© (2014) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMM.660.125
Revised: 21.07.2014
Accepted: 12.08.2014

Analysis of Mechanical Properties for 2D Woven Kenaf Composite

Md Saidin Wahab[1a], Muhammad Nazri Rejab[2,b], Mohd Pahmi Saiman[1,c]

[1]Advanced Manufacturing and Material Centre,
Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat Johor Malaysia

[2]Mechanical Engineering Department, Tuanku Syed Sirajuddin Polytechnic, Pauh Putra, 02600 Arau Perlis, Malaysia

[a]saidin@uthm.edu.my, [b]nazri_554@yahoo.com, [c]pahmi.saiman@gmail.com

Keywords: composite, kenaf, mechanical properties

Abstract: Woven composite based on natural fiber increasingly used for many applications in industries because of their advantages such as good relative mechanical properties and renewable resources, but there are some issues as cost and protracted development period to perform reliability evaluation by experimental with real scale. Predictive modeling technique is use to minimize the need for physical testing, shorten design timescales and provide optimized designs. Mechanical properties of woven fabrics for technical textile depend on a) type of raw materials b) type and count of warp and weft yarns c) yarn density and d) the type of weave structure. The effect of fabric architecture to the mechanical properties is investigated. Woven kenaf composite is modeled using the modeling software to get the properties of the model. Further, the model is analyzed using finite element analysis to predict the mechanical properties of the woven kenaf composite. In addition, the effect of the combination of yarn size and weave pattern to the woven kenaf composite is stated base on the mechanical properties to predict the optimum structure of woven kenaf composite.

Introduction

Composite material performance is affected by the fiber architecture and fiber –matrix interface [1]. Fiber architecture which consists of (i) fiber geometry (ii) fiber orientation (iii) packing arrangement and (iv) fiber volume friction, controls many composite mechanical properties [2]. The interface between fiber and the matrix is also crucial in terms of composite performance [3]. The interface serves to transfer externally applied loads to the reinforcement via shear stresses over the interface. Therefore, many researches are conducted to determine early prediction mechanical properties of composite material [4,5,6,7]. Finite element analysis is based on the modeling of the composite material. Several methods were adopted for the mechanical modeling and analysis of the composite structures. A basic classification, according to the modeling method used, divides them into the analytical and numerical or computational approaches [8,9]. The dominant engineering design culture played important role for the development and the succession of these approaches. Another essential classification of the modeling of the textile structures is made according to the scale of the model. There is micromechanical, meso-mechanical and the macro-mechanical modeling [10,11].

The micromechanical modeling stage focuses on the study of the yarns, tows even fabrics taking into account the structure, orientation and mechanical properties of the constituent fibers. The meso-mechanical modeling, on the other side, studies the mechanical characteristics of the fabric unit cell considering the yarns as homogenous structures. Finally the macro-mechanical modeling stage is referred to the prediction of mechanical performance of the composite in complex deformations, as drape, studying the composite as a continuum material [11,12]. Thus the textile society implemented a modeling hierarchy based on three modeling scales: the micromechanical modeling of yarns, the meso-mechanical modeling of the fabric unit cell and the macro-mechanical modeling of the fabric sheet [13,14,15].

Modeling of Kenaf Composite

The yarn size used for woven kenaf composite is 759 tex, 413.4 tex and 276 tex. It is combined with Plain 1/1, Twill ½ and Satin 5/2 for the weave pattern. Different combinations are modeled using Wisetex and the model meshing used Fetex software. The sequence to model begins with kenaf fiber properties, followed by weave pattern, yarns and woven fabrics, as shown in Figure 1.

