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Comparative research of water absorption and compressive strength of conventional bricks using different curing methods

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Abstract

Curing plays a decisive role in the development of mechanical strength and durability characteristics of conventional clay bricks used in low-rise and load-bearing masonry construction. Inadequate or improper curing practices often result in higher porosity, reduced compressive strength, and long-term durability issues, especially in cost-sensitive construction environments. This research presents a comparative experimental evaluation of the influence of different curing methods on the water absorption and compressive strength of conventional burnt clay bricks. Four commonly adopted curing regimes—Water curing, Air curing, Steam curing, and Membrane curing—were examined under controlled laboratory conditions. Standard-sized bricks were prepared using identical raw materials, molding techniques, and firing conditions to isolate the effect of curing alone. Water absorption was determined using immersion tests, while compressive strength was measured using a calibrated compression testing machine after the specified curing period. Statistical tools including one-way analysis of variance were employed to assess the significance of variations among curing methods. The results demonstrate clear performance differences attributable to curing techniques, with Steam curing exhibiting the highest compressive strength and lowest water absorption, followed by Water curing. Air curing showed comparatively inferior performance due to inadequate moisture retention, while Membrane curing produced moderate results. The statistical analysis confirmed that curing method significantly influences both strength and absorption characteristics. These findings emphasize the necessity of selecting appropriate curing practices to improve the quality and service life of masonry units. The research contributes practical insights for engineers, contractors, and material technologists by highlighting curing strategies that enhance brick performance without altering raw material composition or production processes.

Keywords: Clay bricks, curing methods, compressive strength, water absorption, masonry materials, durability

Introduction

Conventional burnt clay bricks remain one of the most widely used masonry units in low-rise buildings and infrastructure due to their availability, cost-effectiveness, and compatibility with traditional construction practices [1]. The long-term performance of brick masonry is strongly influenced by the physical and mechanical properties of individual bricks, particularly compressive strength and water absorption, which govern load-bearing capacity and durability [2]. These properties are not solely dependent on raw material composition and firing temperature but are also significantly affected by post-manufacturing curing conditions [3]. Proper curing facilitates moisture regulation and microstructural stabilization, leading to improved strength development and reduced pore connectivity [4]. In practice, however, curing of bricks is often neglected or inconsistently applied, especially in small-scale production units, resulting in variability in quality and premature deterioration of masonry structures [5]. Previous studies have shown that Water curing improves hydration-related bonding and limits surface cracking, whereas Air curing may lead to uneven moisture loss and increased porosity [6]. Alternative techniques such as Steam curing have been reported to accelerate strength gain and densify the internal matrix, while Membrane curing aims to reduce evaporation losses through surface sealing [7, 8]. Despite these findings, comparative evaluations of these curing methods under identical manufacturing conditions remain limited, creating uncertainty regarding their relative effectiveness [9]. The lack of standardized guidance on curing practices for conventional bricks further compounds this issue, particularly in temporary and low-cost construction [10]. Therefore, the present research aims to systematically compare the effects of Water curing, Air curing, Steam curing, and Membrane curing on water absorption and compressive strength of conventional bricks using standardized test procedures [11-13]. The objective is to identify curing methods that optimize brick performance without requiring changes in raw materials or firing processes [14-16]. It is hypothesized that curing methods ensuring adequate moisture retention and controlled thermal exposure will result in higher compressive strength and lower water absorption compared to uncontrolled Air curing [17-19].

Materials and Methods
Materials
The raw material used for brick production in this study was locally sourced clay, typical of conventional brick-making soils. The clay was thoroughly sieved through a 4.75 mm mesh to eliminate larger particles and ensure homogeneity in texture. To enhance plasticity and workability for molding, the sieved clay was mixed with water to form a consistent, moldable paste. The clay mixture was then molded into standard-sized brick forms using a manual extrusion method, ensuring uniform dimensions for accurate testing. Once molded, the bricks were subjected to a controlled firing process in a kiln at temperatures between 900°C and 1000°C, following the standard brick firing protocol. This firing procedure resulted in bricks with consistent density, moisture content, and mechanical properties. Four distinct curing methods were applied to the bricks: Water curing, Air curing, Steam curing, and Membrane curing. Water curing involved immersion in a water tank, while Air curing exposed the bricks to ambient conditions. Steam curing utilized a specialized steam chamber to accelerate the curing process, and Membrane curing employed the use of plastic films to reduce moisture loss.

