A SHORT REVIEW ON POTENTIAL OF KENAF CORE IN CEMENTITIOUS FOR ACOUSTICAL ABSORBER MATERIAL

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Article History: Received xxxxx; Revised xxxx; Accepted xxxx

ABSTRACT: Natural fibers, including kenaf core, possess significant potential as substitutes for synthetic fibers due to their high absorbency, eco-friendliness, cost-effectiveness, and low density. Consequently, the utilization of natural fibers has garnered considerable interest among researchers, particularly in industries such as aircraft and automotive, where they are employed as reinforcements to create composite materials with superior strength properties. However, despite extensive research on natural fiber-based composites for concrete reinforcement, there have been limited studies exploring the application of kenaf core in acoustical panels.This study aimed to experimentally examine the effects of different sizes of kenaf core in the development of acoustical panels. The acoustic panels were then subjected to impedance tube testing, which focused on evaluating their performance across low, medium, and high frequency ranges. The fabrication process and testing methods adhered to the ASTM E1050-09 standard. Overall, kenaf core exhibits tremendous potential for development due to its cost-effectiveness, high performance, and biodegradability. The utilization of natural fibers, including kenaf, can significantly reduce material costs compared to synthetic fibers. This review paper will revealed latest information related to potential of kenaf used in cementitious application for acouctical optimization.

KEYWORDS: *Kenaf Core; Cementitious; Acoustical; Absorber Material; Green Materials.*

1.0 INTRODUCTION

Several studies have revealed that natural fibre has huge potential to replace the synthetic fibre in acoustical application. Since natural fibre comes from plant material, it becomes the main focus due to its cost, availability, low density, good mechanical properties, eco-friendliness and biodegradability characteristic as mentioned by Siakeng et al. [1] and it offers remarkable advantages over synthetic fibre. Besides that, it can also be used as a replacement for convectional fibres, such as carbon glass, aramid and others. Zhu et al. [2] concluded that natural fibre should have the same mechanism for acoustic absorption as other conventional synthetic fibrous materials such as glass fibre and mineral wool [3]. These fibres are often light and they are not harmful to human health and therefore can be used in room acoustic products and noise barrier as sound absorber. Mohanty and Fatima [4] have reported that so many studies have been discovered on the eco-friendly and biodegradable materials such as jute [4], hemp [5], cotton, coir, banana leaf and kenaf [6] for noise control applications. There are some of natural fibre such as jute, sisal, banana and coir that can be made into composite panels with a suitable resin for sound absorber application as they have low density and cost application that is similar to synthetic reinforced composites. It can be concluded that natural fibres have huge potential to replace synthetic noise materials according to their similar acoustic mechanical properties. Therefore, in this paper review, it focuses on potential to uses kenaf core in cementitious for acoustical performance for future application in acoustical absorber materials.

2.0 KENAF FIBER AND CORE IN PREVIOUS RESEARCH

Radzuan et al. [7] claim that the extruded, moulded, and non-woven products made from kenaf bast fibre have good flexural strength and good tensile strength. According to Arjmandi et al. [8], cellulose, hemicellulose, lignin, waxes, and a few water-soluble chemicals make up the majority of plant fibres, with cellulose, hemicellulose, and lignin serving as the main elements. According to Lim et al., [6] findings, the coefficient of variation of the kenaf fibre sample rose with increasing thickness. Table 1 shows the thickness and mass of the kenaf fibre.

Table 1: Thickness and mass of the kenaf fibre [6]

Thickness, t (mm)	**75**	**60**	**50**	**40**	**25**
Mass, m (g)	**6.0**	**4.8**	**4.0**	**3.2**	**2.0**

Figure 1 shows the results of the normal incidence absorption coefficient of 75 mm, 60 mm, 50 mm, 40 mm and 25 mm thickness. Based on the results obtained, the fibre thickness of more than 40 mm fluctuates at high frequency from 0.8 to unity. The sound absorption performance of kenaf fibre is similar to the sound performance coefficient of synthetic rock wool.

