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UTILIZATION OF PADDY HUSK IN LIGHTWEIGHT BRICKS FOR SUSTAINABLE CONSTRUCTION AND WASTE MANAGEMENT

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ABSTRACT

The construction industry is a major consumer of natural resources and contributors to environmental pollution, primarily due to high embodied energy in conventional materials such as concrete and clay bricks. This study explores the innovative use of paddy husk, an abundant agricultural waste product in the production of lightweight bricks as a sustainable alternative. The bricks were formulated by mixing paddy husk with cement in a 1:1 ratio, molded into standard dimensions, and cured through air drying. Physical and mechanical tests demonstrated that the lightweight bricks are significantly lighter by approximately 8% over 7 days than traditional bricks, with compressive strength values comparable to commercial silica sand bricks; 4.3 to 6.3 N/mm². These bricks offer benefits including reduced structural load, lower carbon footprint due to lighter weight and reduced transportation emissions and improved thermal insulation. This approach addresses environmental challenges by managing paddy husk waste, reduces reliance on high-energy materials, and offers economic advantages through cost savings and rural income generation. The findings support the viability of paddy husk lightweight bricks for sustainable construction, aligning with global sustainability goals for responsible consumption and clean energy.

1. Introduction

The construction industry is a substantial consumer of natural resources and a significant contributor to environmental pollution. Traditional building materials like concrete and clay bricks have high embodied energy and substantial carbon footprints. As global demand for housing and infrastructure grows, there is an urgent need to develop sustainable and environmentally friendly construction materials. Lightweight bricks which also known as lightweight concrete blocks or aerated concrete blocks are an innovative alternative to traditional building materials like clay bricks and conventional concrete blocks. These bricks are designed to be lighter in weight while maintaining adequate strength and durability for construction purposes. They are typically made using lightweight aggregates; foams or by incorporating air voids within the material.

Recent advancements in sustainable building materials have highlighted the potential of using paddy husk in the production of lightweight bricks. Moreover, the disposal of agricultural waste, such as paddy husk poses a significant environmental challenge. Paddy husks a by-product of rice milling produced in large quantities globally as it accounts for 20 percent of rice grains. By that, almost 9 million tons of rice husks are discharged into the environment, a huge volume of waste which if not treated will cause pollution. This agricultural waste also often burned or dumped hence lead to air pollution and land degradation. Despite efforts to recycle and reuse agricultural waste, a substantial amount of paddy husk remains unutilized. Hence, the use of paddy husk not only addresses waste management issues but also aligns with the growing demand for eco-friendly construction solutions. The primary objective of this study is to explore the potential of using paddy husk in the production of lightweight bricks. This research also aims to address both the challenges of sustainable construction and the management of agricultural waste.

2. Methodology

2.1 Materials Selection

This study utilizes paddy husk as the primary material for producing lightweight bricks. Paddy husk (Figure 1) is chosen for its abundance, low cost, and beneficial properties such as lightweight and thermal insulation. Other materials include cement and water, necessary for binding and curing.

Figure 1. Paddy husk

2.2 Brick Formulation

The formulation involves mixing paddy husk with cement in 1:1 ratio to create a homogenous mixture. The ratio of paddy husk to cement is optimized to ensure the bricks are lightweight yet strong enough for construction purposes.

2.3 Production Process

The manufacturing process starts with mixing the paddy husk, cement, and water thoroughly. The mixture is then poured into moulds of standard brick dimensions. After moulding, the bricks are subjected to a curing process by air and sun drying, to achieve the desired strength and durability (Figure 2).

Mixing process of paddy husk, cement, and water

Moulding process to standard brick dimensions

Curing process by air drying

Lightweight Brick

Figure 2. Production process of lightweight brick using paddy husk

2.4 Experimental Design

Various tests are conducted to evaluate the physical and mechanical properties of the lightweight bricks produce. The tests include density measurement and compressive strength. All sample had been tested at Centre of Excellence for Engineering and Technology (CREATE), Public Works Department Malaysia, Alor Gajah, Melaka. Density tests were conducted to ensure the bricks are lightweight and compressive strength test were conducted to assess the load-bearing capacity.

2.5 Product Analysis

The final process was product analysis which compared this lightweight brick with traditional bricks. This includes assessing their strength, weight and overall suitability for construction. The analysis also considers the environmental benefits, such as reduced carbon footprint and effective waste management, resulting from using paddy husk.

3. Results and Discussion

The lightweight brick with paddy husk as aggregates materials had been tested with several methods to determine its physical and mechanical properties.