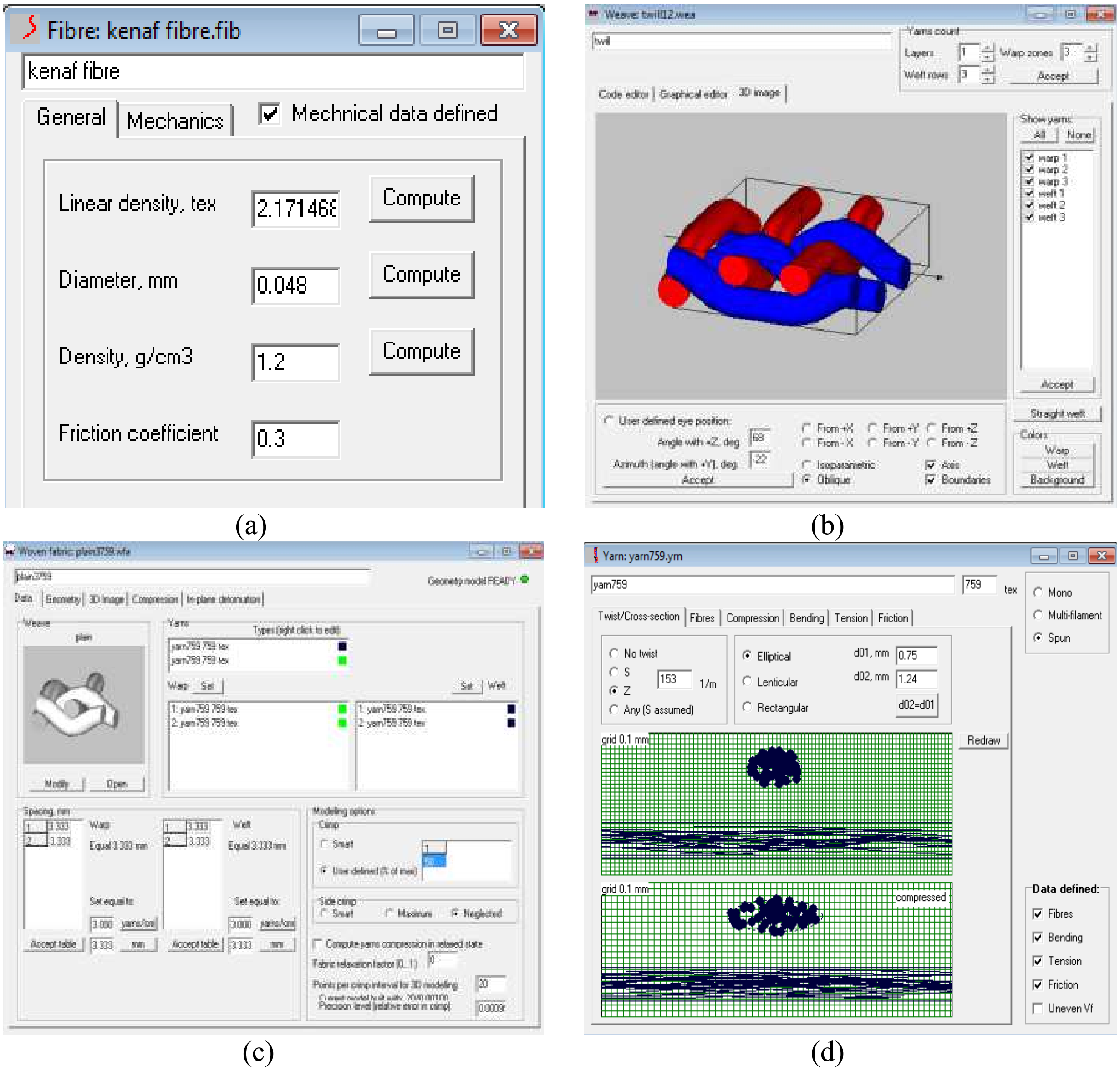

Figure 1: The modeled sequence (a) kenaf fiber properties (b) weave pattern (c) yarns (d) woven fabrics

Result and Discussions

The yarn size for the woven kenaf composite influent the porosity, weft crimp and warp crimp. The porosity of the woven kenaf composite decreases but the percentage of the warp crimp and weft crimp increases with the yarn size starting from 759 tex to 276 tex. It is clearly observed that the weave pattern only give the significant effect to the unit cell size, warp and weft length also to the warp and weft crimp. The porosity, fiber volume fraction and fiber volume fraction inside a yarn only slightly changes corresponding to the type of the weave pattern [16]. The optimum value is observed to prevent the tight structure of the woven fabric shown in Table 1.

