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Jhama Brick in Construction: A Sustainable Alternative

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Abstract

This research project aimed to assess the feasibility and potential advantages of substituting a portion of the coarse aggregate in concrete with Jhama brick aggregates. With concrete being a fundamental construction material, the selection of coarse aggregates significantly impacts its properties. Traditionally, natural resources like gravel and crushed stone are utilized, but concerns regarding resource depletion and environmental impact have spurred interest in alternative materials. Jhama bricks, commonly used in construction across various regions, possess proper- ties that make them promising candidates for replacing coarse aggregates in concrete partially. Laboratory experiments were conducted to evaluate the mechanical, durability, and workability properties of concrete mixes containing different proportions of Jhama brick aggregates. The findings offer valuable insights into the viability of Jhama brick aggregates as a sustainable alternative to conventional coarse aggregates in concrete construction. This research has potential implications for reducing the environmental footprint of concrete production and promoting the utilization of locally available materials.

Keywords

Jhama brick aggregates, Construction material, Replacement, Natural resources, Resource depletion, Environmental impact, Alternative materials

1. Introduction

S. Gupta and D. Srivastava Concrete is the cornerstone of modern construction, serving as the foundation for buildings, bridges, highways, and various infrastructure projects. The primary components of concrete include cement, water, fine aggregates, and coarse aggregates. Coarse aggregates, typically composed of gravel or crushed stone, play a critical role in providing structural strength and stability to concrete. However, the extraction of natural coarse aggregates has raised environmental concerns due to resource depletion and habitat disruption.[12][15][16]

Figure 1. Jhama Brick Aggregates

Jhama bricks (as shown in Fig.2) are a locally available construction material in many regions. They are known for their durability, strength, and thermal insulation properties [23,18]. Jhama bricks are produced by firing clay at high temperatures, resulting in hard, dense bricks suitable for load-bearing structures [1,24]. However, these bricks are stronger than typical burnt clay bricks. On occasion, they have even been proven to be stronger than first-class bricks. Bricks that have been over burned have a high compressive strength of 120 to 150 Kg/cm2 [10,11,13]. They are, however, in terrible state. These bricks require 40% more mortar than conventional bricks do in masonry. They are lightweight in comparison with traditional bricks [9].

Sustainable construction practices have gained momentum in recent years [19]. This includes the use of environment friendly materials, reduction of carbon emissions, and minimizing resource consumption. The utilization of Jhama brick aggregates aligns with these principles by promoting the use of locally available, sustainable materials.

Figure 2. Jhama Brick

2. Objectives of the Study

The primary objectives of this project are as follows:

- To investigate the feasibility of replacing a portion of conventional coarse aggregates in concrete with Jhama brick aggregates.
- To assess the compressive strength of concrete mixes containing Jhama brick aggregates.
- To evaluate the workability and durability characteristics of Jhama brick aggregate concrete.
- To analyse the environmental and economic implications of using Jhama brick aggregates in concrete construction.

3. Literature Review

Before The compaction factor decreased with increasing percentage of Jhama class brick, while unit weight also decreased compared to conventional concrete. Initially, concrete with Jhama class brick as coarse aggregate exhibited higher compressive strength at 20% and 40% replacement, but decreased at 60% and 80%. For instance, at 3 days, compressive strength was 6.08% and 10.02% higher than conventional concrete at 20% and 40% replacement, but 3.73% and 8.16% lower at 60% and 80%. Similarly, at 7 days, compressive strength was 9.23% and 12.08% higher at 20% and 40% replacement, but 5.69% and 9.25% lower at 60% and 80%. By 28 days, Jhama class brick concrete showed higher compressive, split tensile, and flexural strengths at 20% and 40% replacement, but strengths decreased at higher replacement percentages [4].

