A REVIEW ON POTENTIAL OF KENAF CORE AS NEW ROOFING MATERIAL IN MALAYSIA WEATHER

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ABSTRACT: The rapid development of housing now requires a solution to the use of alternative materials as a new roofing material by considering several important factors such as the availability of materials, green materials, local materials, cost, manufacturability, strength, environmental friendliness and long-term use durability in today's Malaysian weather. Literature review on roof, type of roofing material, current roof material, kenaf as potential natural material, and relevant testing on roof are discussed and prediction on potential are proposed. This manuscript review on potential of kenaf core as new roofing material specifically in Malaysia weather.

KEYWORDS: *Kenaf Core; Roofing Material; Roofing Design; Manufacturability; Malaysia Weather.*

1.0 INTRODUCTION

Today, the main commercial roofing materials are made from the main types of raw materials which are cement, clay, and iron. All these raw materials have their own advantages and disadvantages such as the weight of the roof (need a strong support structure), easy to crack / micro crack (the natural nature of cement and clay that is brittle when dry), heat conductor - source of hot roof temperature (close molecules - conductive), moderate strength (easy to break/ dent if exposed to external impact), useless conductors and sound generators (non-sound insulating properties), rust/ moss/ undergrowth (effect of being exposed to current climate conditions and a certain period of time). Based on the current challenge, a new alternative material is needed so that the current lack of roofing material can be reduced.

Kenaf is a commercial plant that has been in Malaysia for a long time and is aggressively used as one of the green alternative materials to replace the use of jute and flax which are not produced in Malaysia. Until today, no scientific study shows the use of kenaf core in the production of structural or semi-structured products, especially for outdoor use. Studies on kenaf core are mostly focused on non-structure applications such as sound absorbers and light board form.

All products that are exposed to the real environment at prolonged will experience deterioration in the value of mechanical and physical properties. Malaysia, which has quite extreme weather (plus the humidity factor and UV exposure) will accelerate the decline in product performance. Until today, no scientific studies have been found to study the exposure of house roofs in tropical climates in Malaysia.

Based on the statement of this problem, it shows that this review study is important and relevant to find and understand the potential of kenaf core for future roofing material that can be use in Malaysia one day.

2.0 ROOF

A roof is the uppermost part of a building or structure that covers and protects the interior space from the weather elements. It acts as a barrier against wind, sunshine, excessive heat, and wetness, such as rain or snow. The major purpose of a roof is to preserve the safety and dryness of a building's interior while also providing insulation and ventilation to maintain a pleasant internal climate. Since then, human intelligence has advanced and are able to invent machines or devices that can make our daily routine easier and faster. In line with this advances the house design also have been through some development, where each country has embedded their own culture when design and building the houses without disregard the climate of the country or places [1]. There are clear differences in the design of the house and the material that was used as a roof.

The continent which has hot climate such as Asia, Australia, America and Africa they adopted green roof in the constructions elements in building their houses [2]. These houses use an environmental material which does not require a manufacturing process to use it. The material to make a house back then, are easier to collect and does not require a lot of human resources and tools to build it. This reflect in Malaysian house design in the early period where the houses were made very tall as a caution to when the region experience flooding [3]. But it does come with great disadvantages such as it is flammable, weak and prone to rot. In Figure 1 shows different example of house design that are found in places that had hot climate. This design is assimilated with their culture and based on the weather experienced in the region. The house designs that are found in Africa have a rounded shape which possibly for air ventilation. Europe houses had a cone-shaped design which may be because of snow. This design can prevent the snow from sticking onto the roof and make it fall. Other than that Asia and America had similar design, nothing abnormal. The design may because to provide better air entering the house.

