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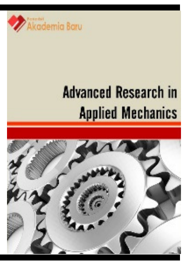


# Tensile properties for MWCNT filled jute-Epoxy composites

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**ABSTRACT**

This paper presents the tensile properties of jute-epoxy composite laminates with different weight percentage of multi-walled carbon nanotube (MWCNT). The jute fibre and epoxy resin that dispersed with MWCNT were used. The composite laminates were prepared by hand lay-up technique. Tensile test according to ASTM D3039 was carried out to obtain the tensile properties of the composite laminates. Three different weight percentages of MWCNT filled jute-epoxy were tested in this study. The experimental result found that the maximum tensile properties were recorded at 3% of MWCNT filler.



## 1. Introduction

Natural fibres have a great potential to be substituted a conventional petroleum-based composites. These fibre is an environment-friendly materials and has a comparable mechanical properties with glass and carbon fibres [1-2]. Composite structure experienced damaging problems such as delamination, fiber-matrix debonding and fibre failures that reduces their performance [3]. In order to overcome this problem, the endowment of carbon nanotubes (CNT) as filler in the composites has offered them with new scientific and technology opportunities. CNT reinforced polymer composites promised an innovative division of composite materials applied in military, automotive and aerospace industries. It has been addressed that CNT have excellent mechanical properties, depending on its size and structure. The tensile strength of CNT is between 10 to 200 GPa and the Young's Modulus is ranged between from 600 to 1.4 TPa [4].

Due to its superior mechanical properties and small size, CNT facilitate a stronger and lightweight composite making the possible application of CNT-polymer as structural material. As example, the potential application includes the vehicle armor and racing car body panels that is made from carbon

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and glass fibre reinforced composites. In addition, these high strength-to-weight of the CNT-polymer may also offered the outstanding of energy absorbed and damage resistance laminates [5]. Prusty *et al*. [6] studied on the CNT/polymer interface in polymeric composites pointed out that volume content of CNT in the polymer influence on the mechanical performance of a structure. Shin *et al*. [7] suggested that factors that influence the performance of these composites including the CNT types, the geometrical structure, processing, fabrication and dispersion method.

Generally, CNT were dispersed in solvent before mixed with polymer solution through mechanical mixing, magnetic agitation or high energy sonication. The proper dispersion of CNT without contributing to damage or breakage is very crucial in order to produce effective load transfer structural composites. Recently, many attempts have been made in order to characterise the mechanical properties of CNT-polymer in composites applications. However, the results are varies and far from the satisfaction level [8-9].

Therefore, this study aims to investigate the effect of different MWCNT weight percentage into the tensile strength, Young's Modulus and energy absorption of jute-epoxy composite laminates.

## 2. Material, Fabrication and Testing Procedures

The natural fibre used in this study was2/2 twill of jute fibre that purchased from Easy Composites Ltd. This fibre has a density of 1.46 g/cm3 with tensile and modulus strengths of 400 MPa and 40 GPa respectively. A 10-20 nm in diameter with length approximately 1 to 2 µm MWCNT was to be modifying in the epoxy resin.

In this study, laminates were prepared using hand lay-up technique. The composition between epoxy and jute fibre was used at 40:60 by weight fraction. Following, MWCNT was dispersed in the preweighted epoxy resin and then stirred by using probe sonicator at 0.5 cycles and 70% of amplitude. The process was undergoes for 1 hour to facilitate better dispersion of MWCNT in epoxy as showed in Figure 1. Then required amount of hardener was added to epoxy /MWCNT suspension followed by hand lay-up technique with jute fibre. Then, the laminate was kept overnight at room temperature for the curing process. In order to examine the effect of MWCNT content in the composite laminate, three different compositions were chosen, i.e. 1%, 3 wt.% and 5wt.% MWCNT with respect to the weight of epoxy.

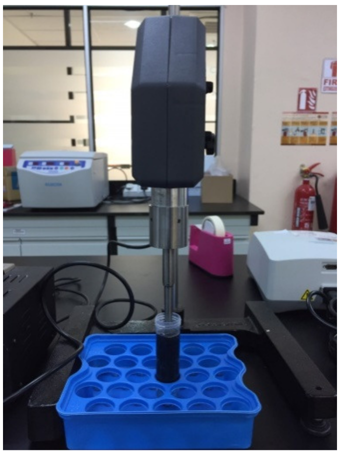

**Fig. 1.** The sonication of MWCNT in epoxy resin

The tensile samples were sectioned from the composite laminates using bend saw according to ASTM D3039 [8]. Figure 2 shows a schematic diagram of tensile test geometry. The dimension of the specimen was 25 × 25mm with 150 mm gauge length. The ends were threaded for easy adaptation to the machine grips. This test was carried out using Shimadzu AG-X Testing Machine at crosshead displacement rate of 1 mm/min.