Table 1: The optimum value of yarns/cm

Yarn size , tex	Optimum Value, (yarns/cm)	Spacing, mm
759	5 (weft & warp)	2
413.4	7 (weft & warp)	1.429
276	9 (weft & warp)	1.11

If the optimum configuration not fulfill, the tight structure of fabric occur and it will cause the wrinkle (hill and valley) to the fabric. This is because the spacing between weft and warp is too small and it will increase the crimp in the woven fabric. 759 tex give the highest value of crimp compare to the other yarns size followed by the 413.4 tex and 276 tex. Conversely, 759 tex give the optimum value of force occur and the toughness to stand the deformation in the woven fabric. 759 tex can stand the percentage of deformation until 5% before significantly change until rupture point [11]. Even though 759 tex give the optimum value, it must combine with the Plain 1/1 to achieve the value. The suitable value of meshing for yarn is observed according to N1 is 4 and N2 is 1 [15]. The significant effect of force 1 kN to the woven kenaf composite clearly observed. Satin 5/2 give the highest value of stress and displacement in woven followed by Twill ½ and Plain 1/1, as shown in Figure 2.

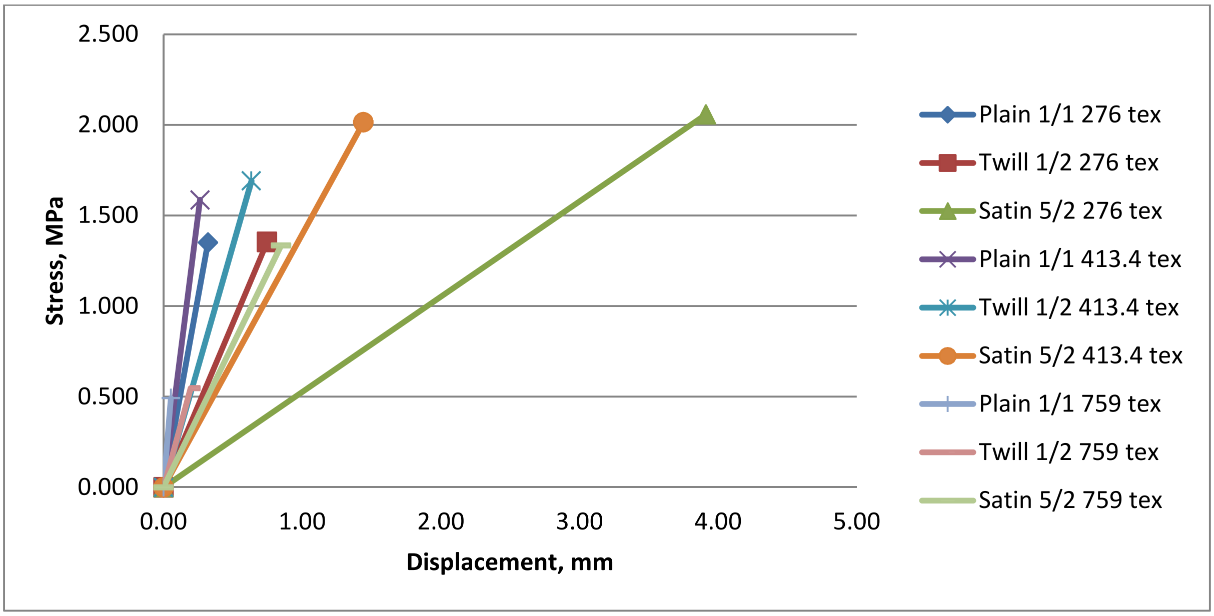

Figure 2: The stress versus displacement for woven kenaf composite

Conclusions

The yarn size and weave pattern of the woven kenaf composite influent the porosity, unit cell, weft crimp and warp crimp. The yarn size 759 tex give the optimum value of force occur and the toughness to stand the deformation until 5% before significantly change until rupture point in the woven fabric. The mechanical properties of woven kenaf composite depend on the crimp and porosity.