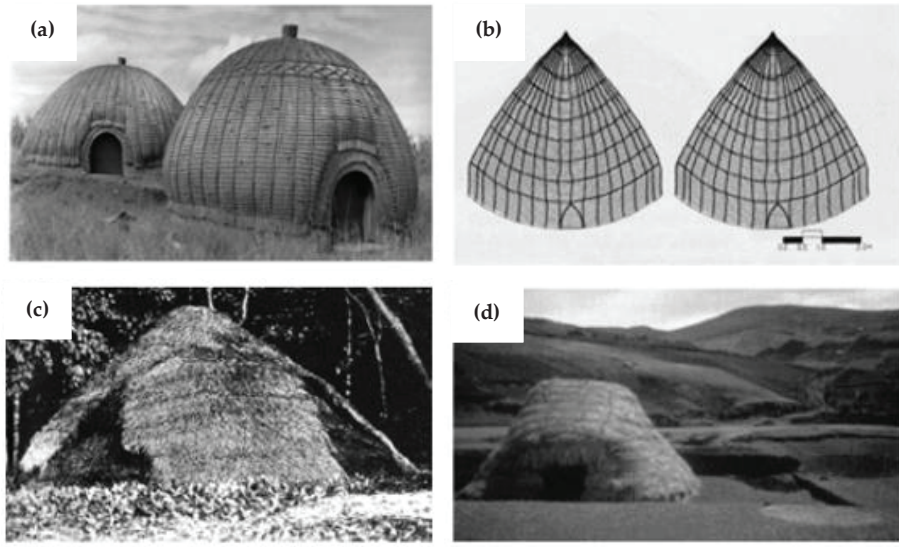

Figure 1: Example of roof in hot climate (a) africa, (b) europe, (c) america, (d) asia [2]

The primary function of a roof is to provide protection and shelter from the weather elements, such as rain, snow, wind, sunlight, and extreme temperatures. A building's internal space and contents can be protected by a well designed and built roof, which can keep out water and other environmental elements. In addition to offering protection, roofs are crucial for establishing a cozy and secure indoor atmosphere. Roofs do have a role in a building's energy effectiveness. The amount of heat that enters a building, for instance, can be reduced with the use of a roof that is intended to reflect sunlight, which can lower cooling expenses in the summer. A building's roof design may enhance its aesthetic appeal. An attractive and well-designed roof can improve a building's overall appearance and make it mix in with its surroundings.

2.1 Type of Roof

The roof's purpose is to keep out bad weather and to provide shelter. Each country has its distinctive design. The influence of local culture is due to variations in each type of design. Figure 2 shows the different types and designs of roof houses. Design (a) the gable roof is popular due to the straightforward design of the roof timbers and the rectangular shape of the roof sections. Gable roof is a simple, triangular-shaped roof with downward slopes on either side of a ridge. This avoids details that take a lot of work or cost and are prone to damage. Design (b) hipped roof is a type of roof in which all the sides slope downward to the walls, usually with a fairly gentle slope, design (c) hip and valley roof, design (d) hipped roof with dutch gables, (e) skillion roof. According to Tominaga et al. [4], a roof's pitch has a major influence on the flow of the environment surrounding the building. Every one of these designs has its own set of benefits.

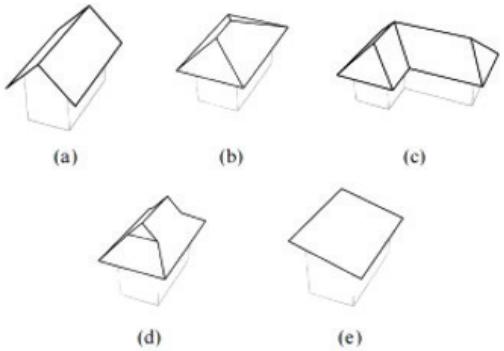

Figure 2: Type of roof (a) gable, (b) hipped, (c) hip and valley, (d) hipped with dutch gables (e) skillion [5]

2.2 Type of Roofing Materials

A clay roof, also known as a tiled roof, is a type of roof covering made from fired clay. One of the oldest and toughest types of roofing materials, clay roof tiles have been used for thousands of years. Homes built in the Mediterranean, Spanish, and Southwestern architectural styles frequently have clay roofs, which are renowned for their toughness, beauty, and energy efficiency. Clay roofing tiles come in a variety of forms, dimensions, and hues, and they can be made to complement almost any architectural design. They can be glazed or unglazed and come in a variety of finishes, from smooth to textured. Each tile is fastened to the roof decking or battens with nails or clips when it is normally set in an overlapping manner. Aside from that, Amin [6] found that they are typically sold in their natural earthy color, earning them the nickname "terracotta tiles," but they can also be glazed in a color of any choice before being baked into shape. One of the key benefits of clay roofs is their durability. Clay tiles as shown in Figure 3(a) can last for several decades or even centuries with the right upkeep since they are resistant to fire, insects, and rot. Additionally, clay tiles are great insulators, keeping homes warm in the winter and cool in the summer, which can lower energy costs.

