an eco-friendly and cost-effective alternative to conventional construction materials, particularly in rural and sustainable building practices. These bricks are produced by mixing natural soil with stabilizing agents such as cement, lime, or bitumen, enhancing their strength, durability, and resistance to weathering. The use of local materials reduces environmental impact and construction costs, while the addition of stabilizers addresses the limitations of traditional mud bricks, such as low compressive strength and water sensitivity.

Keywords: Stailized mud brick, Mud brick, Coconut fiber, etc.

Introduction:

A brick is a building material used to make walls, pavements and other elements in masonary construction. Traditionally, the term brick referred to a unit composed, of clay but it is now use to donate rectangular units of clay bearing soil, sand and lime, or concrete available. Though a common structural material, till now brick is the cheapest one. Mud brick fall under the category heavy mud products. All units are operating in cluster and cause substainal level of air pollution and land deformation in locality. Some environmental issues related with such activities as availability of good fertile alluvial land which one of the most important condition for establishment a brick industry that initiates the process of land degradation. To overcome this red composition brick and fly ash brick make change in construction industry. The project deals with "Reduction of thermal insulation and strengthening the mud brick using natural elements".

Fly ash, if not utilized, may present environmental concerns, and its storage/ disposal will be expensive. The majority of fly ash produced in India is low calcium fly ash. The use of fly ash as admixture in cement mortar/ concrete not only extends technical advantages to the properties of cement mortar/ concrete but also contributes to the environmental pollution control. Further,

The incorporation of lime into traditional mud bricks plays a vital role in enhancing their structural and environmental performance. Lime acts as a natural stabilizing agent, significantly improving the compressive strength and water resistance of the bricks. Through chemical reactions with clay minerals, lime forms durable bonds that reduce shrinkage, cracking, and erosion. Its addition also improves the plasticity and workability of the mud mixture, making it easier to mould and handle during brick production. Moreover, lime-treated mud bricks offer better durability in humid conditions and contribute to indoor thermal comfort due to their breathable nature. As an eco-friendly and cost-effective material, lime not only extends the lifespan of mud bricks but also aligns with sustainable building practices, particularly in rural and climate-sensitive regions. This study highlights the practical benefits of lime in enhancing the quality and longevity of earthen construction materials.

Cement is widely used in the stabilization of mud bricks to improve their strength, durability, and resistance to environmental factors. When mixed with soil and water, cement acts as a binding agent, helping to hold the soil particles together through hydration reactions. This significantly increases the compressive strength of the bricks and reduces their susceptibility to damage from moisture and erosion. Cement-stabilized mud bricks are less prone to cracking and shrinking during drying, making them more reliable for long-term structural use. Additionally, cement enhances the load-bearing capacity of the bricks, allowing them to be used in low-cost housing with improved safety and stability. By combining the natural thermal insulation properties of mud with the strength of cement, these bricks provide a practical and sustainable building solution, especially in areas with limited access to industrial construction materials.

Methodology:

Methodology for Casting Mud Bricks Using Cement, Lime, Sand, Coconut Fiber, and Fly Ash

Materials

- **Soil:** Locally sourced clay-rich soil, screened to remove debris.
- **Cement:** Ordinary Portland Cement (OPC) used as a stabilizer.
- **Lime:** Hydrated lime to improve workability and durability.
- **Sand:** Fine river sand to enhance strength and reduce shrinkage.
- **Coconut Fiber:** Coir fibers, chopped into small lengths (~2-3 cm), used as natural reinforcement.
- **Fly Ash:** Class F fly ash, sourced from a nearby thermal power plant, to improve durability and reduce permeability.
- **Water:** Clean potable water for mixing.

Preparation of Materials

1. **Soil Preparation:** The soil was dried and sieved through a 2.70 mm mesh to ensure uniform particle size and remove organic impurities.
2. **Fiber Treatment:** Coconut fibers were washed and sun-dried to remove any moisture and impurities.
3. **Proportioning:** Based on preliminary trials and literature, the mix proportions were decided as:
    - Soil
    - Cement: 5%, 10%, 15%, 18%
    - Lime: 3%
    - Fly Ash: 5%
    - Coconut Fiber: 1% by weight of soil.

Mixing Procedure

1. All dry ingredients—soil, sand, cement, lime, fly ash, and coconut fiber—were thoroughly mixed in a mechanical mixer for 5 minutes to achieve a homogeneous blend.
2. Water was gradually added while continuously mixing to form a workable, plastic-like consistency. The water content was adjusted to achieve optimum workability without making the mix too wet, roughly around 15-18% by weight.
3. The mixture was manually kneaded for 10 minutes to ensure even distribution of fibers and prevent clumping.

