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Investigating the Potential of Hybrid Bricks using Prosopis Juliflora and Betel Nut Shell Ash

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ABSTRACT

The increasing demand for sustainable construction materials has resulted in the efficient use of agricultural and biomass waste in brick production. This study examines the feasibility of utilizing hybrid bricks that incorporate Prosopis Juliflora ash and betel nut shell ash as partial substitutes in traditional brick manufacturing. The ashes' physical and chemical properties were examined and contrasted with normal brick-making materials. The ash was integrated in quantities of 10%, 20%, and 30% by weight into the brick mixture. The cast specimens were cured and evaluated for compressive strength, water absorption, density, and durability at 7, 14, and 28 days. The testing findings indicated that bricks with a 20% mixed ash replacement demonstrated optimal performance regarding compressive strength and satisfactory water absorption relative to other mix ratios. The research indicates that the application of Prosopis Juliflora Ash and betel nut shell ash can provide environmentally friendly hybrid bricks with adequate mechanical and durability characteristics, hence supporting sustainable construction methodologies.

Key words -Hybrid bricks Prosopise juliflora ash, Betal nut shell ash sustainable construction

1. INTRODUCTION

Fly ash, a fine powder produced as a byproduct of coal-fired thermal power stations, serves as the principal component in fly ash bricks, a category of construction material. This debris is repurposed to produce durable and enduring bricks instead of being discarded in landfills. This study investigates the partial substitution of fly ash with ash derived from Prosopis juliflora and betel nut shells. Fly ash bricks are produced by incinerating plant and agricultural waste to generate ash, which is subsequently mixed with fly ash, sand, cement, and water. The objective is to utilize a greater quantity of locally available waste materials and reduce the consumption of fly ash. The objective is to diminish the use of fly ash and optimize the use of locally sourced waste materials.

The fabrication of fly ash bricks entails the precise amalgamation of elements followed by the incorporation of water to form a uniform composition.
Subsequently, the mixture is transferred into molds and subjected to compression using a hydraulic press to achieve the requisite strength and form. To attain optimal hardness and durability, the bricks are hydrated for many days post-moulding. They do not require high-temperature firing in kilns, like traditional clay bricks do, resulting in energy conservation.
Utilizing Prosopis juliflora and betel nut shell ash in hybrid bricks offers several benefits. It reduces production expenses, mitigates environmental contamination, and facilitates waste management. These bricks provide

exceptional thermal insulation, are lightweight, and possess excellent compressive strength. They can be utilized for the construction of houses, compound walls, and several other edifices. This strategy promotes the use of eco-friendly building materials and sustainable construction practices.

2.MATERIALS

2.1 Cement

Cement is a major ingredient that serves as a binder in the manufacture of fly ash bricks. Portland Pozzolana Cement (PPC) is preferred for its strength and durability. When PPC is combined with fly ash and water, it generates a chemical reaction that produces strong binding agents, which then bind all the components together to form a solid brick. This also enhances the strength of the brick and helps to minimize the formation of cracks.

2.2 Prosopis Juliflora ash

Prosopis Juliflora Ash (PJA) is generated by the regulated combustion of Prosopis juliflora, an invasive species, followed by the fine grinding and sieving of the ash through a 300-micron mesh. It possesses a significant reactive silica concentration, imparting substantial pozzolanic characteristics. This enables a reaction with the calcium hydroxide generated during cement hydration, resulting in the formation of more cementitious materials. PJA serves as a substitute for fly ash, accelerating the hydration process, augmenting compressive strength, and filling micro-voids to produce a dense mixture with reduced permeability. This enhances durability and increases the mixture's resistance to moisture and chemical degradation, while also offering an eco-friendly alternative by converting invasive plant biomass into a valuable construction resource and diminishing the need on conventional fly ash.