It has been noted that an increase in the percentage of over burnt brick up to 25% results in medium workability. However, workability diminishes significantly with 37.5% and 50% replacement. An increment in compressive strength, ranging from 6.01% to 11.50%, is observed when 12.5% to 25% of coarse aggregate is replaced by over burnt brick aggregate. Conversely, a decrease in strength, by 3.87% and 28.57%, is noted when 37.5% and 50% of coarse aggregate is replaced. Furthermore, a 3% cost saving is achieved if conventional concrete is substituted with over burnt brick aggregate up to 25% [3].

Brick bat concrete presents a cost-effective alternative to conventional concrete. Studies reveal a 3% increase in compressive strength with a 20% replacement of coarse aggregate by over burnt brick bat waste, yet a 3.3% decrease with a 40% replacement, while maintaining an aggregate cement ratio (A/C) of 4.2 and water cement ratio (W/C) of 0.45. Similarly, there is a 5.3% increment in tensile strength at 20% replacement, but a 12% decrease at 40%, alongside a 7.1% rise in flexural strength at 20%, and a 3.3% decrease at 40%. This suggests that over burnt brick bat waste can effectively substitute coarse aggregate up to 20%, enhancing compressive, tensile, and flexural strength in concrete compositions [4,17,30,21].

When the proportion of Jhama class brick grew and compared to ordinary concrete, the compaction factor dropped. When compared to ordinary concrete, the unit weight likewise reduced as the percentage of Jhama class brick decreased. Jhama class brick is used as coarse aggregate in concrete, which initially provides a better compressive strength for replacing 20% and 40% before declining for 60% and 80%. After three days of concrete age, the compressive strength was found to be 6.08%, 10.02% greater than that of conventional concrete when the coarse aggregate was substituted with 20% and 40% Jhama class brick aggregate, respectively [5].

The optimal replacement level for jhama brick aggregates is determined to be 15%, owing to its balance of strength and cost-effectiveness, making it suitable for use in loaded structures. Additionally, up to 15% of coarse aggregates can be substituted with brick ballasts. Similarly, the 25% replacement of jhama brick aggregates is deemed favorable for moderately loaded structures due to its advantageous blend of strength and economy. This investigation establishes that crushed bricks can be effectively utilized as coarse aggregates to produce concrete with satisfactory strength properties [20]. However, prior to endorsing their use in practical applications, it is imperative to conduct various tests on concrete with different proportions of replaced coarse aggregates [6].

Observations reveal that an increase in the percentage of Over Burnt Brick Bats results in a 3.7% rise in workability at

10%, whereas at 20% and 30%, workability declines by 15.38% and 23.07% respectively. Similarly, a 3.05% increment in compressive strength is noted at 10% replacement, while a decrease of 26.41% and 44.10% occurs at 20% and 30% replacements respectively, maintaining a water-cement ratio of 0.4. This pattern is reflected in both tensile and flexural strength. Over Burnt Brick Bats show promise in mass concrete filling areas and aid in preserving natural aggregate sources. The study concludes that Over Burnt Brick Bats can effectively substitute coarse aggregate up to 10% [6,22].

Based on the findings of an experimental investigation on crushed over burnt bricks as coarse aggregate for concrete, several insights emerge. These bricks' ballast finds application in lime concrete and road metal for foundational and flooring purposes. In concrete manufacturing, crushed over burned bricks can substitute river gravel as aggregates [27,28]. They serve as a viable alternative to natural aggregate to a certain extent, particularly for light applications, although replacing natural aggregate may diminish compressive strength. Utilizing burnt bricks as an alternative raw material contributes to sustainable development by recycling waste [25,26,29]. Moreover, as the percentage of overburnt bricks increases, the aggregate formed demonstrates higher strength compared to conventional concrete initially, but there is a subsequent loss in compressive strength with further increments in over-burnt brick content. [Rajeev Ranjan and Anubhav Rai (2023)]

4. Methodology and Tests

The materials required for preparing the mix design for M20 concrete includes cement, sand, coarse aggregates and Jhama brick aggregates. The size of concrete cubes used are 150*150*150 mm. The tests performed for materials are fineness test of cement, initial and final setting time of cement, sieve analysis of coarse aggregates and compressive strength test of Jhama brick (as shown in Table 1).

