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Compatible Kenaf Composites with the Rapid Manufacturing Concept of Prefab Building Components

Golnar Kiani*[1], Rahinah Ibrahim[2]

the main materials used are thermoplastic materials, epoxy resin, acrylonitrile butadiene styrene plastic, and polyester materials. Natural and biodegradable composites provide important environmental advantages to the automotive industry, and sustainability, eco-friendliness, and obtaining green chemistry materials are the main objectives for the development of industrial materials, products, and systems.

Biocomposites may be a viable substitute for glass ýbre-reinforced composites in automotive by-products and partial building applications. However, to obtain stronger products, hybridisation of these so-called natural ýbres with other ýbres is necessary. Biocomposites employ polymers as matrices, resulting in lighter, stronger, and more cost-effective products that, at the same time, can be melted, sintered, or solidiýed, similar to RM systems.

The combination of Kenaf bast ýbres, a type of natural ýbre, with polymer matrices results in satisfactory ' in " ! ma r ' D r Î S ' t m

***Corresponding author:** Golnar Kiani, Institute of Forestry and Forest Products, University Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia, Tel: +60172921213; E-mail: Golnar.kiani@gmail.com

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a 0.3 mm sieve. e sieved polymer was dried in the oven at 120°C for 4 h and set aside. e prepared bres and matrices were blended in the proportions of 45% Kenaf, 5% carbon, 3% polyester, 45% PP, and 2% maleic anhyride additive. e materials were blended using a Brabender blending machine run for 10 min at 170°C and 50 rpm. A erwards, the compounds were powdered into 0.05 mm particles by cryogenic grinding. Several batches of the prepared powder mixture were set aside to produce 15 samples (15 cm x 15 cm).

Composite compression moulding sample preparation

A mould was precoated with a non-stick mould release agent, and the machine was preheated to 160°C (Limited, 2005). e powdered compound was then moulded carefully into the compartment, preheated for 7 min, pressurised under 50 MPa for 10 min, cooled for 3 min, and then nally removed from the machine to allow cooling at room temperature for 24 h.

Property measurements for compressed moulded composites

Adherence to speci c standards and associated parameters was required during the testing proper. American Society for Testing and Materials (ASTM) standards were followed in the current study. e prepared composites were removed from the mould and cut according to ASTM D638 for tensile strength testing and ASTM D3846 for shear strength testing. In total, three to four specimens were cut from three composite plates for various mechanical tests and measurements. For each test, 10 samples were provided and measured. e measurements were conducted in two directions of longitudinal (0°) and transverse (90°) orientation. e Archimedes method, in which deionised water is used as the immersion and in ltration liquid, was applied to measure the bulk density of each test specimen (Table 1).

Results and Discussion

e failure mode in the tensile tests occurred through bre and matrix breakage. Fibre pull-out was also observed in the present study. When failure of the specimen occurred, the test was stopped and the related data were obtained (Figures 1 and 2).

e speci c Young's modulus and speci c strength of the composites constituted the comparison criteria, while the critical factor for the composites was the tensile property. As shown in Table 2, the speci c strength of the biocomposite is greater than the reported strength of Kenaf/PP bre composites obtained by previous researchers. Such an improvement is attributed to the incorporation of carbon bres into the composite.

e gures illustrate that the composite exhibited properties in good agreement with common structural materials, such as carbon bre-reinforced plastic, and even better than those of Kenaf/PP composites (Figure 3A-3C). e results also show satisfactory properties compared with concrete as a general structural material. e composite can produce curvalinear forms without imposing extremely high costs. Hence, it can be claimed that the composite can be used for a wide range of structural purposes provded that the total distributed stress and strain loads do not exceed its design allowances.

Conclusion

In the current study, we aimed to evaluate the mechanical properties of Kenaf/carbon/PP bre composites fabricated from randomly scattered bres.

Property	Description	Value Gr/cm³	Standard deviation	Coeff cient of variation	Design allowable
ⅉ	Density	1.14	----		----
E_{11}	Longitudinal Young's modulus (GPa)	30.2	8.28	0.27	10.7
E_{22}	Transverse Young's mModulus (GPa)	6.9	0.45	0.065	5.84
X_t	Longitudinal tensile strength (MPa)	72.58	16.22	0.22	34.38
Y_t	Transverse tensile strength (MPa)	40.1	11.34	0.28	13.39
G12	Longitudinal in-plane shear modulus (GPa)	9.92	1.19	0.12	7.11
G23	Transverse in-plane shear modulus (GPa)	8.46	6.8	0.807	0.69
Sc	Shear strength (Mpa)	40	4.1	0.1025	30.34

Table 1: Calculated mechanical properties derived from tensile, compression, and þexural tests.