2.3 Betel nut shell ash

Betel Nut Shell Ash (BNSA) is a fine powder produced by the regulated incineration of betel nut shells, an agricultural byproduct, followed by grinding and screening the resultant material through a 300-micron sieve. It possesses a substantial silica content and significant pozzolanic activity, enabling it to combine with calcium hydroxide during the cement hydration process to generate additional cementitious compounds. BNSA, when used as a fly ash additive, enhances compressive strength, diminishes permeability, and offers improved resistance to corrosion and chemical assaults. The fine powder diminishes the permeability of fly ash bricks, enhancing their compactness and strength. Conversely, the utilization of BNSA offers an efficient method for the disposal of agricultural waste independent of fly ash.

2.4 Fine Aggregate

Fine aggregates utilized in fly ash bricks consist of Msand with a particle size not exceeding 300 microns. These fine particles effectively occupy the interstices in the mixture and adhere appropriately to the cement paste, resulting in a cohesive and dense mass. They enhance the surface polish of the fly ash bricks and augment their overall strength and stability.

2.5 Fly ash

Fly ash utilized in the manufacture of fly ash bricks is a fine, powdery substance derived as a byproduct from the burning of pulverized coal in thermal power plants, typically with particle sizes under 0.075 mm. It has robust pozzolanic characteristics, interacting with lime in the presence of water to produce cementitious compounds that confer strength and durability to the bricks. Fly ash serves as the principal binding and filling agent, diminishing the reliance on natural clay while enhancing workability, uniformity, and surface polish. It facilitates the production of dense, dimensionally stable bricks with less water absorption.

2.6 Water

Water is incorporated into the blend of fly ash, cement, and manufactured sand to formulate a combination for fly ash bricks. The appropriate volume of water is essential for achieving the desired consistency and proper compaction of the mixture. Excessive water can diminish brick strength, cause cracks during drying, and result in shape and surface defects, whereas little water can produce a dry, brittle mixture that is difficult to mold and compact.

Table 1. Physical Properties of cementitious materials

Material	Fineness Test	Specific gravity Test
cement	4%	3.01
Fly ash	29%	2.8
Prosopis Juli flora ash	2.46	2.98
Betel nut shell ash	74%	3.04
Fine aggregate	2.4	2.65

3.MIX DESIGN AND METHODOLOGY

3.1 Casting of specimen

The fabrication of hybrid bricks with Prosopis Juliflora Ash (PJA) and Betel Nut Shell Ash (BNSA) is conducted in accordance with IS 12894:2002 standards. The ashes are generated by open combustion and filtered via a 150-micron sieve for consistent fineness. Fly ash is substituted with PJA and BNSA at levels of 10%, 20%, and 30%. The utilized materials comprise fly ash, manufactured sand as fine aggregate, and cement as the binder. All dry ingredients are meticulously combined in a hand mixer to guarantee consistency. Water is incrementally introduced to attain a malleable mixture, which is subsequently shaped and compressed into brick forms. The bricks are removed from molds and immersed in water for 7, 14, and 28 days to attain the necessary strength and durability.

4.TESTING OF SPECIMENS

4.1 Compressive strength tests

To perform a compressive strength test on bricks of 230 mm × 110 mm × 75 mm, initially select well-cured specimens (typically 7, 14, or 28 days old) and clean them to eliminate dust. The frog, if existent, must be filled with cement mortar (1:1 or 1:3) and permitted to cure for 24 hours to guarantee uniform load distribution. Accurately measure the dimensions to compute the loaded area. Position the brick with its flat face (bed face) oriented horizontally between the plates of a Compression Testing Machine (CTM). Apply load incrementally and uniformly at a steady rate until the brick experiences failure.Record the maximum load at failure. The compressive strength is calculated as load divided by the loaded area (N/mm²). Finally, repeat the test for at least 3 specimens and report the average value as the compressive strength of the brick.