**Fig. 2.** Schematic diagram of tensile test geometry for the composite specimen

## 3. Results and Discussion

This article has presented a review on the frequency synchronization in distributed beamforming nodes. The literature showed the improvement timeline of simulation cases of synchronization based on an ideal situation to practical implementation with parameters that are non-linear. Earlier work on the frequency synchronization has setbacks of wired feedback channels, custom hardware for the CB nodes that might not be compatible with another standard, distance limitation of neighboring CB transmitters and that to the receiver. For those setup with the non-feedback scheme, its takes longer time for rotating phasors to align which quickly misaligns afterward. Other limitations are in the use TDMA which extends the overall convergence time of the algorithm being use and a non-cost effective use of dedicated devices for providing a reference signal to each CB transmitter's oscillator. Also, some of the frequency synchronization algorithms suffer from software latency which leads to drops in measured received amplifier.

Figure 3 shows typical stress-strain traces for the jute-epoxy tensile specimen with 1%, 3% and 5% of MWCNT contents. All the specimens fractured at the strain less than 0.006.Increasing the filler amount in the resin increases the mechanical behaviour in linear fashion.

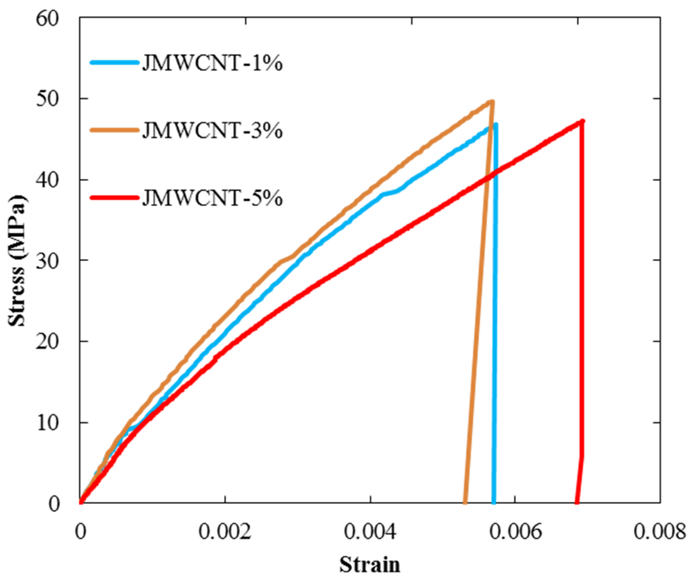


**Fig. 3.** Stress-strain curves for jute-epoxy tensile specimen with 1%, 3% and 5% MWCNT contents

Figure 4 (a) and (b) represents tensile strength and Young's Modulus in the jute-epoxy laminates as a function of MWCNT content. As showed in Figure 4 (a), specimen with 3% of MWCNT filler offers the highest tensile strength which is 49.67 MPa. However, tensile and modulus strength as shown in Figure 4 (b) is slightly dropped at 5% of MWCNT content in jute-epoxy composites. Rathore et. al [10] did an assessment of structural performance of glass epoxy composite with a range of CNT loading in various temperatures. This study proved that there is a drop in strength properties with increasing of MWCNT content. He also pointed that the optimum concentration of MWCNT in the composites is 0.1% (w/v). Excessive amount of MWCNT also reduces the interfacial bonding between the MWCNT and resin that contributed to the agglomeration of MWCNT that presents in a bulk quantity of the matrix [6].