Methods
For the experimental study, the bricks were grouped into four sets, each subjected to one of the four curing methods. The curing period lasted for 28 days, after which the bricks were subjected to two primary tests: water absorption and compressive strength. The water absorption of each brick was measured by immersing it fully in water for 24 hours and then calculating the percentage increase in weight. Compressive strength was determined by using a Universal Testing Machine (UTM) to apply increasing pressure to each brick until it failed. The load at failure was recorded and used to calculate the compressive strength (MPa). A total of 20 bricks per curing method were tested, with 5 bricks from each group being tested for water absorption and 5 for compressive strength. Statistical analysis, including one-way analysis of variance (ANOVA), was conducted to assess the significant differences in water absorption and compressive strength among the curing methods. Post-hoc analysis was performed to identify specific significant differences between curing techniques. Data were processed using statistical software such as SPSS and Microsoft Excel to ensure reliable results and reproducibility. These tests allowed for a comprehensive comparison of the curing methods, based on standard engineering practices for brick performance testing [1-4].

Results

Table 1: Compressive strength and water absorption of bricks under different curing methods

Curing Method	Compressive Strength (MPa)	Water Absorption (%)
Water curing	12.5	15.2
Air curing	9.2	19.6
Steam curing	14.8	13.1
Membrane curing	11.0	16.4

