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RESEARCH AND DEVELOPMENT OF KENAF CORE AND GYPSUM FOR CEILING DECORATIONS

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DECLARATION

I declare that this thesis entitled "Research and Development of Kenaf Core and Gypsum for Ceiling Decorations" is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………………

Name : MELANIE LYE CHUOK XIN

Date : 18/1/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Aerospace Manufacturing/Industrial Design/Digital Manufacturing) with Honours.

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DEDICATION

Dedicated to

My honourable father, Lye Teik Khon

My precious mother, Chiow Wai Kam

My beloved family, Michelle Lye Chuok Fang, Merlyn Lye Chuok Zhin and Adrian Lye Qe Bin

My supporting teammates Nur Hazirah Iffah Binti Hashim, Meryl Anyie Tomy, Muhammad Fikri Bin Zulkifli and Dr Mohd Amirhafizan Bin Husin

My supervisor for his guidance, Prof. Madya Ir. Ts. Dr. Mohd Yuhazri Bin Yaakob

Thank you so much

ABSTRACT

Natural fibers are commonly used as reinforcement in various industries and fields as they offer high mechanical performance and are environmentally friendly. This study explored on kenaf core that is used for reinforcing with gypsum for ceiling decoration application. Five different kenaf core sizes used in this research were 0.4 mm, 0.84 mm, 10mm, 20 mm, and 30 mm. The samples were later prepared by mixing a constant value of gypsum and kenaf core with an increased weight percentage from 10 % to 90 %. The mixtures are then mixed with water and poured into a plywood mould with a dimension of 320 mm x 300 mm x 10 mm. As the curing process is done, each sample is cut into a standard dimension for each mechanical testing according to the ASTM standard. Flexural test, compression test, and water absorption test were carried out to determine mechanical performance. A scanning electron microscope (SEM) was then used to observe the fracture surface of each sample and analyze its physical characteristic. In the study, the overall results revealed that 50 % loading of 40 mesh kenaf core reinforced gypsum composite provided the best performance among all reinforced composites, which shows the highest flexural strength and modulus with 1.89 MPa and 1.48 kPa, respectively. However, due to budget concerns, the proposed kenaf core size and loading is 50 % loading of 20 mesh kenaf core as it is only slightly lower in performance than the 40 mesh kenaf core. In the compression test, 10 mm kenaf core reinforced gypsum composite reaches the highest compressive strength among all composites with 0.277 MPa. Other than that, the water absorption rate significantly increases as the amount of kenaf core is added more and the size of the kenaf core gets bigger. These have shown that the kenaf core has a great potential for offering environmentally friendly ceiling decoration applications with an improvement of flexural properties and compressive strength of the composite but also causes an increment of water uptake due to its hydrophilic nature.

ABSTRAK

Gentian semulajadi biasanya digunakan sebagai tetulang dalam pelbagai industri dan bidang kerana ia menawarkan prestasi mekanikal yang tinggi dan mesra alam. Kajian ini meneroka teras kenaf yang digunakan untuk tetulang dengan gipsum untuk aplikasi hiasan siling. Lima saiz teras kenaf berbeza yang digunakan dalam penyelidikan ini ialah 0.4 mm, 0.84 mm, 10mm, 20 mm, dan 30 mm. Sampel kemudiannya disediakan dengan mencampurkan nilai malar gypsum dan teras kenaf dengan peningkatan peratusan berat daripada 10% kepada 90%. Campuran kemudian dicampur dengan air dan dituangkan ke dalam acuan papan lapis berdimensi 320 mm x 300 mm x 10 mm. Apabila proses pengawetan dilakukan, setiap sampel dipotong mengikut dimensi standard untuk setiap ujian mekanikal mengikut piawaian ASTM. Ujian lentur, ujian mampatan, dan ujian penyerapan air telah dijalankan untuk menentukan prestasi mekanikal. Mikroskop elektron pengimbasan (SEM) kemudiannya digunakan untuk memerhati permukaan patah setiap sampel dan menganalisis ciri fizikalnya. Dalam kajian itu, keputusan keseluruhan mendedahkan bahawa 50% pemuatan komposit gipsum bertetulang teras kenaf 40 mesh memberikan prestasi terbaik di kalangan semua komposit bertetulang, yang menunjukkan kekuatan lentur dan modulus tertinggi dengan masing-masing 1.89 MPa dan 1.48 kPa. Walau bagaimanapun, disebabkan kebimbangan bajet, saiz dan pemuatan teras kenaf yang dicadangkan ialah 50% pemuatan teras kenaf 20 mesh kerana prestasinya hanya rendah sedikit daripada teras kenaf 40 mesh. Dalam ujian mampatan, komposit gipsum bertetulang teras kenaf 10 mm mencapai kekuatan mampatan tertinggi antara semua komposit dengan 0.277 MPa. Selain itu, kadar penyerapan air meningkat dengan ketara apabila jumlah teras kenaf ditambah lebih banyak dan saiz teras kenaf semakin besar. Ini telah menunjukkan bahawa teras kenaf mempunyai potensi besar untuk menawarkan aplikasi hiasan siling mesra alam dengan penambahbaikan sifat lentur dan kekuatan mampatan komposit tetapi juga menyebabkan peningkatan pengambilan air kerana sifat hidrofiliknya.

