

UNIVERSITI TEKNOLOGI MARA

EFFECT OF KENAF CORE AS FINE
AGGREGATE REPLACEMENT
MATERIAL TO BRICK
PROPERTIES FOR NON-LOAD
BEARING WALL APPLICATION

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ABSTRACT

Transformation of agricultural and industrial waste into a functional construction material is a crucial step in reducing environmental implication and supporting a circular economy. In Malaysia, the kenaf core, a low value by product of kenaf cultivation, and quarry dust, the residue of quarrying are normally discarded despite their potential value as construction materials especially as fine aggregate replacement. This disposal practice is particularly problematic given that conventional sand cement bricks are extremely dependent on natural aggregates, which causes resource depletion and greenhouse gases that can be avoided through reutilization of these easily accessible waste products. But very few research works have fully utilized the combined use of quarry dust and kenaf core in mechanical and fire properties for non-load bearing wall systems. The aim of this study was to develop, investigate, and evaluate the feasibility of substituting Kenaf Core Fine Aggregate (KECOFA) in the production of brick as a fine aggregate. Objectives included establishing the best mix design, developing a database for KECOFA properties of the bricks, comparing wall performance and failure mode, and fire resistance and hose stream performance testing. The experimental plan involved sequential optimisation where at first to set the amount of quarry dust replacement, then incremental KECOFA replacement as variable in Design Expert software with Response Surface Methodology (RSM) to identifying the optimum brick mix design. The optimum mix design obtained was then used in further to investigate the performance in comparison with four control bricks which are 100% river sand (M1), 100% quarry dust (M5), 100% KECOFA (M6), and 50% river sand-50% quarry dust (M4). Laboratory testing included physical, mechanical, thermal, and fire performance characteristics. The optimal mix, 10% KECOFA and 50% quarry dust with cement sand ratio of 1:8 recorded a compressive strength of 8.16 N/mm² and density of 1830 kg/m³, comparable to regular bricks and superior to 100% KECOFA bricks. Water absorption (21%) and porosity (30%) were within acceptable levels. In terms of thermal performance, the inclusion of kenaf core reduced thermal conductivity by introducing porous structures that enhanced insulation. The optimum mix (M10) balanced thermal insulation with adequate strength and durability, making it suitable for non-load bearing walls. Wall specimens were able to withstand up to 100 kN axial loads with failure behaviour similar to conventional units. Fire testing also confirmed compliance with standards, with the optimum mix brick wall also providing 7 minutes of insulation time compared to other brick walls. This research is the first to optimize and evaluate a KECOFA quarry dust composite brick for mechanical and fire performance in non-load bearing applications. Beyond that of achieving technical specifications, the research deepens the understanding in cellulosic based aggregates' bonding behaviour, forms a new industry-ready database of properties of KECOFA brick, and is in line with Malaysia's green construction policies. The findings offer the brickmaking sector a bio-composite, lightweight alternative to conventional products where reducing the consumption of natural aggregates, stimulating demand for the kenaf core, and recycling agricultural and quarry wastes to create valuable, sustainable building products.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Issues relating to the sustainability and green technologies have been the main key of concern in the industries and become one of the government policies. Recently natural sand was becoming costly material because of its demand in the construction industry. Some alternatives materials have already been used as a replacement of natural sand such as quarry dust which is the mineral type of waste. Either than mineral waste types of aggregate, there are also utilization of agriculture waste and lignocellulosic waste as fine aggregate in concrete and mortar. Agriculture waste such as sunflower stalk, corn cob and rice husk ash, while lignocellulosic waste such as hemp shiv and flax core shows some positive impact towards the properties of concrete and mortar. One of the lignocellulosic wastes that available in Malaysia is kenaf core. However, utilization and application of kenaf core in Malaysia still very low and there is limited review on the application of kenaf core to the construction and building materials industries available.

Kenaf is scientifically known as *Hibiscus Cannabinus* L. Kenaf planted on a large scale in Malaysia as an alternative plan for tobacco. In 2018 around 2068 hectares of kenaf were planted in Malaysia (LKTN, 2015). Kenaf was planted for its fibres. The fibres are highly in demand by the industries, especially for composite industries. However, agricultural waste from kenaf commercialization activity is unavoidable. This lignocelluloses plant produces 35-40% of commercial fibre and 60-65% of lignocelluloses waste or also known as kenaf core. The unbalance demand has cause the kenaf core produce and stored at Lembaga Kenaf and Tembakau Negara (LKTN) was abundance and eventually become waste. The generation of this waste poses a major disposal problem now that burning is being actively discouraged by the Department of Environmental Malaysia (DOE).

This is an alarm to the industries and researcher to utilize kenaf core in suitable industries and one of it is on the masonry industries. As to support the initiative stated in Sustainable Development Goal 2020 (SDG) that related to affordable and clean energy (7), industry, innovation, and infrastructure (9), sustainable cities and