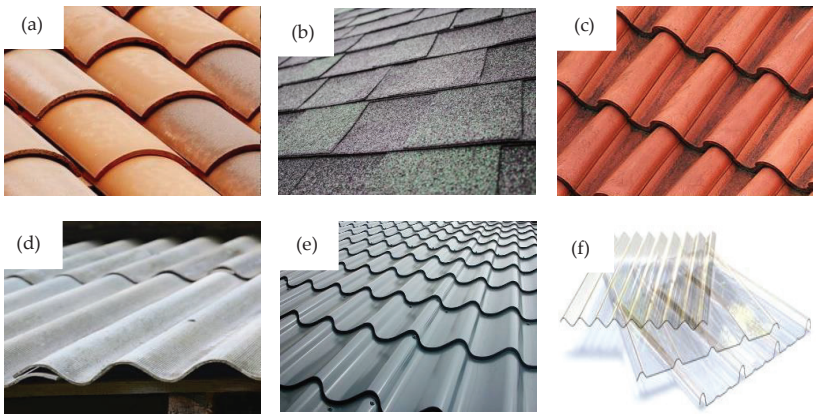

Figure 3: Type of roofing meterial (a) clay [7], (b) asphalt [8], (c) concrete [10], (d) asbestos cement [12], (e) metal [14], (f) polycarbonate [15]

An asphalt roof as shown in Figure 3(b) is a type of roofing material made from asphalt and fiberglass, commonly referred to as a composition shingle roof. It is one of the most widely used roofing materials in North America and is renowned for being inexpensive, long-lasting, and simple to install. Asphalt shingles, which are normally rectangular in shape and stacked one on top of the other, are used to construct asphalt roofs. The shingles are created from a fiberglass mat that has an asphalt coating and is then covered in granules for color and texture. From classic three-tab shingles to architectural or dimensional shingles that resemble other roofing materials like slate or wood, asphalt roofs come in a variety of colors and designs. One of the main benefits of asphalt roofs is their affordability. When properly maintained, asphalt roofs, which are one of the most affordable roofing options, can last up to 20 – 30 years. They may be mounted on most types of roofing structures without the need for extra support because they are also reasonably lightweight. Williams [9] have demonstrated that even newer and tighter adhering seal strips can present challenges when repairing relatively new roof surfaces. Besides, Porter [8] mention the bottom line is that simply removing and replacing damaged shingles in an area that appears to require repair will not necessarily restore the roof's functionality or service life. They reported that asphalt-composition shingles are essentially separate pieces interwoven into a mat of material that covers and protects the roof from the elements. Apart from this, each shingle relies on and supports the integrity of the shingles around it. As a result, the roof must be evaluated as a whole, rather than as individual shingles.

A concrete roof is a particular kind of roof constructed from concrete, a powerful and long-lasting building material. Concrete roofs are frequently utilized in commercial, industrial, and residential structures and come in a variety of shapes and sizes. A form or mold is first built on the roof structure to create a concrete roof, and then cement, sand, and water are poured into the form. The form is removed once the concrete has dried, and the finished roof is left in place. Additionally, Syaiful [10] describes that a concrete roof is a building material composed of cement, sand, stone, and water that hardens to a stone-like mass. Furthermore, as indicated by Eugênio et al. [11] despite the fact that several studies on iron ore tailing in cementitious composites could be found in the literature due to the aforementioned benefits, no studies on the use of such waste in concrete roof tiles, which have gained attention in recent years due to their practicality, aesthetics, resistance to weather conditions, attractive price, easy fitting, and over 50-year lifespan in most climates. Concrete roofs as shown in Figure 3(c) offer several benefits, including strength, durability, and fire resistance. They can withstand strong winds, hail, and other harsh weather conditions. Concrete roofs can also be made in a variety of colors, textures, and finishes, offering a wide range of customizing possibilities. Concrete roofs do have some disadvantages, though. Given their potential weight, additional structural support might be needed. Additionally, they might be more expensive than other kinds of roofing materials and might need specialized installation and upkeep.