3.1 Physical Properties

As for physical properties, the weight was measured on day 2, day 4 and day 7 involving 9 lightweight bricks sample (Table 1). The weight was 8% lighter on day 7 compared to day 2. The dimension brick test was conducted based Test Standard: MS 1933-16: 2017 Method of test for masonry unit – Part 16: Determination of dimensions (First revision) at CREATE, Alor Gajah, Melaka as showed in Figure 3 for bricks samples with 14 days of age. The results showed the mean of dimension of the sample (length x width x height) were 213.3mm x 106.4mm x 63.3mm.

Table 1. Mean of samples weight by day

	Day 2	Day 4	Day 7
Mean weight (g)	1580 g	1530 g	1460 g

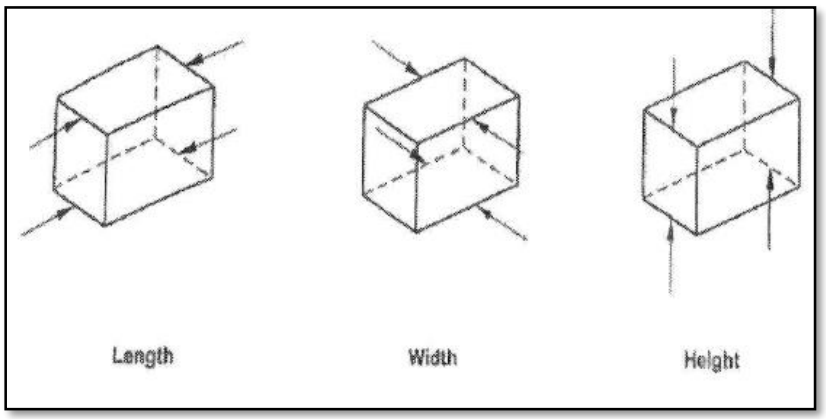

Figure 3. Measurement position (CREATE, Alor Gajah, Melaka)

3.2 Mechanical Properties

As for mechanical properties, brick compressive strength test was conducted based on Test Standard: MS 1933-1: 2017 Method test for masonry units – Part 1: Determination of compressive strength (First revision) at CREATE, Alor Gajah, Melaka. Result of compressive strength from 3 samples brick as showed in Table 2.

Table 2. Compressive strength test report

	Maximum load (kN)	Compressive Strength (N/mm^2)	Mean compressive Strength (N/mm^2)
Brick 1	88.1	3.9	
Brick 2	75.0	3.3	4.5
Brick 3	142.2	6.3	

3.3 Product Analysis

To determine the functionality of lightweight brick for construction purposes, product analysis was conducted by comparing the sample with commercial brick which are clay brick and silica brick.

Table 3: Product analysis of lightweight brick to commercial brick

Type of Bricks	Weight (kg)	Compressive Strength ($N/mm^{2)}$
Lightweight brick	1.4 – 1.7	4.3 – 6.3
Clay brick	2.5 – 3.5	15.0 – 90.0
Silica sand brick	2.1 – 2.3	2.5 -7.0

Result showed that, lightweight bricks have the lighter weight compared to other type of bricks. Hence, it can act as better materials for mobile building structure as it will be easy to move and handle. It can also reduce a carbon footprint by reducing fuel consumption while transporting as low weight consume less energy and resulting in lower greenhouse gas emissions (Shaheen and Lipman, 2007). As for compressive strength, clay bricks are the strongest, whereas the other two types of bricks exhibit similar but lower strength in comparison. However, lightweight bricks possess similar strength to commercial silica sand bricks, thereby confirming their functionality as building materials. Rice husk showed a strong potential to replace cement by up to 10% to 20% without compromising concrete performance in terms of workability, strength, and durability (Endale *et al*., 2023).

4. Conclusion

In conclusion, this study discovers the innovative use of paddy husk in producing lightweight bricks which offering significant environmental and economic benefits. By repurposing agricultural waste, this study also addresses the pressing issue of waste management, reducing the environmental pollution caused by the disposal of paddy husk which align with Sustainable Development Goals (SDGs) 12; Responsible Consumption and Production. Additionally, using paddy husk in brick production can lower the carbon footprint of the construction industry by replacing traditional, high-energy materials as silica with a renewable resource which align with SDGs 7; Affordable and Clean Energy. These lightweight bricks also provide better thermal insulation, enhancing the energy efficiency of buildings and reducing heating and cooling costs. Economically, this approach can lower the cost of building materials due to the

low cost of paddy husk, making construction more affordable. It also creates additional income opportunities for rice farmers, contributing to rural economic development. The study's findings can guide policies and practices in sustainable construction and waste management, promoting greener building practices and aligning with global sustainability goals.

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