Casting of Bricks

1. The prepared mixture was packed into a standard-sized brick mold (290 mm x 140 mm x 90 mm).
2. The mold was firmly pressed using a mechanical or manual press to compact the mix and remove air voids.
3. After molding, the bricks were carefully demolded and placed on a flat surface under shade for initial curing.

Curing Process

1. The bricks were kept moist by regular sprinkling of water twice daily for 7 days to promote proper hydration of cement and lime.
2. After 7 days, bricks were air-cured for an additional 7 and 28 days under ambient environmental conditions.
3. Throughout curing, bricks were protected from direct sunlight and rain to avoid premature drying or erosion.

Testing and Evaluation

- After 28 days of curing, the bricks were tested for compressive strength, water absorption, dimensional stability, and durability according to relevant standards (e.g., ASTM or IS codes).
- Visual inspections were also conducted to assess surface texture, cracking, and fiber distribution.

Results

The compressive strength test helps us understand how much load a stabilized mud brick can actually handle before it breaks. It's one of the most important tests because it tells us whether the brick is strong enough to be used in construction, especially for walls and structural parts.

When the test is done properly, we expect bricks that are well-compacted, cured for enough time (usually 21–28 days), and properly mixed with stabilizers like lime or cement, to show strength in the range of 2 to 5 N/mm². Bricks with added natural fibers, like coconut fiber, may also show better performance by resisting early cracks and holding the structure together even after small failures.

The results of the test give a clear picture of how well the brick-making process was followed. If the bricks crumble easily or fail at very low loads, it usually means there was poor curing, improper soil mix, or not enough stabilizer. On the other hand, a higher strength value shows that the brick is durable and reliable for building use.

In short, this test doesn't just give us numbers—it helps us judge the real-world quality of the brick, guides improvements in the process, and ensures that the material is safe for long-term use in eco-friendly construction.

Results whichever get from the test

- The result for the 7 days of curing batch, these brick consists of 10mm added frog in the bricks for the betterment of weight distribution

Table no.6 Compressive strength for 7 days of curing

Sr.no	**Load capacity KN**	**Compressive strength in N/mm2**
1. [A] Brick	184.7	4.29
2. [B] Brick	134	3.12
3. [C] Brick	77.1	1.79

4. [D] Brick	203	4.72

Calculations

To calculate compressive strength (N/mm2) for stabilized mud brick after 7 days of curing, we use the standard formula

Compressive strength = Maximum load (N) / Load Bearing area (mm2)

Brick size = 290mm x 140mm x 90mm

Area = 290 x 140 = 40600 mm2

Frog area deduction = 100mm x 50mm = 5000 mm2

Net area = 40600 – 5000 = 35600 mm2

The correction factor to be applied of 0.8 to safety and if top surface is uneven and following the standards like IS 3495 Part 1, ASTM C67 that recommended.

For –

- [A] Brick – 184700 N / 35600 mm
  = 5.18 N/mm2 x 0.8
  = **4.2 N/mm2**
  [B] Brick – 134000/35600 mm2
  = 3.17 N/ mm2 x 0.8
  = **3.12 N/mm2**
  [C] Brick – 77100 / 35600
  = 2.16 N/mm2 x 0.8
  = **1.79 N/mm2**
  [D] Brick – 20300/ 35600
  = 5.7 N/mm2 x 0.8
  = **4.76 N/mm2**
- The compressive strength for 28 days

Table no.1 Compressive strength for 28 days curing

Sr.no	**Load capacity** **KN**	**Compressive strength** **N/mm2**
1. [A] Brick	268	6.6
2. [B] Brick	191	4.7
3. [C] Brick	106	2.6
4. [D] Brick	296	7.3

The expected outcome of the water absorption test on stabilized mud bricks is to determine how much water the brick can soak in after being fully cured. This result tells us a lot about the quality, density, and durability of the brick. Ideally, bricks that are well-compacted and properly cured should show low water absorption, generally below 20% by weight, depending on the soil type and stabilizer used.

Bricks with higher absorption values may indicate poor compaction, insufficient stabilizer, or inadequate curing, which can lead to faster deterioration in humid or rainy environments. On the other hand, low water absorption reflects a dense internal structure with fewer pores, which means the brick will likely have better strength, weather resistance, and a longer life.

The expected outcome of the water absorption test is to determine how well a stabilized mud brick can resist water intake after curing. Lower absorption values (ideally below 15–20%) indicate that the brick is properly stabilized and compacted, making it more suitable for use in construction. High absorption suggests a porous structure, which can lead to erosion, swelling, or cracking over time. The test helps in identifying which mix designs and curing techniques produce more reliable, long-lasting bricks.