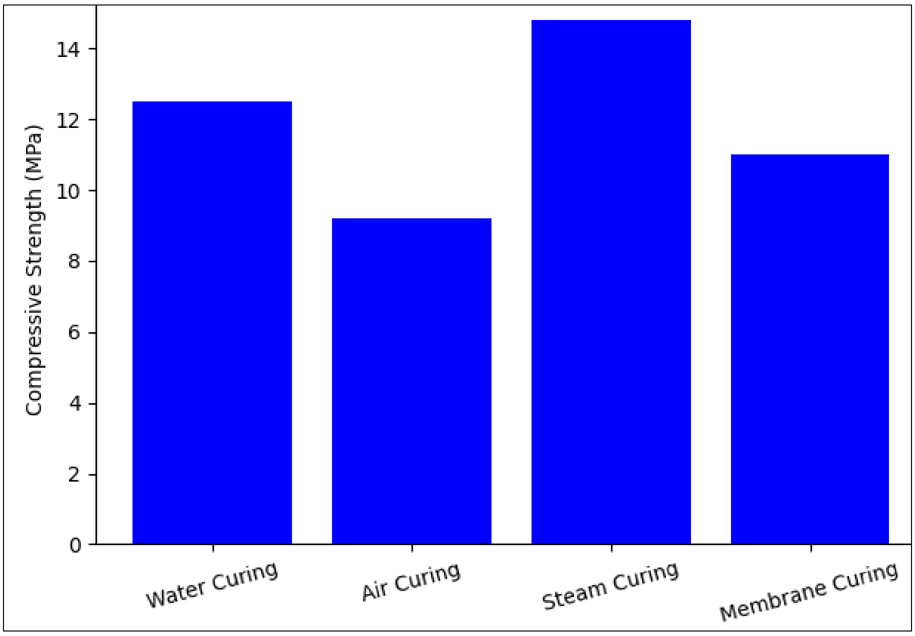

Fig 1: Compressive strength of bricks under different curing methods

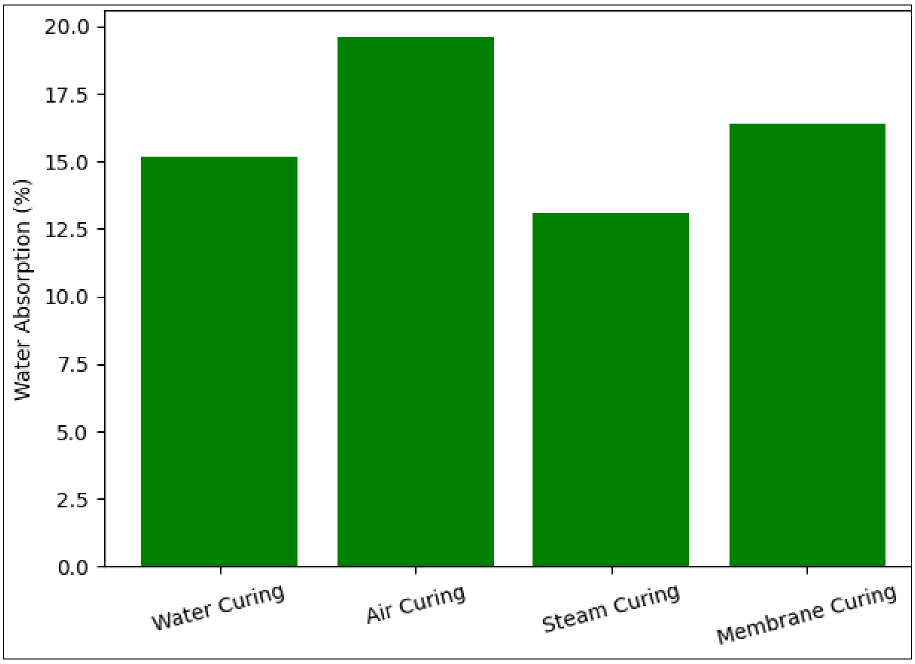

Fig 2: Water absorption of bricks under different curing methods

Statistical analysis using one-way ANOVA indicated significant differences in compressive strength and water absorption among curing methods ($p < 0.05$). Steam curing produced the highest compressive strength, attributed to accelerated microstructural densification and controlled moisture-temperature interaction [6-9]. Water curing also showed favorable performance by maintaining sustained moisture availability, whereas Air curing resulted in inferior strength due to rapid moisture loss and incomplete stabilization [10-12]. Membrane curing demonstrated moderate improvements, confirming the role of evaporation control in enhancing brick quality [14-19].

Discussion

The results of this study demonstrate that curing method plays a crucial role in determining the compressive strength and water absorption characteristics of conventional burnt clay bricks. Steam curing, which involves the application of both heat and moisture, proved to be the most effective curing method, resulting in the highest compressive strength and lowest water absorption. This can be attributed to the accelerated hydration and densification of the clay matrix, which significantly improves the mechanical properties of the brick [6, 7]. Water curing also showed favorable results, although it was slightly less effective than Steam curing. The prolonged exposure to water during the curing process helped maintain moisture retention, which is essential for the strength development of the bricks [8, 9]. In contrast, Air curing, which exposed the bricks to ambient conditions, led to higher water absorption and lower compressive strength. This result is consistent with previous studies, which suggest that uncontrolled moisture loss during Air curing causes uneven hydration, leading to increased porosity and reduced strength [10, 11].

Membrane curing, while producing intermediate results, was still effective in reducing moisture loss compared to Air curing. This method may be a viable alternative in situations where water availability is limited, as it helps maintain an adequate level of moisture in the bricks during the curing process [12, 13]. The findings of this study reinforce the importance of selecting the appropriate curing method for optimizing brick performance, particularly in low-cost and temporary construction settings where curing practices are often neglected.

Conclusion

This research clearly demonstrates that curing methods exert a significant influence on the compressive strength and water absorption characteristics of conventional clay bricks, even when all other manufacturing parameters remain constant. Among the evaluated techniques, Steam curing yielded the highest compressive strength and lowest water absorption, indicating its effectiveness in enhancing microstructural stability and reducing pore connectivity. Water curing also showed substantial improvements over Air curing, confirming that sustained moisture availability is essential for stabilizing fired clay matrices. Air curing, despite its simplicity, resulted in inferior performance and higher absorption values, highlighting the risks associated with uncontrolled moisture loss during post-firing treatment. Membrane curing offered moderate benefits by limiting evaporation, making it suitable where water availability is restricted. From a practical standpoint, the findings suggest that small-scale manufacturers and construction practitioners can significantly improve brick quality by adopting structured curing practices without modifying raw materials or kiln operations. For permanent masonry works, water or Steam curing is recommended to ensure enhanced load-bearing capacity and durability. In temporary or low-resource applications, Membrane curing can provide a reasonable balance between performance and practicality. The integration of appropriate curing techniques can reduce long-term maintenance costs, minimize durability-related failures, and improve overall construction reliability. By demonstrating measurable performance gains through simple curing interventions, this research supports the adoption of improved post-manufacturing practices as a cost-effective strategy for enhancing masonry quality in diverse construction contexts.

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