Table 2. Compressive strengths test result ((N/mm^2)

Mix	7 DAYS	14 DAYS	28 DAYS
Normal Brick	9	121	16
Mix (10%)	10	13	17
Mix (20%)	13	14	15
Mix (30%)	12.5	11	14

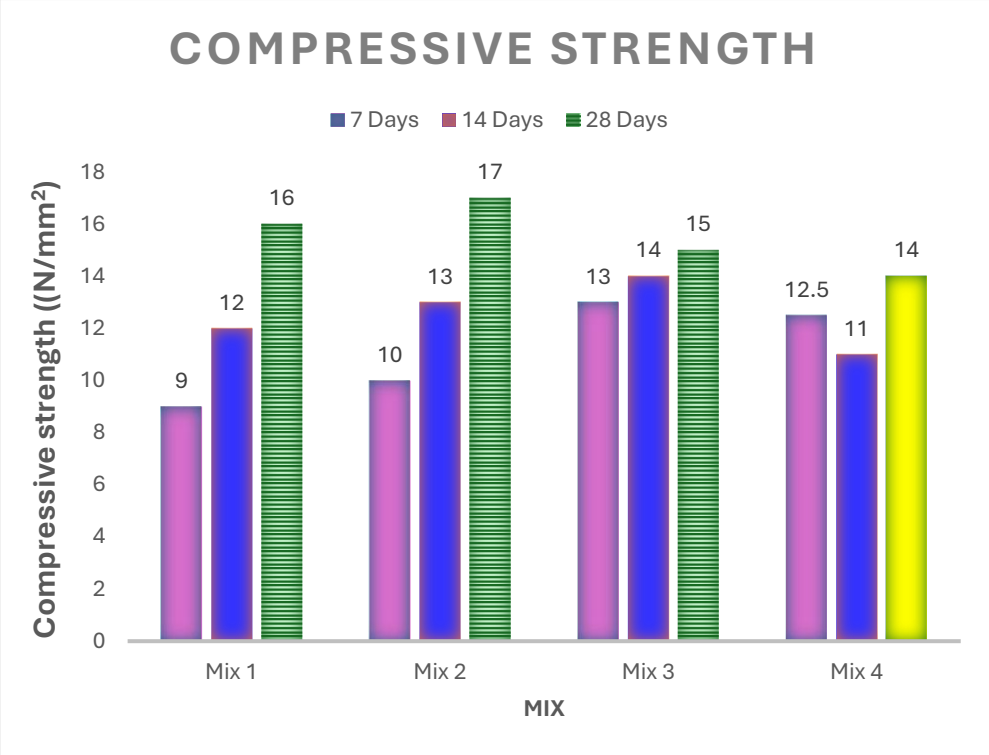

Fig.1 Test findings on compressive strength

4.2 Water Absorption Test

The water absorption test was performed to assess the durability of fly ash bricks with Prosopis Juliflora Ash and Betel Nut Shell Ash at ratios of 10%, 20%, and 30%. The findings demonstrated that all samples adhered to the allowable threshold of 20% according to standard requirements. An increase in ash percentage resulted in a slight elevation in water absorption due to the porous characteristics of betel nut shell ash, with the 10% substitution exhibiting the most compact structure. The use of these agricultural ashes preserves the brick's moisture resistance, rendering them appropriate for sustainable building.