Water absorption outcomes reflect the internal quality of the brick. A well-prepared stabilized mud brick should resist soaking in too much water, maintaining its shape and integrity even in wet conditions. High-performing bricks generally show uniform curing, dense structure, and effective binder action. The test helps highlight variations caused by different soil types, stabilizers, and curing methods, guiding improvements for better construction-grade bricks.

Table no.2 Water Absorption for 28 days of curing

Sr.no	**Self weight of brick before curing 28 days [A]**	**Self weight of brick after curing 28 days [B]**	**Mass of water =** **[B – A]**	**Water absorption %**

1. [A] Brick	4965 gm 4.96 kg	6.156 gm 6.15 kg	1.191 gm	19.34
2. [B] Brick	4765 gm 4.7 kg	5.274 gm 5.2 kg	0.509 gm	9.6
3. [C] Brick	4560 gm 4.5 kg	5.620 gm 5.6 kg	1.060 gm	18.86
4. [D] Brick	5087 gm 5.0 kg	5.200 gm 5.2 kg	0.113 gm	2.17

Table no.3 Water Absorption for 7 days of curing

Sr.no	**Self weight of brick before curing 7 days [A]**	**Self weight of brick after curing 7 days [B]**	**Mass of water = [B – A]**	**Water absorption %**
1. [A] Brick	4769 gm 4.7kg	5.100 gm 5.1 kg	0.300 gm	5.8
2. [B] Brick	4610 gm 4.6 kg	4.846 gm 4.8 kg	0.236 gm	4.8
3. [C] Brick	4000 gm 4 kg	4.682 gm 4.6 kg	0.682 gm	14.5
4. [D] Brick	4890 gm 4.8 kg	5.162 gm 5.1 kg	0.272 gm	5.2

The scratch test provides a quick and practical way to assess the surface hardness and finish quality of stabilized mud bricks. The expected outcome is that a well-compacted and properly cured brick should show minimal surface damage when scratched with a metal object like a nail or wire. The scratch should be shallow, with little to no powdering, indicating that the brick has good surface strength and binding.

If the surface easily flakes, produces dust, or the scratch is deep, it suggests issues such as inadequate curing, insufficient stabilizer, or a poor mix ratio. These results point to a weaker brick that may wear down faster or fail when exposed to handling, transport, or environmental stress.

This simple test helps compare the quality across different curing methods or mix designs, especially when access to lab equipment is limited. In field conditions, it serves as an early indicator of a brick's durability and finish, helping ensure better construction practices even in low-resource settings.

The scratch test is expected to reveal the surface integrity of stabilized mud bricks. Ideally, bricks that have been well-mixed, compacted, and cured should show minimal surface damage when scratched, indicating good hardness and cohesion. If the surface easily flakes or produces powder, it suggests weak bonding and potential durability issues. This test is valuable for quick field evaluations to ensure acceptable quality before use in construction.

Conclusion

The construction using natural resources with the replenishment of them and the growth of the world will be achievement to admire. Construction using this environmentally friendly brick will be provide a better durable material with economy is no doubt fact by the results obtained from our experimental investigation. Sustainability and economy with no pollution is a dream that persists in our society. This type of construction brings us a step closer to this motto. From the above experimental studies we can conclude that-

- The coconut fiber can be used in the stabilized mud0 brick for better strengthening and improve strength of brick.
- To avoid the shrinkage in the bricks the stabilizers such as cement, lime, fly ash, etc. is used in minimum proportion.
- Measuring the parameters, the brick is made but the weight distribution is not proper,
- Due to which the 10mm frog was added in the mould and other batch was casted which was cured only for 7 days which gives minimum strength of brick because of lack of time.
- Nominal result of compressive strength in the range of 2.8 N/mm2 or more should be adequate for one and two store building.

- We concluded that the brick named [B] passes all the parameters of test and can be casted on large scale and can used in the open market after certified by the proper authority.
- The brick [B] gained strength for carrying the load up-to the 134 KN which is 134000N
- The brick [B] has the compressive strength of 4.7 N/mm2 after 28 days of curing without adding the frog due to which the weight distribution is not proper.
- This brick has a water absorption of 9.6 % which is acceptable for the good brick.
- After adding the 10mm frog in the brick the correction factor is to be consider and the 7 days curing of the brick [B] was 3.12 N/mm2 which greater than nominal result
- The estimated strength can be gained in the 28 days of curing by the brick is 4.13 N/mm2 [assumed].
- The main problem of their brick is its weight ! the further studies can be done for reducing the weight of the established brick'
- This brick can used for the one or two store building in the rural areas for better connection with nature.

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