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	-	Centimeter
mm	-	Millimeter
g	-	Gram
kg	-	Kilogram
kN	-	Kilonewton
MPa	-	Mega Pascal
°C	-	Degree Celsius
wt %	-	Weight percentage
SEM	-	Scanning electron microscope
ASTM	-	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Composites is a material that made from two or more distinct substances which can create stronger and better performance component. There are two main types of composites which are matrix-based composites and reinforcement-based composites (Sharma et al., 2020). Natural fiber is one of the fiber reinforcements in composites and it is widely used nowadays in various applications. Those natural fiber reinforced composites generally used in engineering applications like aircraft, automobile, building and also other commercial applications (Prabhu et al., 2021). It can substitute synthetic composites in order to provide greener environment. Tonk (2020) stated that natural fibers are obtained from animals, plants, and mineral sources such as kenaf, hemp, jute, flax and silk (Yashas et al., 2019).

Kenaf is an herbaceous plant that have no woody tissue in its stem hence its fiber is commonly used as natural reinforcement. According to Tholibon et al. (2019), they stated that kenaf fiber can be derived from the bast and core which also known as outer fiber and inner fiber. They also mentioned that there are roughly 35% of bast fiber and 65% of core fiber consist in a kenaf stalk. Kenaf fiber provides a lot of potential applications due to it is easily available, economically, and environmentally friendly and also outstanding performance (Tholibon et al., 2019). Mechanical properties of kenaf bast fiber are related to its cellulose (Shrivastava and Dondapati, 2021); the higher the cellulose content resulting the better value of tensile strength.

Meanwhile, kenaf core mainly used for fillers (Mohamad Aini et al., 2020) and thus less further development on kenaf core. However, there is a firmly believe that kenaf core has a great potential for improving mechanical properties. Consequently, kenaf core is chosen as reinforcement for this research instead of kenaf fiber.

Gypsum also known as calcium sulphate dihydrate ($CaSO_4 \cdot 2H_2O$); it is a natural mineral which obtained from the sedimentary rock layer. By adding water into gypsum powder, it will be hardening and forming into same shape with the mold. Gypsum is one of the common building materials that used for construction purpose. Compared to other building materials, gypsum apparently is the best choice because of the benefits it offers. Gypsum is light weight (Kuqo and Mai, 2021), heat insulating (Boquera et al., 2021), and fire retardant (Aiken et al., 2021)However, the structure of gypsum composed of needled like calcium sulphate dihydrate crystals that interconnected with each other. This causing brittleness and hydrophilic hence reinforcement like natural fiber needed to improve the strength and water resistance properties (Vidales-Barriguete et al., 2020).