Figure 1: A) Failure mode of tensile strength test and B) ultimate tensile strength.

Figure 2: A) In plane-shear property failure and B) Shear stress-strain behaviour (up to 5% strain).

Description	Kenaf/PP 50/50	Carbon/PP 50/50	K/C/PP 50/50
Tensile strength (MPa)	62	2495	72.58
Tensile modulus (GPa)	7.7	125-150	30.2
Flexural modulus (MPa)	3.6	37.92	19.88
Shear strength (MPa)	6.36	310	40
Density (Kg/m^3)	1400–1500	1070	1140
Cost $/kg	6	7.5	6.2

Table 2: Comparison of the properties of Kenaf/PP and carbon/PP composites.

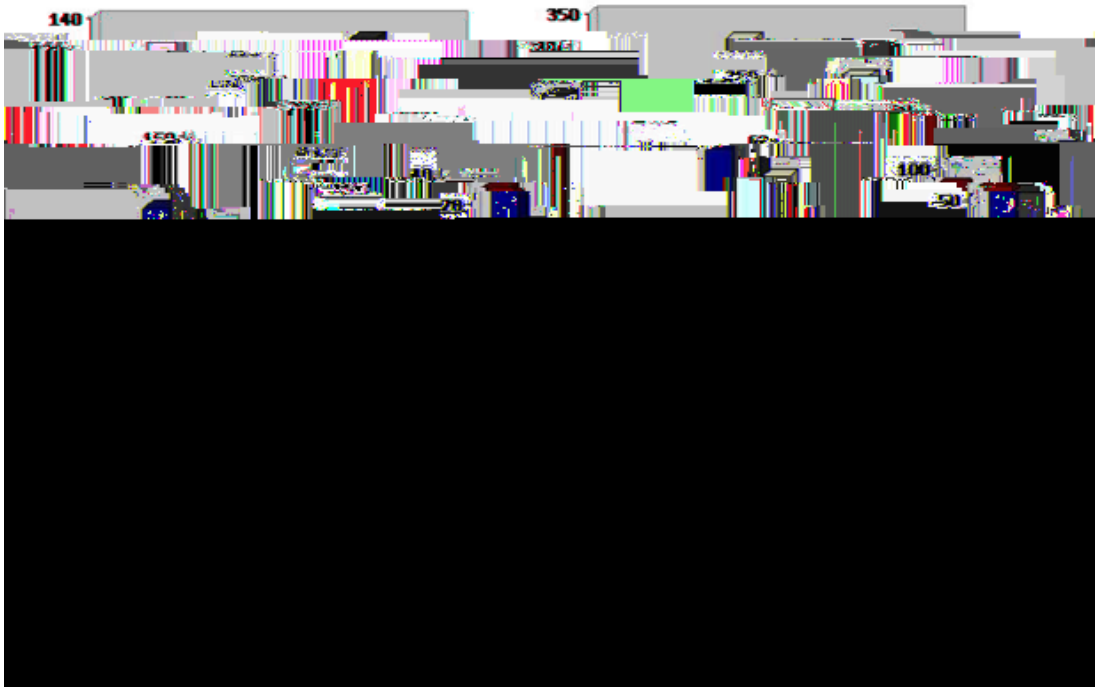

Figure 3: Comparisons of A) Tensile and þexural moduli, B) Tensile and shear strength, and C) Density and cost.

First, the process (heating and compressing) was performed well below 180°C to avoid bre degradation. Control of the moulding process (time, temperature, and press) was crucial to reduce bre damage. During determination of the processing parameters that needed to be adjusted to each thermoplastic polymer, the rheological and thermal properties of neat polymers must be considered. e second part of the study focused on the mechanical behaviour of the polymeric matrix composites reinforced by the hybrid bres. With volume fractions of 45% Kenaf and 5% carbon bres, satisfactory performance levels were obtained for the Kenaf/carbon/PP bre biocomposites.

e substitution of PP by Kenaf/carbon/PP bre biocomposites for RM may yield a stronger product. e results are very encouraging for the development of biocomposites for structural applications. Complementary studies, such as the application of the material under an RM procedure and adoption of di erent bre designs and matrices, will be conducted in the future. e standard deviation and allowable