

SOME PROPERTIES OF KENAF AND KENAF/COTTON COMBING WASTE COMPOSITES

Wan Yunus Wan Ahmad, Jamil Haji Salleh, Mohd Faizul Yahya,
Muhammad Ismail Abdul Kadir and Mohd Iqbal Misnon
Textile and Apparel SIG, Faculty of Applied Sciences
Universiti Teknologi MARA, 40450 Shah Alam, Selangor

Abstract: Kenaf is one of the most promising fibers for composite conversion. In this work, kenaf is being combined with combing waste and polyester resin as matrix. The comparison of properties are based on tensile strength and flexural strength of 100% resin, 100% kenaf and 50/50 kenaf/cotton combing waste in three types of lay-ups of longitudinal, cross-laid and transverse. Interestingly, the highest results of tensile and flexural strength are from different lay-ups of composites. The tensile and flexural strength properties are also compared with similar properties on glass composites.

Keywords: Kenaf, Cotton combing waste, Bio-based composite, Bast fiber

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is herbaceous warm-season annual fiber crop related to cotton, okra and hibiscus, which can be grown under a wide range of weather conditions. It can be found in abundance in the tropical region, but is not a native plant of Malaysia. Kenaf was introduced in Malaysia in 1997 (at the time of the economic recession) and is currently grown in the northern states of Peninsula Malaysia by MARDI. It was an idea initiated by the former Prime Minister Tun Dr. Mahathir to boost Malaysian research and development as well as economy. This is because kenaf seems to be a 'versatile' plant which can generate many products such as food for animals, has herbal medicinal properties, and composite from different parts of the plant (barks, cores and leaves). Kenaf is a minor textile fiber which has been used as cordage, ropes, basket weaving and alike. However, bast fibre such as kenaf can be an alternative to fabricate low-performance composites.

The normal fibers used for composites are kevlar, carbon and glass. As a result of global environment awareness, many workers of composites turn to low cost, biodegradable materials with improved properties [2]. Kenaf is one of the biodegradable and bio-based composites. The combination of kenaf with cotton combing waste from textile factories will be more notable and 'waste saving' as it will form a value added material in a successful conversion.

MATERIALS AND METHODS

Kenaf is supplied by the Malaysian Agriculture Research and Development Institute (MARDI) and is the main component of the composites for this work. Polyester resin is used as the matrix to bind kenaf and cotton combing waste. On the other hand, cotton combing waste is donated by CNLT (M) Sdn Berhad, Senawang, Negeri Sembilan.

Sample Preparation

MARDI carried out the retting process on kenaf and the bast fibers were supplied in strand form. The fibers were then manually combed to straighten and parallelize them. The combed fibers were then cut in approximately six inches length and arranged for composite fabrication in three lay-ups of longitudinal, cross-laid and transverse. These lay-ups of composites were for kenaf only because cotton combing waste is naturally arranged at random. The layers of web form cotton combing waste were also cut in six inches square dimension to be in the same dimension as kenaf fibers.

The 100% Kenaf

The combed and cut fibers were manually laid up to form layers of fibers at a certain weight according to specified proportions. Figure 1 shows the lay-up of 100% kenaf fibers for cross-laid composite fabrication whereas Figure 2 shows the kenaf fibers lay-up for the longitudinal and transverse forms of composite fabrication.

