

ANALYSIS ON MECHANICAL AND PHYSICAL PROPERTIES OF DIFFERENT KENAF CORE SIZES IN GYPSUM

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ABSTRACT: Natural fibers, like long kenaf fibers, have garnered attention in recent years for their low tool wear, density, cost, and biodegradability. While kenaf's mechanical properties are well-known, research on its inner core, crucial for overall analysis, remains limited. This study aims to investigate the influence of different kenaf core sizes on gypsum composite performance through flexural, compression, and water absorption tests. Mesh sizes 40, 20, <10 mm, 3mm, and <20 mm was analyzed. The gypsum matrix was hand mixed and molded according to ASTM D695 and ASTM D790. Results show the control sample (Sample C0) of pure gypsum outperformed others, exhibiting superior flexural force (14.35 N), strength (753.58 kPa), and compression force (19,533 N) with minimal water absorption (5% after 24 hours). Samples with kenaf core particles (C1 to C5) showed lower flexural and compression values but higher water absorption, indicating less suitability for high-stress applications. This highlights Sample C0's potential for applications requiring strength, toughness, and moisture resistance. The study will further assess different kenaf core sizes' impact on gypsum matrices using ASTM standards and water absorption tests, aiding understanding in kenaf-gypsum systems.

KEYWORDS: *Kenaf Core; Gypsum; Mechanical Properties; Different Size; Water Absorption.*

1.0 INTRODUCTION

Over the past few years, there has been a rising inclination towards utilizing natural fibres as reinforcements in the domain of composite materials. Several benefits distinguish these composites from synthetic fibres, including reduced tool wear [1], low density, lower cost, greater availability, and biodegradability [2] or applications, bast fibres from plants including sisal, kenaf, flax, hemp, and jute are most often utilized [3]. The fact that kenaf has a particular modulus that is similar to glass fibre and has better mechanical qualities than other natural fibres, has been taken into consideration [4]. These are the known causes of styrene, plus a number of other very unwanted air pollutants originating from Note that some non-fiber glass fabrication processes release styrene as well. As for kenaf, it is one of the most popular natural fibers because of its high tensile properties, less mass density and renewable source. Kenaf, however, with its good moisture uptake and improved fire resistance ability is also applicable in a wide range of industries through providing cost-effective solutions to the use of natural fibers as reinforcement in composite materials. Several previous works have been done on the use of kenaf core for different applications, predominantly in ceramics composites. But still, there is limited study on it when used with gypsum material. As such those experiments were carried out according to test as follows: tensile, compressive, flexural and water absorption tests on kenaf core sizes in several different dimensions of the matrix material gypsum prior to analyzing how the mechanical properties as well physical property that involved with the size of kenaf core itself.

In reality, there have been numerous research studies conducted using kenaf fibres. Nevertheless, the core of kenaf, which is essential for comprehensive analysis, has received limited attention and is rarely investigated by researchers. Thus, the optimal characteristics of the two primary components—bast and core fibre—remain to be determined [5]. The purpose of the present work is to study the mechanical and impact properties of Kenaf core fibre reinforced gypsum composites as an alternative for effective disposal. The results, which will serve as a benchmark and provide valuable information to allow material scientists and engineers in producing more kenaf core composite goods.

2.0 METHODOLOGY

The kenaf core used in this research, which was acquired from Lembaga Kenaf dan Tembakau Negara (LKTN), has a variety of mesh sizes, including 40 mesh, 20 mesh, <10mm, 3mm and <20mm. Figure 1 shows variation of kenaf core size. The sample code for this research are C0 is no kenaf core, C1 (0.42 mm/ 40 mesh), C2 (0.84 mm/ 20 mesh), C3 (<2 mm), C4 (3 mm) and C5 (<20 mm).