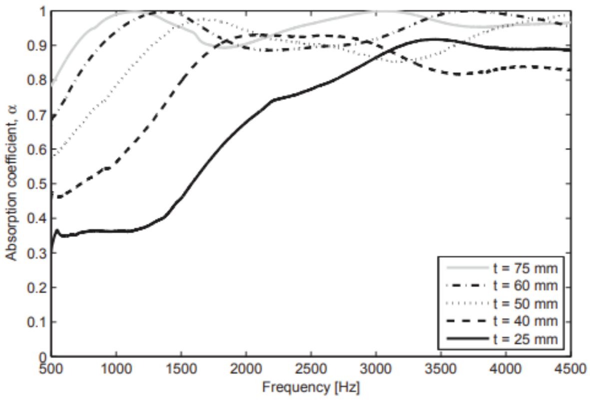
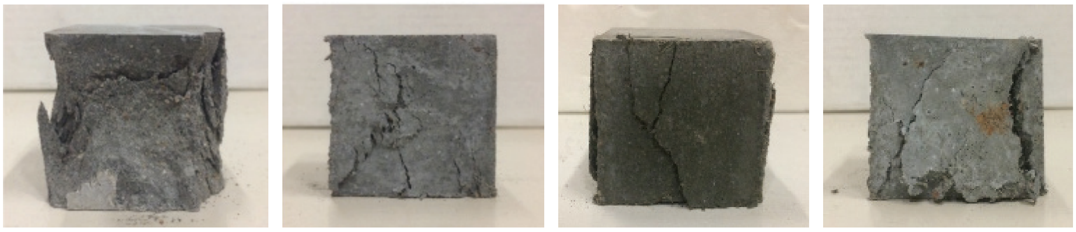


Figure 1: Absorption coefficient of kenaf fibre of varied thickness with constant bulk density of 93.5 kg/m^3 [6]

In 2022, Awoyera et al. [9] published a paper in which they described kenaf core is almost similar to fine aggregate and has a potential to replace sand. Besides, it is useful in production of insulation board low, density particle boards, fire retardant-treated particle boards polymer composites, thermos-acoustic applications and sound barriers [6].

According to earlier research by Shahar et al. [10], kenaf fibres and cores are more affordable and stronger than other natural fibres. Three distinct techniques, including hand harvesting and retting, decorticator machines, and whole stalk harvesters, can be used to obtain kenaf fibres. They added that the core fibre would be totally ground into powder in order to produce kenaf powder. According to Taban et al. [11], because it is mostly made of carbon, hydrogen, and oxygen, kenaf can function as a porous material. We can therefore draw the conclusion that kenaf fibre and kenaf core have the potential to absorb more noise due to their better porosity behaviour.

According to Baghban and Reza [12], researchers are continuously striving to enhance concrete mixtures not only to improve various properties but also to minimize their environmental impact. In line with these objectives, the utilization of additional cementitious materials (SCMs) and fiber-reinforced concrete (FRC) has gained traction. The use of natural fibers presents an intriguing option from a sustainability perspective, especially as fibers are increasingly replacing steel reinforcing bars in concrete applications. Kenaf fiber, a widely available non-wood plant fiber, exhibits a relatively high tensile strength (930 MPa), a high Young's modulus (53 GPa), and is cost-effective, making it a favorable choice for reinforcement in cement composites, as supported by Zhou et al. [13]. Abdalla et al. [14] conducted an investigation revealing that the kenaf fiber concrete exhibited a hardness index approximately three times higher than that of the control concrete. The microstructural analysis also demonstrated strong bonding between the concrete matrix and kenaf fibers. Figure 2 showcases kenaf fiber-reinforced concrete with varying fiber content.



(a) (b) (c) (d)

Figure 2: Kenaf fibre-reinforced concrete (a) 0%, (b) 1%, (c) 1.5%, (d) 2% [13]

Based on Saravanan and Buvaneshwari [15], fibre reinforced concrete is composed of cement, water, fine and coarse aggregate, and discontinuous discrete fibres. The natural isolated fibre known as sisal is frequently used. The leaves of the sisal plant are used to make it. A form of concrete that uses sisal fibres is known as sisal fibre reinforced concrete (SFRC). Sisal fibre reinforced concrete is a material that can be used to enhance the engineering attributes of many fundamental materials, including fracture toughness, flexural strength, and resistance to fatigue, impact, thermal shock, and spalling.

3.0 ACOUSTICAL PROPERTIES BY NATURAL MATERIAL

There are many researchers try to find some alternative materials and have been comprehensively applied in the making of acoustical panel to minimize the noise level. The common acoustical panels are made from synthetic fibre which commonly of glass fibre, glass foam and other materials that can possibly be very harmful to the environment at the same times towards the human society [16]. Taban et al. [17] stated that passive noise reduction techniques are commonly used using sound-absorbing materials. These porous or fibrous acoustic absorbers typically have pores, canals, cracks, or cavities where acoustic energy is lost due to friction between air molecules and the walls and viscous effects and converted into heat, resulting in acoustic absorption over a broad frequency range. These acoustic panels are the ideal material for noise suppression in the construction, building, and transportation industries since they are lightweight, affordable, and have excellent formability.

According to Kishore et al. [18], natural fibres have a porous structure that provides excellent acoustic performance. When porous material is exposed to accidental sound waves, the air within the pores vibrates and transforms into different energy types. Because natural fibres are environmentally friendly, biodegradable, cost-effective, and have no negative effects, they are referred to as green materials. Fibre geometry, such as diameter, length, cross-section shape, and regularity, has a considerable impact on acoustic characteristics. The impedance tube approach was used to characterise the sound absorption measurement. Without the use of a binder, the acoustic properties of natural fibres such as kenaf, wood, hemp, coconut, cork, cane, mineralized wood, and cardboard are investigated . The mineralized wood and dense kenaf have the highest airflow resistivity.

