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"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition

Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

Bauchemic (Malaysia) Sdn Bhd

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PALMCRETE LINTEL

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Abstract
Sustainability is increasingly crucial in concrete construction as awareness of environmental degradation and climate change grows. The conventional method of producing concrete is notorious for its significant release of greenhouse gases, particularly carbon dioxide from cement manufacturing. Furthermore, palm oil mill effluent poses environmental risks, contaminating air and water, and impacting human health with respiratory and cardiovascular issues. This study investigates the potential of oil palm shells (OPS) as lightweight aggregates in concrete, varying the OPS percentages to optimise mechanical strength and workability.
The objectives include determining the optimal OPS ratio in mix designs for adequate mechanical strength, assessing workability through OPS replacements with acceptable water absorption rates, and identifying the benefits of utilizing OPS waste in construction. Field experiments in a concrete lab analysed four OPS specimen variations to enhance both strength and workability. Moulds with different OPS percentages were fabricated using iron casts and other materials. Tests measured compressive strength, flexural strength, water absorption, and ultrasonic pulse velocity. Results highlighted the mix design's significant role in achieving strength, lightweight properties, and sustainability simultaneously. Oil palm shells, as a byproduct of the palm oil industry, offer promise in construction due to their lightweight nature, heat insulation properties, and environmental benefits. This study evaluates their practicality and commercial viability, specifically in precast lightweight concrete lintels, underscoring their potential contribution to sustainable building practices.

Keywords: *Oil palm, lightweight and material in construction*

1. INTRODUCTION

The construction industry is a major consumer of concrete, the primary building material (Aslam et al., 2016). This sector heavily relies on both renewable and non-renewable resources such as water, sand and gravel. With an annual global consumption estimated at 7.5 billion tons, concrete production significantly impacts natural stone reservoirs and contributes to ecological imbalances (Paidar et al., 2021; Vandanapu et al., 2018). However, several challenges impeded the optimal utilisation of OPS in concrete. The incorporation of OPS can lead to a reduction in mechanical strength, particularly in compressive and flexural strength (Shafigh et al., 2014; Nadh, 2021; Shafigh et al., 2012). The high-water absorption capacity affected the workability of concrete, posing challenges in construction practices (Alengaram et al., 2013; Nadh, 2021; Shafigh et al., 2012). The disposal of waste from coal and palm oil industries poses environmental challenges, and the high cement content in lightweight aggregate concrete contributes to sustainability issues (Muthusamy et al., 2021). The massive production of palm oil wastes in Malaysia, particularly oil palm shell (OPS) waste and palm oil fuel ash (POFA). These by-products pose environmental challenges when disposed of in landfills, leading to health and environmental issues (Ul Islam et al., 2016).

This project aims to investigate the sustainable concrete performance of workability and durability using oil palm shell as a lightweight aggregate. In achieving this aim, several research objectives have been developed as follows:

a) To investigate the suitable OPS percentage in mix design for acceptable mechanical strength.
b) To evaluate the workability in different percentage of OPS replacement for acceptable water absorption.
c) To identify the benefits of waste materials like OPS for the construction industry.

The literature surrounding concrete construction emphasises the imperative to mitigate environmental impact and enhance sustainability. Conventional concrete production is recognised for its high carbon footprint due to significant CO2 emissions from cement manufacturing. Additionally, concerns over palm oil mill effluent highlight environmental contamination and health risks associated with its disposal. Studies have explored alternative materials like oil palm shells (OPS) as lightweight aggregates in concrete, focusing on their potential to improve mechanical properties while reducing environmental impact.

The study conducted field experiments in a concrete lab to assess the performance of OPS in concrete mixes. Four OPS specimens were fabricated with varying percentages to optimise mechanical strength and workability. Moulds were created using iron casts and other materials to standardise the specimen production. Testing included measurements of compressive strength, flexural strength, water absorption, and ultrasonic pulse velocity to evaluate the effectiveness of OPS in enhancing concrete properties.

Results from the experiments demonstrated that adjusting OPS percentages in concrete mixes significantly influenced mechanical properties. Mix designs incorporating OPS showed improved compressive and flexural strength compared to traditional concrete, highlighting OPS's potential as a lightweight aggregate. The study also indicated that OPS reduced water absorption and enhanced the sustainability profile of concrete, aligning with global efforts to adopt environmentally friendly building materials. Overall, the findings underscored the feasibility of utilising OPS waste from the palm oil industry to enhance concrete performance while reducing oil palm impact.

2. MATERIALS AND METHODS

The materials used to perform the Palmcrete lintel were Oil palm shells, and they were sourced as a byproduct from the palm oil industry. They underwent a thorough cleaning, drying, and processing phase to eliminate impurities before being utilised as lightweight aggregates in concrete mixes. OPS were selected for their lightweight properties, ability to provide thermal insulation, and potential to decrease the environmental impact associated with traditional concrete production.

Ordinary Portland Cement (OPC), a widely used binding agent in construction, was employed in the concrete mixes. OPC was chosen for its availability and reliable performance in achieving the desired strength and durability necessary for construction applications. Sand served as a fine aggregate in the concrete mixes. Sand contributed to the workability and strength of the concrete, playing a crucial role in filling voids between larger aggregates and ensuring overall cohesion.

Crushed stone acted as the coarse aggregate in the concrete mixes. It provided structural integrity and stability to the concrete, essential for achieving the required compressive strength and durability in construction projects.

Potable water was used for mixing concrete batches. Water played a critical role in the hydration process of cement, facilitating the chemical reaction that binds the ingredients together. It also contributed to the overall workability and consistency of the concrete mixes during preparation.