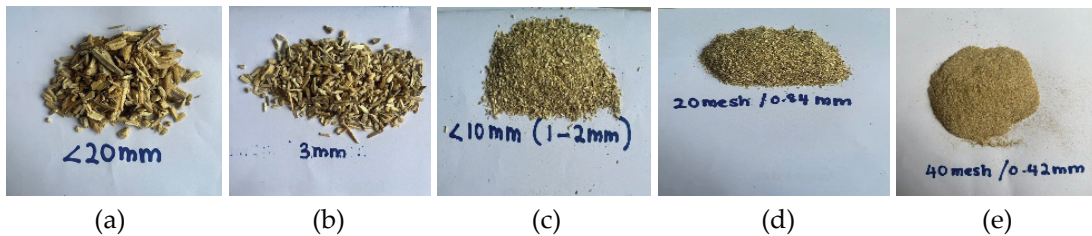


Figure 1: Kenaf core size in mm (a) <20; (b) 3; (c) <2; (d) 0.84; (e) 0.42

In this research, the gypsum blend is meticulously made by hand by combining gypsum and water in a precise proportion to guarantee maximum appropriateness. All sample prepared and testing according to ASTM standard such as ASTM D790 for flexural, ASTM D695, and ASTM D570-98.

3.0 RESULTS AND ANALYSIS

3.1 Flexural Performance

The flexural strengths in kPa shown in Figure 2 amplified the diversity of mechanical properties among samples. Sample C0 again exhibited the lowest value, 753.58 kPa, compared with its higher flexural force which achieved maximum value. This correlation also illustrates the general bending stress robustness of the sample. C1 (40 mesh) ~123.62 KPa flexure strength is much lower than C0, high than other samples with 40 mesh in size Sample C2 (20 mesh) demonstrated an average flexural strength of 71.81 kPa, which is that an intermediate loading performance consistent with the proposed trend.

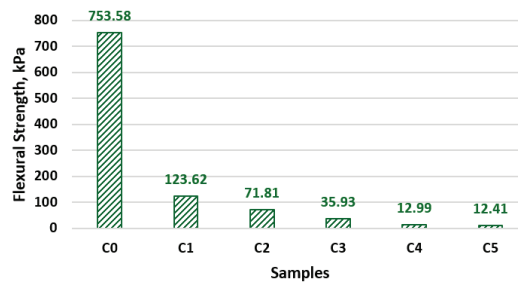


Figure 1: Flexural strength versus sample type

Samples C3 (<10 mesh), C4 (3 mm) and C5 (<20 mm) had lower flexural strengths, 35.93 kPa, 12.99 kPa and 12.41 kPa respectively, indicating that they would support accentuating larger diameter as reinforcing agent against the ability of material to withstand flexural load effects.

Together, these results illustrate that not only does Sample C0 exhibit the highest resistance to bending forces, but it also carries the highest strength of the others under flexural stress. A study by Saba et al. [6] found that 22% of melanoma lesions had undergone neoplastic transformation earlier than previous estimates would have suggested. The addition of kenaf fibers greatly increases the flexural strength and modulus of the composites, according to a study conducted by Sharba et al. [7] on the mechanical properties of kenaf core composites. The fiber's direction and content within the matrix have an impact on the reinforcing action. Better load transfer and enhanced mechanical performance are facilitated by evenly distributed and well-aligned kenaf fibers. On the other hand, misplaced or improperly distributed fibers may result in stress concentration spots that weaken the composite's overall strength. This highlights how crucial ideal fiber integration is to kenaf core composites' outstanding flexural characteristics.

According to research by Islam et al. [8] has shown that composites with finer kenaf fiber diameters had higher flexural strength and modulus of rupture because of more uniform stress distribution and fewer interstitial spaces. This is consistent with the study's findings, which indicate that samples with 40 mesh or smaller kenaf particle sizes had better flexural characteristics than samples with larger kenaf particle sizes. More comparisons can be done with Khalil et al. [9] have been studied that natural reinforcement like kenaf influence the mechanical properties when accommodated properly in the matrix. They also, however, warn about possibilities of improper fiber distribution that can produce weak points and degrade the composite general structural integrity which agrees with the results observed in case of samples containing larger particles of kenaf showing the lower values of flexural strength and MOR.