Table 3.Water absorption test result

MIX DESIGN	DRY WEIGHT W1	WET WEIGHT W2	WA=W2-W1/W1*100%
10 %	3.1	3.18	6.45%
20 %	3.4	3.48	5.88%
30 %	3.2	3.29	6.25%

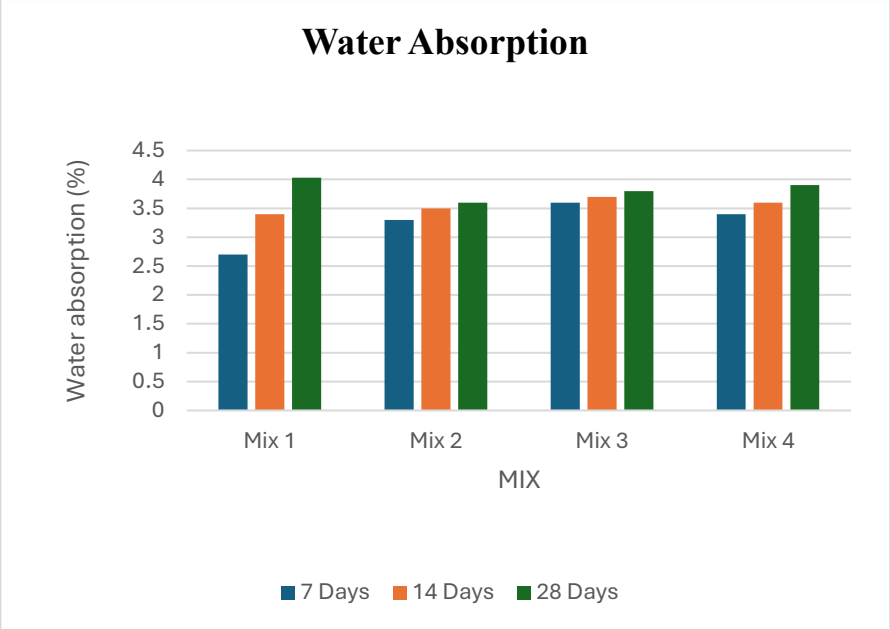

Fig.3 Test findings on Water Absorption

4.3 Efflorescence Test

In these fly ash bricks, fly ash is partially substituted with Prosopis juliflora and betel nut shell ash, which are partially immersed in water during the efflorescence test. This test detects soluble salts that may ascend to the surface as the brick dries. The soluble salts derive from the raw ingredients utilized in brick manufacturing. The brick surfaces exhibit minimum to slight white salt deposits, suggesting that the efflorescence of these modified fly ash bricks is negligible to slight. This verifies the appropriateness of these bricks for building, with negligible risk of surface discoloration..

5.DISCUSSION ON TEST RESULTS

The experimental investigation conducted on fly ash bricks with varying percentages (10%, 20%, and 30%) of Prosopis Juliflora Ash (PJA) and Betel Nut Shell Ash (BNSA) replacement revealed several noteworthy findings, as summarized below:

i. Compressive Strength:

The maximum compressive strength was observed at 20% replacement, showing optimal performance after 28 days of curing. This suggests that incorporating PJA and BNSA up to this percentage enhances the bonding properties of the brick. It is observed that the strength increases gradually from 7 to 28 days, indicating a stable hydration process. However, beyond 20% replacement, a slight decline in strength was noted due to increased porosity.

ii. Water Absorption:

The water absorption test results showed that all mix ratios remained within the permissible limit of 20%. While the addition of organic ashes slightly increases the water intake compared to conventional bricks, the 10% and 20% mixes exhibited excellent durability. This indicates that these agricultural waste ashes can be effectively used without compromising the brick's resistance to moisture.

iii. Efflorescence:

The efflorescence test on fly ash bricks with Prosopis juliflora and betel nut shell ash shows minimal to slight white salt deposits. This indicates that the modified bricks have negligible efflorescence. As a result, they are suitable for construction with minimal risk of surface staining. The use of these materials ensures durability and performance.

6. CONCLUSIONS

- The experimental work of this project involves the utilization of Prosopis Juliflora Ash (PJA) and Betel Nut Shell Ash (BNSA) as partial replacement materials in the production of hybrid bricks.
- The engineering properties of the bricks were assessed in terms of water absorption, compressive strength, flexural strength and split tensile strength.
- The maximum compressive strength is attained at 20% combined ash replacement i.e., 15N/mm² for 28 days of curing.
- The microstructural analysis indicates improved bonding and reduced voids in hybrid bricks containing PJA and BNSA, which enhances strength and durability.
- Based on these results, the utilization of Prosopis Juliflora Ash and Betel Nut Shell Ash minimizes waste disposal issues and promotes sustainable and eco-friendly brick production.

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