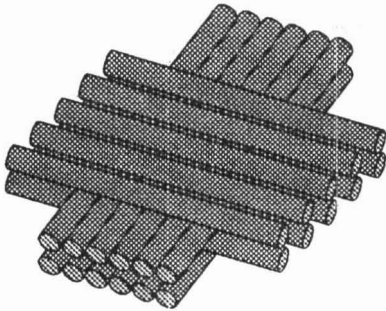


Figure 1: Kenaf Lay-ups for Cross-laid Composite

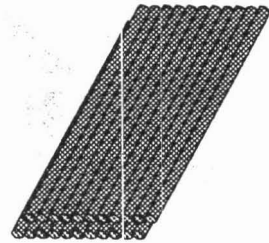


Figure 2: Kenaf Lay-ups for Longitudinal and Transverse Composite

The 50/50 Blended Kenaf with Cotton Combing Waste

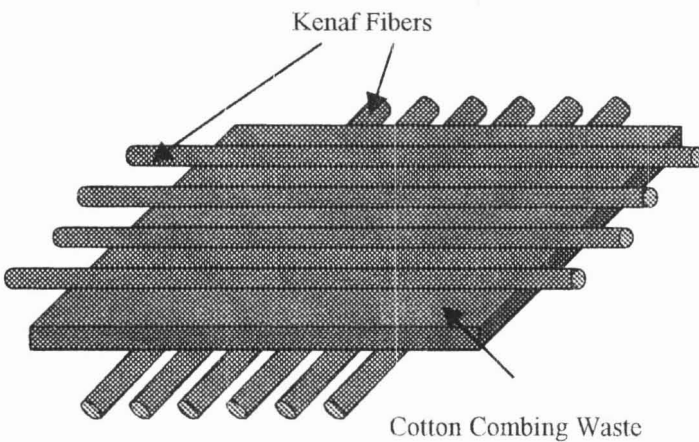


Figure 3: Fibers Lay-ups of 50/50 Blended Kenaf for Cross-laid Composite

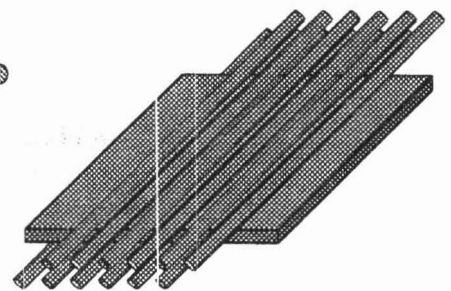


Figure 4: Fiber Lay-ups of 50/50 Blended Kenaf for Longitudinal and Transverse Composite

The combined samples were prepared by layering cotton combing waste in between layers of kenaf fibers. Figure 3 shows the diagram of the 50/50 kenaf for cross-laid composite. The fiber lay-ups of 50/50 kenaf for longitudinal and transverse composite are shown in Figure 4.

The fibers which were already arranged to be converted into composites were then applied with polyester resin and pressed in between two aluminum plates (12" x 12") using G-clamps and 2 mm spacers (thickness controller) for twelve hours (Figure 5).

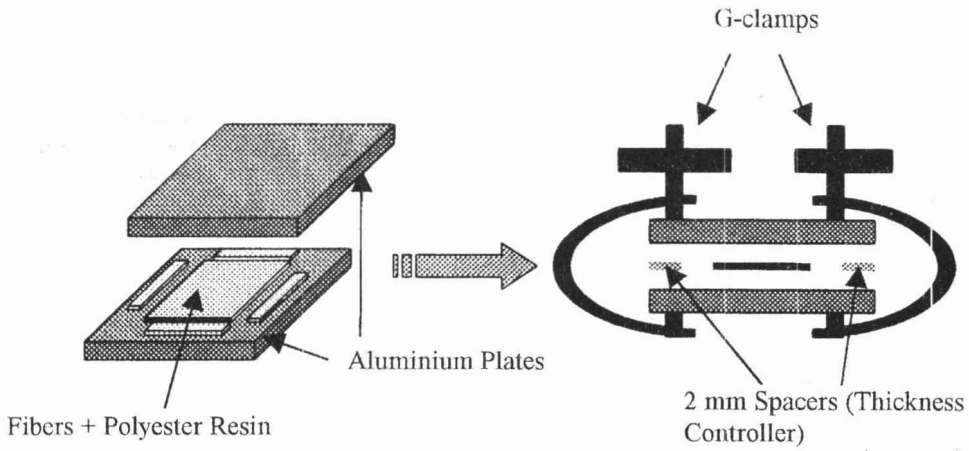


Figure 5: A Typical Composite Fabricating

Mechanical Testing

Tensile tests were performed using Testometric Micro – 500 testing machine in accordance with Composite Research Advisory Group, CRAG – 302 standards. The specimens were tested at the rate of 10 mm per minute. Tensile strength was calculated from load-extension curves.

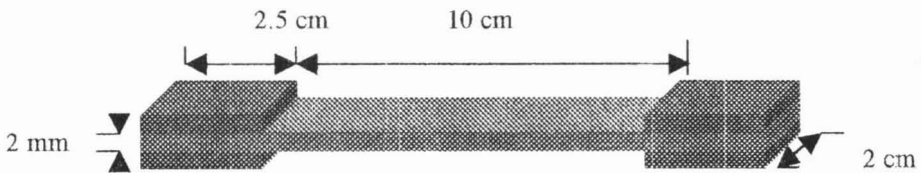


Figure 6: Sample Dimensions for Tensile Test

Flexural rigidity tests were performed on the same testing machine using the three points bending method as per CRAG – 200 standards. The sample dimensions used for this standard testing method are shown in Figure 7.