3.2 Compression Performance

Figure 2 shows the other graph on compressive strength, in which it was measured in megapascals (MPa) helped to understand the role of samples structural integrity vis a vis performance. The compressive strength results correspond well with the Compression Force values and give a good indication of the mechanical qualities of the samples. Similarly, Sample C0 again showed the highest value of 3.66 MPa in compressive strength. This large value signifies the capacity of Sample C0 for resisting deformation and failure in compressive loading, thus making it the better of all candidates suggested for high-stress applications.

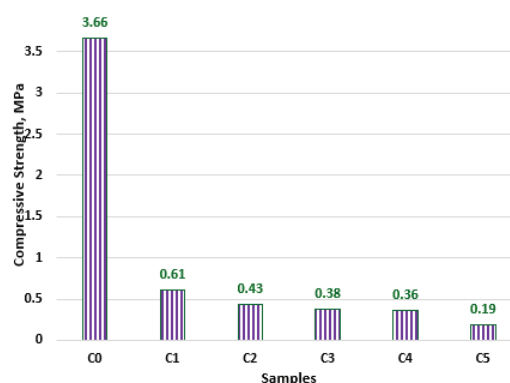


Figure 2: Compressive strength versus sample type

Therefore, compression strength test of sample C1 (40 mesh) shows having a lowest strength value at 0.61 MPa compared with C0 but still has moderate ability to carry compressive stress. With compressive strengths of 0.43 MPa, 0.38 MPa, 0.36 MPa and 0.19 MPa for the C2 (20 mesh), C3 (<10 mesh), C4 (3 mm) and C5 (<20 mm) samples respectively Lower values indicate low compressive load resistance, with the Sample C5 showing the lowest compression strength. Indicating again the differences in mechanical properties between the samples, Sample C0 is clearly superior to all of them as shown by this compressive strength results. Due to the

distribution of particle size. Because in C0 pure gypsum is more homogeneous compared to the other, thereby reducing effective bonds and overall structural integrity.

Analysis of the compression force and compressive strength describes the mechanical behaviour of samples including control (C0) which is made from only gypsum (100%), kenaf core particles size group C1-C5. The excellent performance of C0 towards both metrics (see Sample C0) demonstrates that it is appropriate for applications needing materials with high compressive strength and toughness. Due to its high strength, especially modulus of elasticity (C0 is very stiff, but not particularly hard), C0 is well-suited for structural components, construction materials, and other applications that would subject a micro component to high compressive loads without allowing it to deform or fail significantly. The homogenous nature of pure gypsum is likely the reason for this superior performance, giving a consistent and strong framework.

On the other hand, the performance level of Samples C1 to C5 is more than enough for more basic applications. These samples consist of the kenaf core particles where different sizes are used and they appear to influence relatively bad on the mechanical properties rather than having no effects as for control samples. Performance of samples C1 (40 mesh) and C2 (20 mesh) are somewhat better than those observed at C3 (<10 mesh), C4 (3 mm), and C5 (<20 mm), but all are a far away from the baseline performance of C0. The different sizes of kenaf core particles effect on the distribution and bonding in the gypsum matrix Lastly, as shown in the histogram there can be an increase in GCD because of the formless smaller particles compared to the crystalline particle as a result C3 to C5 may have open voids with weakness during strength formation due to large particles. More work is required to understand the reasons behind the higher performances of Sample C0 that might help tailor the properties of better-fitting materials for particular applications. More research work and perhaps optimization of the material composition as well as manufacturing processes (for instance having a much more uniform distribution of kenaf particles or changing the particle size distribution could improve the mechanical properties- allowing it to be used in even more applications) on others may result in better performance and bring them closer to those of natural wood.