Recommended for future work

The prediction model shows significant effects on mechanical properties at different woven design parameters. Validation results of this analysis will be available on next coming publication.

Acknowledgement

The authors are thankful to all UTHM staff for their cooperation during this research and also to Prof. Stepan Lomov for his kindness and consultancy during the modeling stage of the woven kenaf composite.

References

[1] Paul A Fowler, J Mark Hughes, Robert M Elias (2006) Biocomposites: Technology, environmental credentials and market forces-A review. Journal of Sciences of Food and Argiculture 86:1781-1789

[2] Alif, N., L. A. Carlsson, et al. (1998). "The effect of weave pattern and crack propagation direction on mode I delamination resistance of woven glass and carbon composites." Composites Part B: Engineering **29**(5): 603-611.

[3] Poe, C. C., and Harris, C.E. (October 1995). "Mechanics of Textile Composites Conference." NASA Conference Publication 3311(Part 1&2).

[4] Lomov, S.V., Huysmans, G., Luo, Y., Parnas, R.S., Prodromou, A., Verpoest, I. and Phelan, F.R., (2001) Textile composites: Modelling strategies. Composites - Part A: Applied Science and Manufacturing, Vol.32, No.10, pp. 1379-1394.

[5] Hallett, (2008). "Finite Element Modelling Of 3d Woven Composites For Stiffness Prediction." Mechanical Response of Composites Computational Methods in Applied Sciences, 10.

[6] Tan P, Tong L, Steven GP (1997) Modelling for predicting the mechanical properties of textile composites - A review. Composite Part A –Applied Science and Manufacturing 28(11): 903-922.

[7] Crookston JJ, Long AC, Jones IA (2005) A summary review of mechanical properties prediction methods for textile reinforced polymer composites. Proc. IMechE, Part L: J. Materials: Design and Applications 219: 91-109.

[8] Tetsusei Kurashiki et. all., 'Damage development of woven composites Based on multi-scale analysis" , Proc. 16th ICCM, Japan, 2007, pg 1-7

[9] J. E. Booth, Textile Mathematics, The Textile Institute,Manchester, 1997, p.p. 445–458.

[10] Takano, N., Uetsuji, Y., Kashiwagi, Y. and Zako, M., (1999) Hierarchical modelling of textile composite materials and structures by the homogenization method. Modelling and Simulation in Materials Science and Engineering, Vol.7, No.2, pp. 207-231.

[11] Zako M., Uetsuji Y., and Kurashiki T., "Finite element analysis of damaged woven fabric composite materials", Composites Science and Technology, Vol.63, pp.507-516, 2003.

[12] A. Bogdanovic, K. Pastore, Textile Structures for Composites, NCSU, p.p. 235–237 (1998).

[13] Jiang W.G., Hallett S.R., Wisnom M.R., Development of Domain Superposition Technique for the Modelling of Woven Fabric Composites, in Mechanical Response of Composites," edited by P. P. Camanho, C. G. Dávila, S. T. Pinho and J. J. C. Remmers, Springer, 2008.

[14] Bogdanovich, A.E., (2006) Multi-scale modeling, stress and failure analyses of 3-D woven composites. Journal of Materials Science, Vol.41, No.20), pp. 6547-6590.

[15] Whitcomb, J. and Srirengan, K., (1996) Effect of various approximations on predicted progressive failure in plain weave composites. Composite Structures, Vol.34, No.1, pp. 13-20.

[16] H.Lin et.al (2012) Multi scale integrated modeling for high performance flexible materials. Computational materials science: Vol 65: 276-286