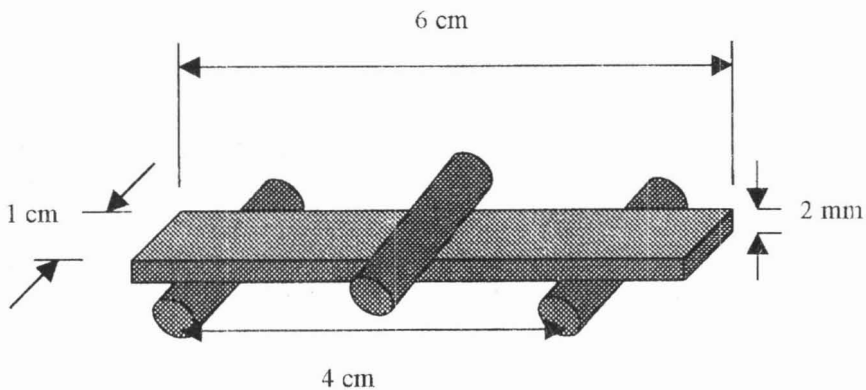


Figure 7: Sample Dimensions for Flexural Test

RESULTS AND DISCUSSION

Tensile Strength

Table 1: Tensile Strength of Composites

Composite Types	Tensile Strength (MPa)
100% Polyester Resin	37.73
100% Cotton Combing Waste (CCW)	70.90
100% Kenaf (Longitudinal)	90.09
100% Kenaf (Crosslaid)	35.45
100% Kenaf (Transverse)	9.56
50/50 Kenaf/CCW (Longitudinal)	75.37
50/50 Kenaf/CCW (Crosslaid)	35.68
50/50 Kenaf/CCW (Transverse)	33.47

Table 1 and Figure 8 show the value of tensile strength of composites. In terms of tensile strength, the 100% longitudinal kenaf composite has the highest strength of 90.09 Mpa followed by the 50/50 longitudinal kenaf and cotton combing waste composite. The 100% cotton combing composite has a tensile strength of 70.9 MPa. The other composites lay-ups have lower values than the 100% polyester resin (matrix). Hence only combination and lay-up of 50/50 longitudinal kenaf and cotton combing waste in terms of tensile strength is considered useful for future fabrication.

Similar work on composite as kenaf and cotton combing waste has been carried out on glass fiber but using epoxy resin as matrix. The tensile results are shown in the Table 2. In all cases, the tensile strength of glass fabric is much higher than tensile strength of 100% longitudinal kenaf. The work on polypropylene matrix with non-woven glass composite gave a tensile strength of 100 Mpa [1].

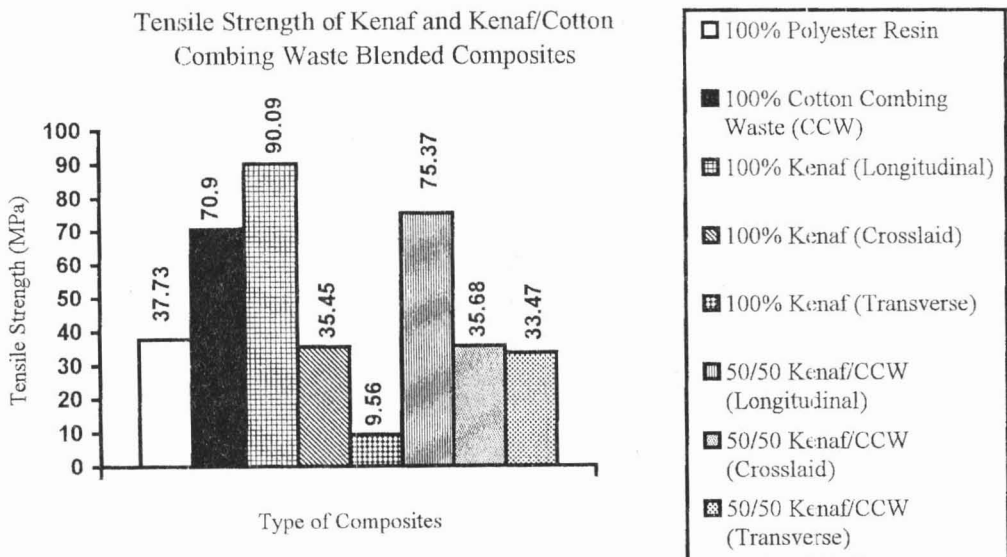


Figure 8: Graphical Presentation of Tensile Strength of Composites

Table 2: Tensile Strength of Glass Composites

Type of fabric	Layers of fabric	Strength (MPa)	Direction
Plain weave glass	12 layers (2 mm composite)	149.7	Warp
		160.9	Weft
Satin weave glass	10 layers (2 mm composite)	268.7	Warp
		208.2	Weft

Table 3: Flexural Strength of Composites

Composite Types	Flexural Strength (MPa)
100% Polyester Resin	86.20
100% Cotton Combing Waste (CCW)	126.85
100% Kenaf (Longitudinal)	125.98
100% Kenaf (Crosslaid)	65.71
100% Kenaf (Transverse)	20.29
50/50 Kenaf/CCW (Longitudinal)	133.07
50/50 Kenaf/CCW (Crosslaid)	136.29
50/50 Kenaf/CCW (Transverse)	35.78