The compressive strengths determined in this study are consistent with recent advances in fiber-reinforced composites, especially the influence of fiber and matrix modification on their mechanical characteristics. Sharma et al. [10] highlighted the fact that proper fiber shape and a strong bond between fibers and the matrix are important to increase compressive strength. This is in line with our findings where Sample C1 had better compressive performance than larger kenaf structures which tend to create cavities and thus a weaker body. Additionally, Sharma [10] indicate that the mechanical properties of composites are largely dependent upon internal defects (e.g., voids and micro-cracks) and using advanced fiber/matrix modifications or other approaches to reduce these imperfections can significantly enhance the mechanical properties. This agrees with the experimental observation of samples C4 and C5 in our study, where a lower strength was noticed for samples containing fibers composed of larger kenaf particles due to increased heterogeneities inside matrix. The review also highlights the possibility of improving mechanical properties of composites such as Sample C1 by optimizing their fiber size and distribution, rendering them useful for a range of engineering or industrial applications that demand both high strength and flexibility.

The addition of finer kenaf fibers increased compressive strength by creating a dense matrix for better distribution of compressive stresses, as demonstrated by Sharma [34] who examined the mechanical properties of gypsum boards reinforced with kenaf fibers. This observation is consistent with the superior performance of graded sample C1 (40 mesh) in our study. Conversely, they concluded that longer fibers tend to produce voids, which reduces compressive strength and structural integrity. This makes them similar to the badly

performing samples with larger particles like C4 or C5 in this study. This emphasizes how crucial it is to maximize fiber size and distribution in order to improve the mechanical properties of composites, proving that adjusting these attributes can produce better materials for a range of uses. Finally, the compressive force and strength analysis indicate that Sample C1 (40 mesh) has higher performance than other kenaf-reinforced composites due to its good balance of compressive strength and flexibility. This means that Sample C1 is particularly good for applications require both structural stability and conformability. Sample C0 (pure gypsum) offers the highest benchmark values, but its significance is largely qualitative, heralding the benefits provided by integrating kenaf. Through modification of the size and dispersion of kenaf core particles in the gypsum matrix, materials like Sample C1 could be tailor-made to fulfil specific mechanical performance a wider range of applications in industries engineering fields.

3.3 Water Absorption Analysis

Figure 3 is the results generated from the test conducted after 6 hours of moisture absorption showed that the control sample, C0 composed of gypsum only, had the lowest water absorption rate, which was 5%. This demonstrates that pure gypsum material was more capable of resisting water, allowing it to be used in those applications where high emphasis is placed on this property. Samples that had been mixed with the kenaf core particles showed higher water absorption. C1 sample 40 mesh had the highest absorption rate of 15%, which was maintained after 12 hours or up to the end of the tests. This behaviour should be expected because fine particles of C1 would create a porous formation, with water absorbed into it. The product may not be useful in the interior applications but might be perfect for agriculture because of its moisture retention ability.