Figure 2.1 Process of Palmcrete lintel

Figure 2.1 shows the method to produce the Palmcrete Lintel, the mix design process aimed at finding the right amounts of cement, OPS, sand, and crushed stone to achieve specific concrete properties. Different percentages of OPS were tested to see how they affected mechanical strength, workability, and durability. We followed standard concrete mix design principles, considering OPS's lightweight nature. Concrete specimens were made in a controlled lab setting. The moulds were made using iron casts and other materials to ensure all specimens were the same size and consistent. We prepared multiple batches of concrete with varying OPS percentages to see how they performed in terms of compressive strength, flexural strength, water absorption, and ultrasonic pulse velocity.

3. RESULTS AND DISCUSSION

This chapter presents an experimental investigation into using oil palm shell (OPS) as a lightweight aggregate in concrete, focusing on both destructive and non-destructive tests. Destructive tests, such as compressive and flexural strength tests, assess OPS concrete's load-bearing capacity and failure characteristics, crucial for structural applications. Non-destructive tests, like ultrasonic pulse velocity, evaluate concrete integrity and durability without damage, providing insights into internal structure and long-term performance. OPS concrete is anticipated to offer reduced density and satisfactory compressive strength, making it viable for weight-sensitive applications. Results from non-destructive tests are expected to demonstrate consistent internal structure and effective OPS distribution within the concrete matrix.

Following the guidelines specified in BS EN 12390-3 (2009), the test was conducted on 100 mm concrete cubes using a GT-7001-LACU compression testing machine with a maximum capacity of 3000 kN. The load was applied at a rate of 3.0 N/sec. Results were obtained by averaging the measurements of different specimens cured for 7 and 28 days. The cube compressive strength can be determined by dividing the load by the unit area, applying the equation 3.1 as adopted from BS EN 12390-3 (2009).

$$fc = \frac{f}{\mathrm{Ac}} \qquad \text{(Equation 3.1)}$$

fc is the compressive strength, in megapascals (N/mm²);
F is the maximum load at failure, in newtons.
Ac is the cross-sectional area of the specimen on which the compressive force acts, calculated from the designated size of the specimen.

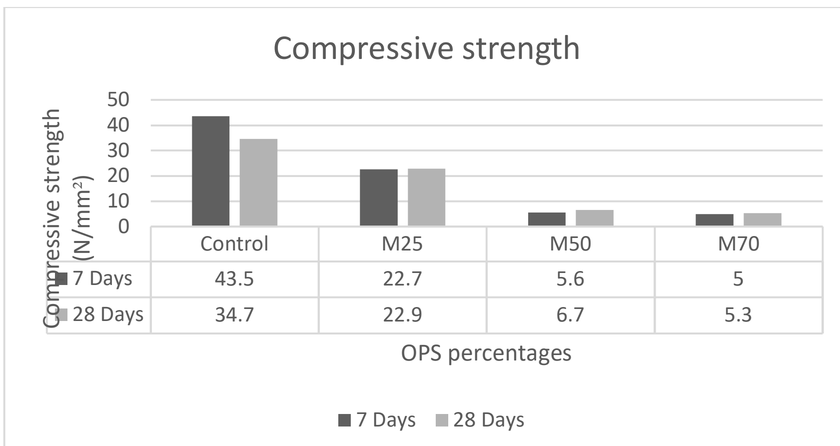

Figure 3.1 Chart of compressive strength

Figure 3.1 shows that from Control to M25, M50 and M70, there is a consistent decrease in compressive strength. Hence, we can argue that OPS content impacts compressive strength. Higher OPS percentages lead to lower compressive strength. The consistent decrease in compressive strength achieved by OPS contributes to its suitability as a sustainable lightweight aggregate, while still maintaining acceptable levels of strength necessary for structural components like doors or windows to withstand specified loads.

4. CONCLUSION

The study confirms that incorporating oil palm shells (OPS) as lightweight aggregates in concrete mixes can enhance mechanical properties such as compressive and flexural strength. This supports the principle that OPS, as a sustainable alternative aggregate, offers viable solutions to reduce the environmental footprint of concrete construction. The optimised mix designs demonstrated improved performance compared to conventional concrete, indicating the potential of OPS to contribute positively to sustainable building practices. However, challenges such as variability in OPS quality and availability may affect consistent performance in concrete mixes. The study identified that achieving optimal mechanical strength requires careful calibration of OPS percentages and thorough quality control during production. Variations in OPS characteristics, such as particle size and density, could pose challenges in achieving uniformity across different batches of concrete.

The findings have significant theoretical and practical implications for the construction industry and environmental sustainability. The theoretical implication lies in validating OPS as a viable alternative aggregate, promoting its adoption to reduce carbon emissions associated with conventional concrete production. Practically, incorporating OPS in concrete offers a sustainable solution that meets performance standards while mitigating environmental impact. This supports global efforts towards sustainable development goals and green building certifications.

In conclusion, Palmcrete Lintel offers numerous benefits that make it a superior choice for construction. It's easy to install and store due to its lightweight nature, which also reduces labour and transportation costs. This innovative product promotes economic growth by providing new revenue streams for farmers and supporting rural economies. Palmcrete Lintel embodies sustainable construction practices by recycling agricultural waste and reducing carbon emissions. Additionally, it is thermally efficient, providing better insulation and energy savings. As an eco-friendly alternative, Palmcrete Lintel reduces the overall environmental impact of building projects, making it a smart and responsible choice for the future of construction.

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