Table 3 and Figure 9 show the flexural strengths of composites. The 100% cotton combing waste and the 100% longitudinal kenaf composites recorded almost the same flexural strength. However, the 50/50 longitudinal kenaf and cotton combing waste as well as 50/50 cross-laid kenaf and cotton combing waste have higher strengths than both 100% cotton combing waste and 100% longitudinal kenaf. Other lay-ups for composites show lower flexural strength than the matrix. Comparison with glass composites as in Table 2 indicates that the kenaf and cotton combing waste composites has better flexural strength than glass composites.

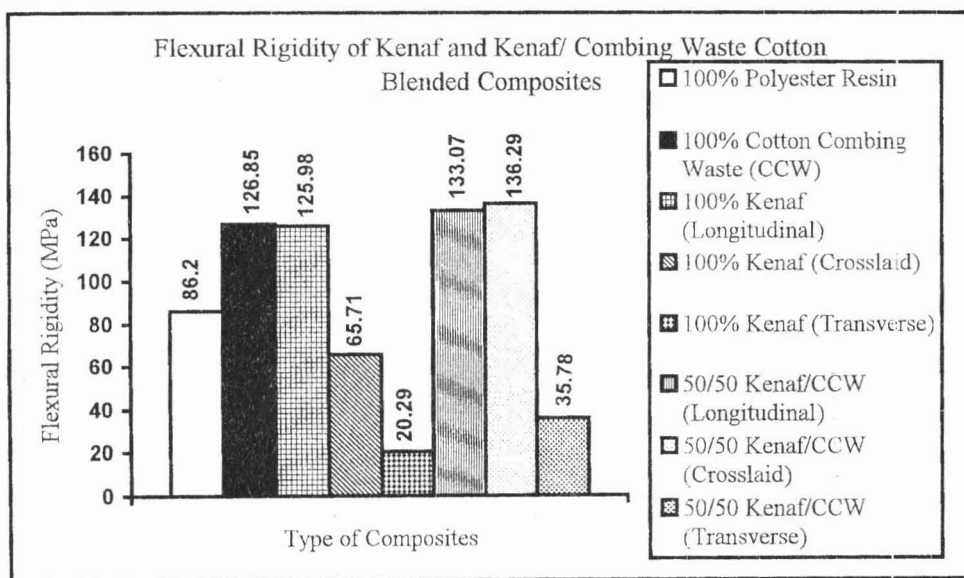


Figure 9: Graphical Presentation of Flexural Rigidity of Composites

Table 4: Flexural Strength of Glass Composites

Type of fabric	Layers of fabric	Strength (MPa)	Direction
Plain weave glass	12 layers (2 mm composite)	68.8	Warp
		63.2	Weft
Satin weave glass	10 layers (2 mm composite)	85.8	Warp
		70.1	Weft

It has been indicated that natural fiber materials have the potential to compete with glass fiber in composite materials [3-7]. This has been clearly shown in the flexural strength property of kenaf and cotton combing waste composites. The result of kenaf and cotton combing waste will be higher if the preparation and parallelization of kenaf fiber lay-ups can be improved using machines that can straighten and parallelize the fibres. It could be at par with glass composites and at the same time the flexural strength may be even much higher than glass composites.

ACKNOWLEDGEMENT

The authors wish to thank MARDI, CNLT (M) Sdn Bhd for their cooperation in supplying raw materials and Mohd. Khairi Yusoh who performed part of the testing.

REFERENCES

1. Baumgartl, H. and Schlarb, A. 1993. Symposium Nachwachsend Rohstoffe-perspektiven für die Chemie, Frankfurt.
2. Canché-Escamilla, G., Rodriguez-Lavadia, J., Cauch-Cupul, J.I., Mendizbal, E., Puig, J.E. and Herrera-Franco, P.J. 2002. Composites: Part A 33, 539-549.
3. Hornsby P.R., Hinrichsen, E., Taverdi, K. and Mater, J. 1997. Sci 32, 1009.
4. Mleck, K.P., Nechwatal, A. and Knobelsdorf, C. 1995. Die Angew Makromol Chem, 225 73.
5. Raj, R.G. and Kokta, B.V. 1991. Proc Ann Tech Conf ANTEC' 91, SPE 1883
6. Sterzynski, T., Triki, B. and Zelzany, S. 1995. Polimery 40, 7/8, 468.
7. Zafeiropoulos, N.E., Williams, D.R., Baillie, C.A. and Matthews, F.L. 2002. Composites: Part A 33, 1083-1093.