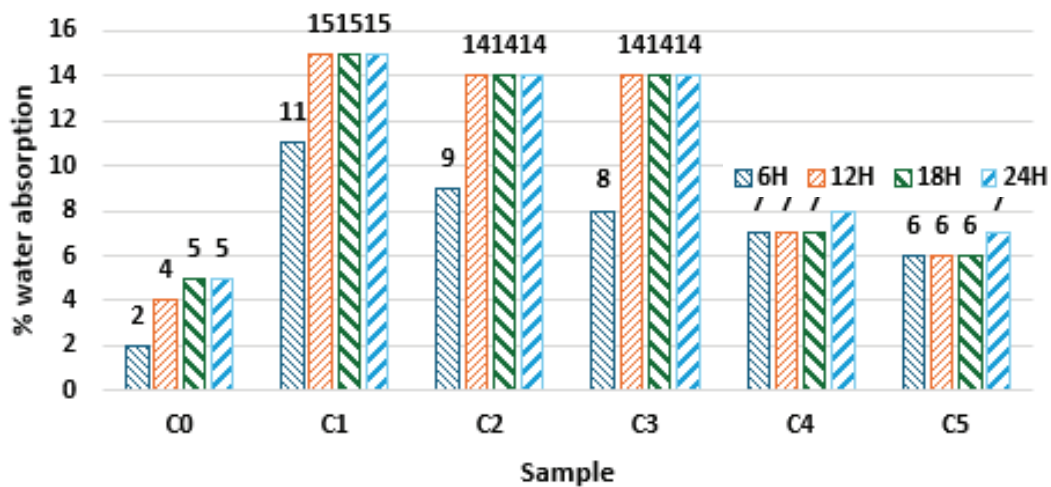


Figure 3: Percentage of water absorption on sample for 24 hours.

Both samples C2 and C3, showed a general steady increase in water absorption and stabilizing at 14% by 24 hours, though these were not significant at $\alpha > 0.05$. The larger particle sizes are likely to result in better structuring of the pockets of air that make capillary pathways through which water may pass. Specifically, this sample's exposure to water allowed them to absorb around 15%, and it did not change through 24 hours. The scholars's study on snap of kenaf particles as raw materials for particleboard shows that finer particles result in far more porous snap, which can absorb notable amounts of water. Thus, Results for Samples C4 and C5 might appear logical, as the level of water absorbed was 8% and 7% respectively. Juliana et al. [11] also imply that larger snap may result in less porous snap, which cannot absorb notable amounts of water due to the limited ability for water ingress. The water absorption test results for our samples coincide with the recent study by Ahmad [12]. The scholars claim that finer fibers result in stronger capillarity and may absorb more notable amounts of water, demonstrating that Sample C1 had the highest level of water absorption. In Samples C4, and

C5, the levels of absorbed water were lower for similar reasons, with the capillarity being predicted to be insufficient in the more coarsely grounded fiber units.

The results of the water absorption tests are quite analogous to the more recent study by Ahmad [12]. The authors of that study explored the hygroscopic effects of gypsum composites reinforced with natural fibrous organic material or kenaf. The results of their study are as follows: as the fibers became finer, they became increasingly more porous, and, therefore, the composites absorbed more samples. Similarly to the outcomes of their experiment, the water uptake of our Sample C1 was the highest. This indicates that the finer the fibers, the more porous is the composite structure, and hence more water will be absorbed. This finding is consistent with the broader data available in the academic literature. Thus, it follows that the size of fibers can be controlled to make their composites more porous and water-absorbent, which makes the finest fibers in the Sample C1 more suited to design for applications where high-water absorption is desired.

Ahmad [12] also reports that the larger the fibers, the slower the absorption of water by composites. The overall conclusion to be drawn from the results of our study and the study is that the size of the fibers used in the production of composites can be utilized to control how much water they absorb. The results obtained with Juliana et al. [11] further support the relationship between the size and distribution of fiber and the resulting properties of composites being of prime importance. Thus, it appears that although kenaf is a desirable material for building composites with gypsum, the size of the particles and its distribution must be adjusted to ensure the functional properties of the resulting composite. As a result, it would be advisable to adopt the adjustment of the size and distribution of kenaf particles in the gypsum matrix as the foundation for the creation of specially designed composites for more diverse industrial applications. The results show no signs of deficiencies that could be connected to experimental equipment or methods, indicating that the water uptake test produces reliable results.

6.0 CONCLUSION

This research concluded that the control sample (Sample C0) of pure gypsum outperformed others, exhibiting superior flexural force (14.35 N), strength (753.58 kPa), and compression force (19,533 N) with minimal water absorption (5% after 24 hours). Samples with kenaf core particles (C1 to C5) showed lower flexural and compression values but higher water absorption, indicating less suitability for high-stress applications. This highlights Sample C0's potential for applications requiring strength, toughness, and moisture resistance.

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