The concrete mix is first prepared and poured into the molds of 150*150*150 mm dimension. It is compacted uniformly and kept for a day to set (as shown in Fig.3). When the cube is set, it is placed into water for 7, 14 and 28 days for curing process (as shown in Fig.4). Traditional concrete cubes are made first and then concrete cubes with coarse aggregates replaced with Jhama brick aggregates by 5%, 10% and 20%, following the same procedure [14]. The cubes are kept in air to dry before testing (as shown in Fig.5). The compressive strength test of the concrete cubes is done using the Compression testing machine (as shown in Fig. 6 and 7). The test is performed after the cubes are kept in water for respective days.

Table 1. Tests performed for the study

S. No.	Tests	Results
1.	Fineness of cement	96.64% passing
2.	Initial Setting Time of cement	35 min
3.	Final Setting Time of cement	312 min
4.	Sieve Analysis of coarse aggregates	88% passing
5.	Compressive Strength test of Jhama brick	16.5 N/mm^2

Figure.3. Concrete mix poured into molds to set

Figure4. Concrete cubes placed into water for curing

Figure5. Concrete cube placed out of water for few hours to dry before testing

Figure.6. Compression Testing Machine

Figure.7. Cube in Compression Testing Machine

5. Cost Estimation

The cost estimation of the materials is shown below in Table 2.

Table 2. Cost Estimation

S. No.	Materials Used	Quantity	Amount
1.	Cement	48.96 kg	Rs. 300 (per 50 kg bag)
2.	Sand	85.68 kg	Rs. 13700 (Rs. 150 per kg)
3.	Coarse Aggregates	141.82 kg	Rs. 176 (per 50 kg)
4.	Jhama Brick Aggregates	13.6 kg	Rs. 150 (per 50 kg)

All the costs of materials are taken and calculated from 'STATE SCHEDULE OF RATES FOR 2023-24'.

6. Results and Discussions

We performed the test for 0%, 5%, 10% and 20% replacement of coarse aggregates with jhama brick aggregates in concrete mix of M20 and prepared cubes for 7, 14 and 28 days testing (as shown in Table 3 and in Fig. 8, 9, 10 and 11 as graph).

Table 3. Compressive strength test results

Replacement Percentage (%)	No. of Days	Compressive Strength (N/mm^2)			Average Compressive Strength (N/mm^2)	Average Compressive Strength as per IS 1077 (1992): Common Burnt Clay Building Brick
		Cube 1	Cube 2	Cube3		
0%	7	11.8	12.8	13.2	12.6	
	14	18.6	18.3	18.5	18.4	
	28	22.5	22.7	22.4	22.5	

5%	7	13.6	12.4	12.7	12.9	
	14	18.2	18.5	17.8	18.1	
	28	21.8	22.5	22.3	22.2	
10%	7	12.4	12.7	13.1	12.7	
	14	17.5	17.9	18.2	17.8	
	28	20.7	20.4	20.6	20.5	
20%	7	11.5	11.3	11.8	11.5	
	14	15.6	16.2	15.8	15.8	
	28	18.2	17.7	18.3	18.1	**15 N/mm²**