A roof type with asbestos fibers is called an asbestos roof. Due to its heat resistance and durability, asbestos, a naturally occurring mineral, was once widely used in the construction industry. Buildings built between the 1930s and the 1970s frequently had asbestos roofs, especially industrial and commercial structures. They were also utilized in residential structures, especially for affordable housing. Aside from that, as shown in Figure 3(d) asbestos cement sheets are a type of construction material that is commonly used in roofing and siding. In 2022, Soroushian et al. [13] found that to improve weather resistance and corrosion resistance, asbestos fibers were mixed into cement. Because it was lighter than heavy cement also asbestos cement sheeting was popular. Moreover, asbestos also increased the durability and resistance of cement sheets to heat and weather. According to him again, roofing and other building materials can become weathered and damaged as they age. As a result, asbestos cement sheets may emit asbestos fibers into the air. However, it was later discovered that exposure to asbestos fibers can lead to serious health problems, including lung cancer and mesothelioma. As a result, the use of asbestos in construction was banned in many countries, including the United States.

A metal roof is a type of roofing material made from metal panels or shingles. Due to its strength, energy efficiency, and aesthetic appeal, metal roofs are a popular choice for both residential and commercial buildings. Metal roofs are frequently constructed from steel, aluminum, or copper, and they can be covered with a variety of coatings to improve both their functionality and aesthetic. There are several different types of metal roofs that can be placed, such as standing seams, corrugated, and shingle-style. One of the main benefits of metal roofs is their durability. Metal roofs can endure up to 50 years or more with good maintenance and are resistant to damage from wind, hail, and fire. They may be fitted on most roofing structures without the need for extra support because they are lightweight. Furthermore, in Figure 3(e) shows the metal roof tile. Koumbem et al. [14] reported that the results show that, for the same geometric parameters, the earth roof terrace and earth tile roof improve thermal comfort by lowering the interior temperature by 5 °C and 4.6 °C, respectively, in comparison to a corrugated metal roof.

A type of thermoplastic material known as polycarbonate is used to create polycarbonate roofing. Lightweight and strong polycarbonate roofing is a popular choice for both residential and commercial construction projects. Because of its great impact resistance, polycarbonate roofing is renowned for being resistant to damage from hail, wind, and other sorts of severe weather. Additionally, it is UV-resistant, so exposure to sunlight won't cause it to age or turn yellow over time. Polycarbonate roofing is available in a variety of colors and styles, including clear, opaque, and tinted. It can be installed in a variety of roofing configurations, including flat and pitched roofs. Moreover, Polycarbonate as shown in Figure 3(f) is the best transparent or semi transparent roofing material because it is a very durable material with 200 times the impact resistance of glass while weighing half as much [15]. As a result, it can withstand a wide range of climates and environmental impacts. It can also be carried, moved, handled, and installed with ease because of how light it is. Injuries on the job site may be decreased because it is also less prone to fracture or break during installation than heavier roofing materials.

3.0 KENAF CORE

Kenaf core refers to the inner woody part of the kenaf plant stem that remains after the fibrous outer part is removed. The kenaf core is also known as the hurds or shives, and it makes up about 30-40% of the plant's total biomass. The kenaf core is composed of cellulose, hemicellulose, and lignin, and it has several potential uses Besides, it has rigid open cell structures, and it is not easy to compact. However, the applications of kenaf core are still little in the industry but it will have a high potential for developing if there are more studies are carrying out. Currently, most of the use of kenaf core materials are as absorbents especially in animal bedding material or paper products as it is excellent in water absorption. Unlike other filling materials, kenaf core is biodegradable at the same time provides perfect water absorption and low dust content [16]. Preparation of kenaf core fraction from Lips et al research in 2009, they were performed by dry fractionating with a stack of vibrating DIN 4188 sieves while kenaf pith was manually separated from core particles. They stated that the large kenaf particles originate mainly from the bottom part of the stem and that contains only 1 to 2% of pith material. It is obvious that despite the high absorption capacity, differences in amount of pith cannot be the only cause of the higher absorption of the fraction with the large core particles. They believed that internal structure of pores and water transport vessels of the large particles or a different chemical composition must be the reason for the higher water absorption. However, in this research that covered with gypsum-based ceiling application, large kenaf core size are not preferable as it will decrease the performance of composite due to the reinforcement dislocation interactions. Figure 4 shows variotion of kenaf core size.

Figure 4: Kenaf core size (a) 20 mm; (b) 10 mm; (c) 20 mesh; (d) 40 mesh

4.0 FUTURE POTENTIAL AND CONCLUSION

This technical review reveal that, there are huge potential of kenaf core can be used as new roof material in Malaysia climate. Figure 5 shows new design using kenaf core will be further fabricate and investigate more to meet local culture need, strength and manufacturability. This design shape called as singgora roof tile.