In 2012, Saad and Kamal [16] demonstrated that kenaf core as a particleboar in their research. Saad and Kamal prepared particleboard to study the effect of resin loading with three different densities board of 350 kg/m^3, 450 kg/m^3 and 550 kg/m^3 of urea formaldehyde resin loadings of 8%, 10% and 12 % respective;y. This particular study found that particleboars with high kenaf fibre and UF loading showed less sound absorption coefficient. The sample diameter were prepared in two different diameter which is 100 mm to measure frequency range 125 Hz to 1600 Hz and 28 mm for frequency range of 1200 Hz to 6000 Hz. The result obtained from the sound absorption coefficient with 8% and 10% UF loading show that they can become a good sound absorber compared to a UF loading of 12%. It was found in low, medium and high sound frequency. Saad and Kamal [16] revealed that the lower the value of sound absorption coefficient, the higher the frequency range depends on their specific characteristic of the sound absorber in lower range but the sound is reflected in medium and high frequency range. Figure 3 shows the kenaf core particleboard sample for sound absorption test.

Figure 3: Kenaf core particleboard for sound absorption test [16]

4.0 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 [19]. 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

5.0 FUTURE POTENTIAL AND CONCLUSION

Many interesting information was found from previous research related to the kenaf core and kenaf fibre. The findings from this literature review include theoretical aspect had been done in the knowledge of kenaf core, kenaf fibre, natural fibres, concrete composites, acoustic properties of natural fibres and its mechanical properties of the kenaf fibre. All the related information and knowledge gathered in this chapter which is related to this research have been summarized including theory aspect as the guidelines and references. In recent times, various materials have been employed in manufacturing for their acoustic properties. However, in light of environmental concerns, researchers have undertaken studies to explore natural materials as alternatives for acoustic panels. Taban et al. [17] highlighted several advantages of these natural materials, including their lower cost, sustainability, ease of production, favorable mechanical properties, and, notably, their eco-friendliness. The primary objective of utilizing natural fiber reinforced composites in industries is to achieve weight reduction and cost reduction. Multiple studies have demonstrated that the adoption of natural fiber composites can lead to approximately a 20% decrease in costs and a 30% reduction in weight.

Furthermore, natural fibres come from either plants,animals, or other natural resources. The highest demand natural fibres nowadays are from kenaf plant that consist of kenaf fibres and kenaf cores. According to previous journals, kenaf core have been a great potential of mechanical and chemical properties to replace other materials in the future in the application of new technologies. Table 2 summarized of previous research finding in the reported work on the application of kenaf core. Also, Harmaen et al. [20] stated that density of kenaf core is higher and the absorption of the particles performed well than other materials thus kenaf core is one of the materials that have the potential to be used as the acoustical materials.

In addition, concrete has been studied by many researchers as a matrix component of kenaf core as a reinforcement in composites. When mixed with water, sand and cement, often known, as concrete, plays a critical role in the construction industry, particularly in structural engineering and mortars. It was also discovered that building structures made of cement or concrete have a lifespan of up to 100 years. Despite the fact that numerous studies on the acoustical properties of natural fibres have been conducted, it was discovered that few research on acoustical properties employing kenaf core reinforcement and concrete composite had been conducted. As a result, the focus of this research will be on the development anad analysis of an acoustic panel made of kenaf core and concrete or cementitious.

Table 2: Reported work on the application of kenaf

Matrix	Reinforce	Findings	References
Cement	Kenaf fibre	Kenaf fibre yielded improved mechanical strength of the cement- based composites	[13]
Cement	Kenaf fibre	The use of the appropriate length and content of KF improves the tensile and flexural strengths of cementitious composites	[14]
Clay	Kenaf fibre	The more fibre is used, the material ductility will more likely to be increase and in this study the inclusion of reinforce	[21]
HDPE	Kenaf core	The mechanical properties of 60/40 kenaf/HDPE mixture was improved with the pre-treatments of core particles.	[22]
Bast fibre	Kenaf core	The improvement of mechanical properties will increase the life services of the boards as the kenaf core and bast fibre have great potential.	[23]
Polythelene	Kenaf core	Addition of kenaf core, the tensile strength and modulus of the low density improved.	[24]
Kenaf core	Polylactide	Dry-distillation surface modification appears to be successful for improving the interfacial interaction and compatibility.	[25]
Polyurethene foams	Kenaf core	Freely expanding foams lead to poor reinforcement when mixed.	[26]

ACKNOWLEDGMENTS

The authors would like to thank Department of Mechanical, Politeknik Merlimau Melaka and also Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka. This research was not funded by any grant or any institutions.

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