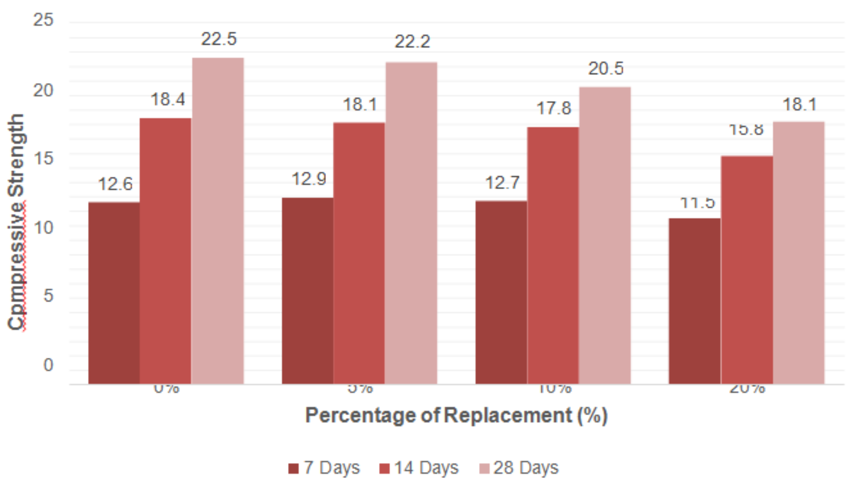

Figure 8. Graphical representation of Compressive Strength of the Concrete cubes

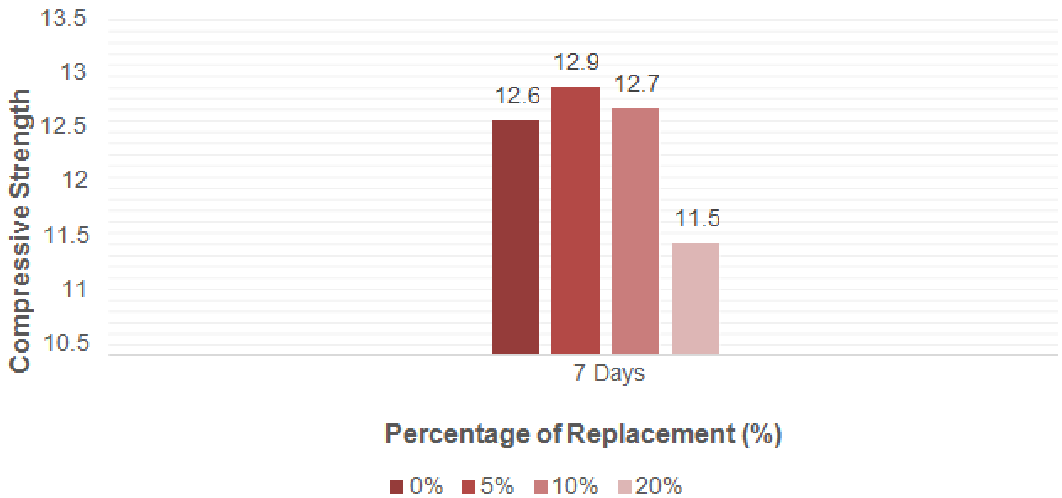

Figure 9. Compressive Strength at 7 Days

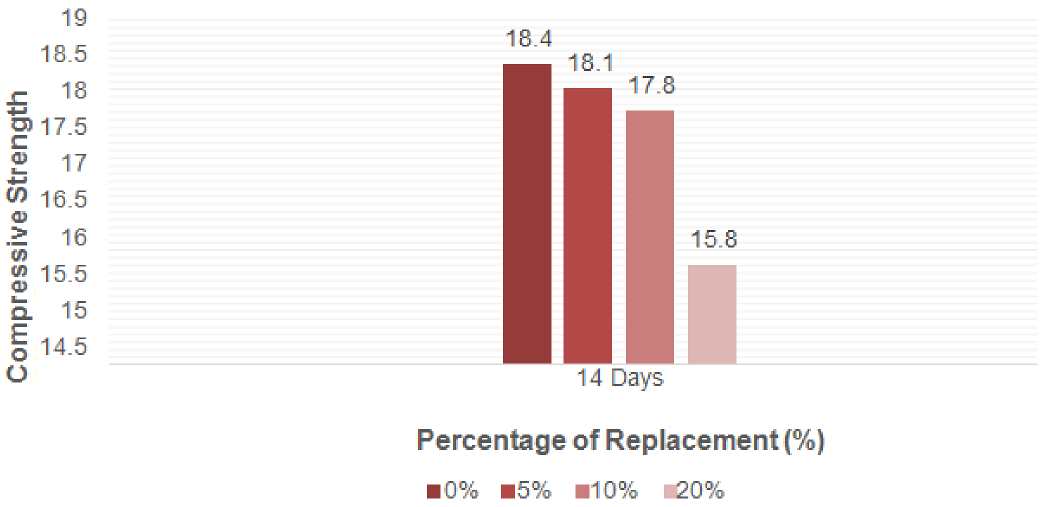

Figure 10. Compressive Strength at 14 Days

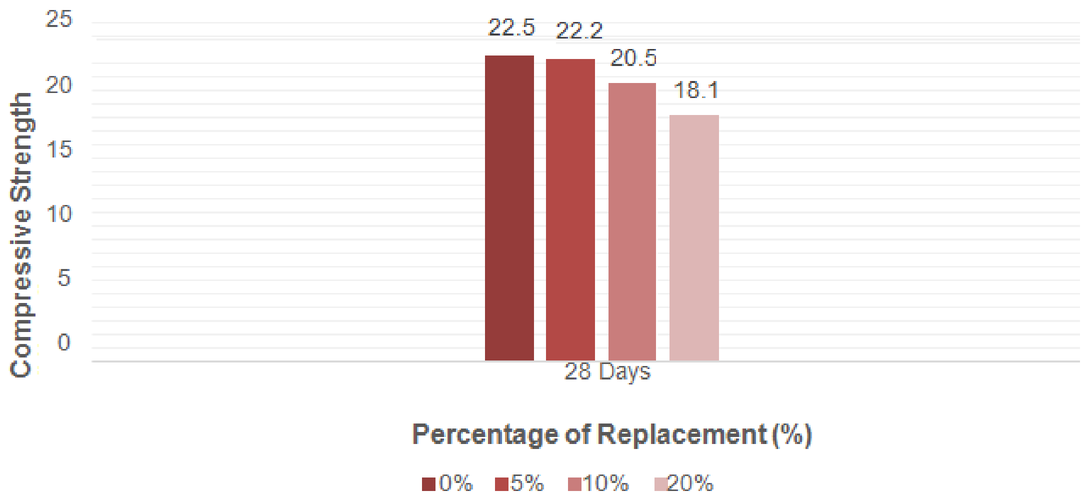

Figure 11. *Compressive Strength at 28 Days*

7. Conclusion

The observations concluded from the study are as follows:

1. The difference between the strengths of 0%, 5%, 10% and 20% replacement for M20 are not too much and hence making it useful as it suggests that they can withstand heavy loads without undergoing significant deformation or failure.
2. The water absorption test shows that Jhama bricks have a low water absorption rate, it signifies that they are less porous and have good resistance to moisture penetration. This is beneficial for preventing water-related damage and improving durability.
3. The cost of Jhama brick aggregates (50 kg) was Rs. 150 and that for coarse aggregates (50 kg) was Rs. 176. So, we had a saving of 14% if we use jhama brick aggregates in place of coarse aggregates.

4. As Jhama bricks are locally available or produced as a byproduct in brick manufacturing processes, it is cheaper as compared to the traditional ones. They contribute to sustainable construction practices by recycling waste materials and reducing the demand for natural resources. By utilizing jhama brick aggregates, the environmental impact associated with their disposal or production of traditional aggregates can be minimized.
5. Foundations are subjected to various environmental factors, such as moisture, temperature fluctuations, and chemical exposure, which can affect their durability over time. Concrete made with jhama brick aggregates should be assessed for durability to ensure long-term performance in foundation applications.
6. Concrete made with these aggregates results in a lighter weight material compared to traditional concrete mixes. This can be advantageous in applications where weight reduction is desirable, such as in precast concrete elements, lightweight concrete blocks, or in construction projects where structural load considerations are important.
7. The unique texture and appearance of over burnt jhama brick aggregates can be utilized to create decorative finishes in concrete surfaces. This can add aesthetic value to architectural elements such as facades, walkways, or outdoor landscaping features, providing a visually appealing and distinctive design.
8. In some cases, over burnt jhama brick aggregates can be used as structural fill material in construction projects, such as in backfilling trenches or excavations. This can help to reduce the need for importing or disposing of excess soil or aggregate materials.

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