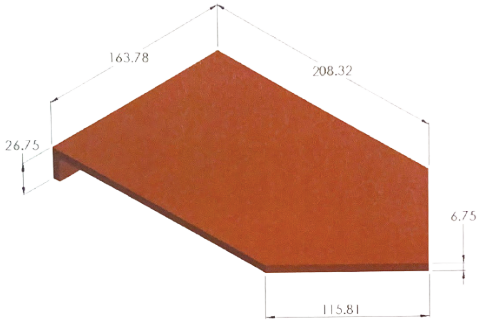

Figure 5: Proposed future prototype using kenaf core called as singgora

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REFERENCES

[1] S. Rashid, N. Baharuddin and K. Alauddin, "The history and transformation of perak malay traditional house", *Malaysian Journal of Sustainable Environment*, vol. 8, no. 1, pp. 71-86, 2021.

[2] F. Abass, L.H. Ismail, L.A. Wahab and A.A. Elendi, "A review of green roof: definition, history, evolution and functions", *I0P Conference Series: Materials Science and Engineering*, vol. 713, no. 1, pp. 1-8, 2020.

[3] N.W. Chan and D.J. Parker, "Response to dynamic flood hazard factors in peninsular malaysia", *The Geographical Journal*, vol. 162, no. 3, pp. 313-325, 1996.

[4] Y. Tominaga, "Computational fluid dynamics simulation of snowdrift around buildings: past achievements and future perspectives", *Cold Regions Science and Technology*, vol. 150, pp. 2-14, 2018.

[5] M. Ponni and B. Rajaram, "Comparative study of different types of roof and indoor temperatures in tropical climate", *International Journal of Engineering and Technology*, vol. 7, pp. 530-536, 2015.

[6] Sh.K. Amin, N.M.F. Ashmawy, M.F. Abadir, "The use of tannery waste in the preparation of clay roof tiles", *Construction and Building Materials*, vol. 325, no.126393, pp. 950-618, 2022.

[7] L. Shiyu, W. Runkai, Y. Jin, P. Xingqian, C. Yanyan and T. Bingxiong, "Effectiveness of the anti-erosion of an MICP coating on the surfaces of ancient clay roof tiles", *Construction and Building Materials*, vol. 243, no. 118202, pp. 950-618, 2020.

[8] K. Porter, "A Benefit-Cost Analysis of Impact-Resistant Asphalt Shingle Roofing", Institute for Catastrophic Loss Reduction, Toronto, no. 72, pp. 1-66, 2022.

[9] C. Williams, "Use of the repairability assessment method for evaluating asphalt composition shingle roof repairs." *Journal of the National Academy of Forensic Engineers*, vol. 37, no. 1, 2020.

[10] S. Syaiful, "Additional betonmix to increase the strength of concrete press", *ARPN Journal of Engineering and Applied Science*, vol. 16, no.15, pp. 1583-1589, 2021.

[11] T.M.C. Eugênio, J.F. Fagundes, Q.S. Viana, A.P. Vilela and R.F. Mendes, "Study on the feasibility of using iron ore tailing (iot) on technological properties of concrete roof tiles", *Construction and Building Materials*, vol.279, no. 122484, 2021.

[12] E. Raczko, M. Krówczyńska and E. Wilk, "Asbestos roofing recognition by use of convolutional neural networks and high-resolution aerial imagery", Building and Environment, vol. 217, no. 109092, pp. 360-323, 2022.

[13] P. Soroushian, A. Balachandra, S. Nassar, R Weerasiri, N. Darsanasiri and mN. Abdol, "Effect of fiber type and content on the performance of extruded wood fiber cement products, *Case Studies in Construction Materials*, vol. 16, p.968, 2022.

[14] W.N.D. Koumbem, I. Ouédraogo, W.D.A. Ilboudo and P.F. Kieno, "Numerical study of the thermal performance of three roof models in hot and dry climates", *Modeling and Numerical Simulation of Material Science*, vol. 11, no.2, pp. 35-46, 2021.

[15] T. Molkens and B. Rossi, "On the simulation of real fire for post fire resistance evaluation of steel structures", *Fire Technology*, vol. 57, no.2, pp. 839-871, 2021.

[16] N.F. Alias, H. Ismail and K. Ishak, "The effect of kenaf loading on water absorption and impact properties of polylactic acid/ natural rubber/ kenaf core powder biocomposite", *Materials Today: Proceedings*, no. 17, pp.584-589, 2019.