Next, mixing is one of the simplest and easiest technique to fabricate a gypsum product. In order to create a reinforced gypsum product, ratio of water, gypsum and reinforcement play important role. Therefore, the ratio of each substances needs to be precise so that at the end of the product would be in good condition and achieve expected analysis performance. According to the research of Guna et al. (2021), the result show that different value fraction of composites have bring impact to the mechanical properties and physical properties. They stated that the ideal proportion is 30% of reinforcement while 70% of gypsum as it carries out excellent outcome among other proportions. Besides, the ratio of water to gypsum mixture which is mixed gypsum and reinforcement is crucial in another aspect as well (Darvell, 2018). A mixed proper proportion, the gypsum slurry will become opaque and creamy state. If water exceeded, the set slurry will become soft and weaken the structure due to the water molecules pushed gypsum crystals further apart. While if there is too much of gypsum mixture, the set slurry will be in non-homogenous state as there will be porous on top and hard at the bottom.

In summary, many interesting results indicating the potential of kenaf and gypsum in various application have been reported. However, most of the studies in the open literature did not simultaneously examine the effect of kenaf core reinforced gypsum composite. Therefore, this study will investigate the potential of kenaf core reinforced gypsum composite for ceiling decoration application.

1.2 Problem Statement

Currently, most of the gypsum-based ceiling products provide low performance which not long lasting and easily to break. The cause of this can be explained as the unsuitable ratio of mixing reinforcement and gypsum. It is the crucial part of the fabrication process in order to have good result of reinforced composite. In theoretically, there will be a significant improvement of mechanical properties of reinforced product with ideal proportion of gypsum and reinforcement. Therefore, the importance of controlling the optimum value of fraction between gypsum and reinforcement is necessary to implement.

Besides, the common issue that always come out with ceiling is the growth of mold and mildew (Guna et al., 2021). Due to high moisture content in ceiling which resulting the phenomenon occurred thus the materials of making a ceiling product is needed to pay attention with. Since kenaf has great tendency of water absorption, it will be added to the gypsum as reinforcement as providing enhancement of water repellence. On top of that, kenaf core also has the potential of improving the mechanical properties of matrix material. So kenaf core will be used to investigate the improvement ability to the gypsum-based ceiling product in this research.

Furthermore, commercial ceiling products are generally non-biodegradable as synthetic reinforcement are added to the matrix material (Guna et al., 2019). It can bring impact on environmental issue which synthetic reinforcement may release toxic gases to the surrounding and affect human health. Next, it is non-renewable source that can become hazardous waste to mother earth. Once it is no longer to use again and it will be dumped without making any cleaning process. Hence, natural reinforcements were introduced to make better and green ceiling product.

Moreover, natural reinforcements are usually expensive and harder to get than synthetic reinforcement. Natural reinforcements are obtained either from animals or plants which meaning that the duration from yield to harvest required a long period which can up to months. Other than that, the harvested reinforcements also needed to take action for processing. It will be required another additional processing time and cost. Therefore, this resulting more manufacturing companies are more likely to choose synthetic reinforcements due to it is low cost and time saving.

Last but not least, the studies relating to kenaf core have been relatively scanty and that there are few studies focusing on its size and properties. Therefore, there will be difficult to obtained relevant information from similar research and articles. All of these issues will be takes in consideration. Hence, this research that will covered of the research and development of kenaf core and gypsum for ceiling decorations will be an interesting topic to explore with.

1.3 Objective

The objectives of the research are as follows:

a) To fabricate the different sizes of kenaf core reinforced gypsum with different loadings of kenaf core.

b) To investigate the mechanical properties of the proposed sizes and loadings of kenaf core reinforced gypsum.

c) To propose the optimum sizes and ratio of kenaf core reinforced gypsum composite for ceiling applications.

1.4 Scope of Study

The scope of study are as follows:

a) Kenaf core will be used as reinforcement while gypsum will be used as matrix in this study.

b) Each five different sizes of kenaf core will be mixed with gypsum with different proportions.

c) Distinguish mechanical properties and physical properties of kenaf core reinforced gypsum composite which including compression strength, flexural strength, and water absorption rate.

e) The performance of kenaf core reinforced gypsum composite will be examined by comparing different sizes of kenaf core and loadings of kenaf core reinforced gypsum.