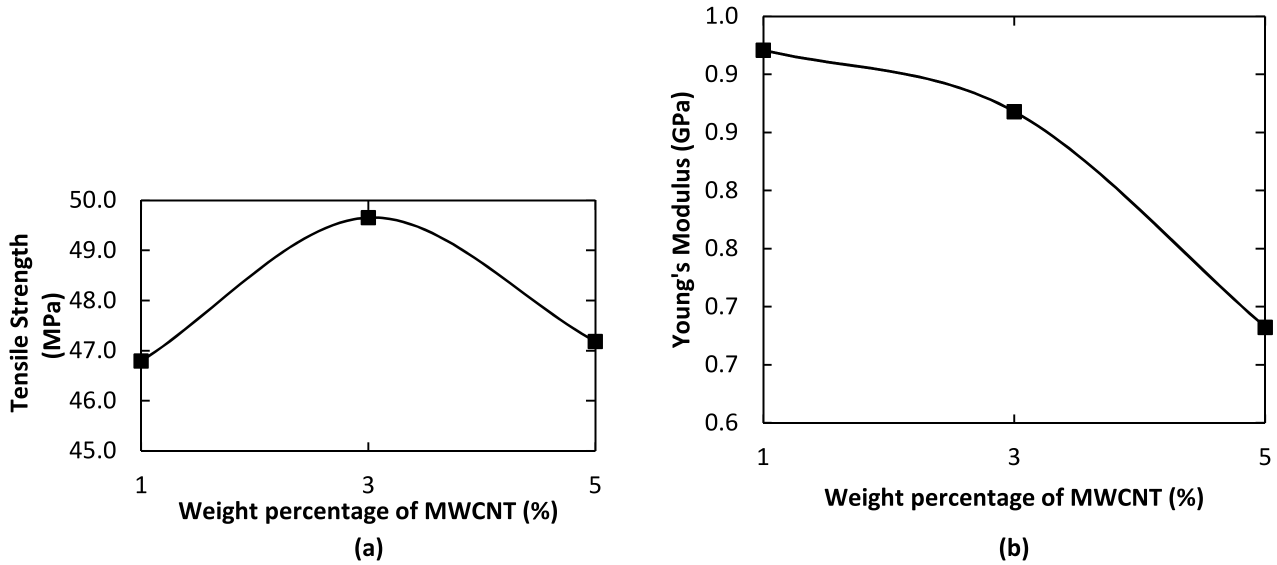


**Fig. 4.** The effect of weight percentage of MWCNT on (a) tensile strength and (b) Young's Modulus of jute-epoxy composite laminates

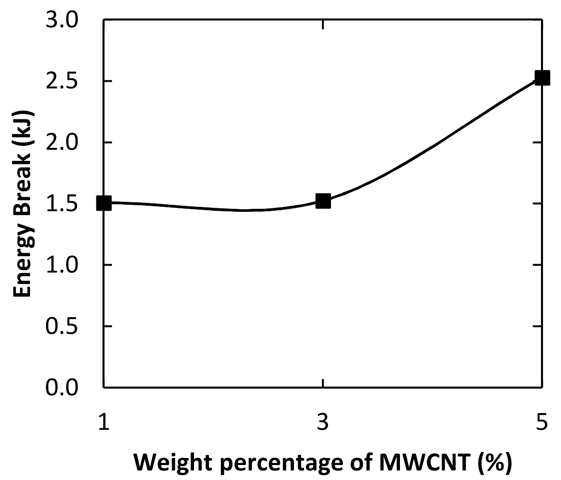


**Fig. 5.** The effect of weight percentage of MWCNT on energy absorbed of jute-epoxy composite laminates

Total energy absorption was calculated by measuring the area under the fore-displacement curve. The effect of MWCNT contents in energy absorption is shown in Figure 3.3. As can be seen, increasing the weight percentage of MWCNT to the jute-epoxy laminate increased the total energy absorption capability of the composites. Larger amount of MWCNT increases the deformation of the laminate and resultant in higher energy absorbed capabilities.

Summary of the experimental results for MWCNT-filled jute-epoxy laminate is tabulated in Table 1. An examination of the table, it also included the result from unfilled of jute-epoxy laminate. Tensile strength for jute-epoxy composite without MWCNT filler is 46.268 MPa and approximately 7% lower than that measured from the 3% of MWCNT filler. In contrast, an average Young's modulus value at jute-epoxy laminate was found to be higher than that measure at other systems. Du et. al [11] reported the present status of CNT-polymer composite in Young's Modulus and tensile strength. They stated that oriented randomly of CNT-polymer show only sensible or no improvement in mechanical properties if compared with aligned CNT-polymer composites. This is the reason to poor dispersion within the untreated MWCNT and matrix that causes poor load transfer between them. Using nano-fillers in expecting for mechanical improvements in composite, having homogenous dispersion without disturbing the integrity of MWCNT is very crucial to ensure good interfacial bonding throughout the resin [7]. Optimum interfacial bonding is required to achieve effective load transfer across the MWCNT-epoxy resin interface which is one of the key factor in improving the mechanical properties.

**Table 1**
Experimental results from tensile testing

| Specimen | Tensile Strength (MPa) | Young's Modulus (GPa) | Energy Absorbed (kJ) |
|---|---|---|---|
| JE | 46.268 | 1.207 | 1.168 |
| 1%MWCNT_JE | 46.791 | 0.921 | 1.442 |
| 3%MWCNT_JE | 49.655 | 0.868 | 1.523 |
| 5%MWCNT_JE | 47.182 | 0.683 | 2.528 |

## 4. Conclusion

In this study, the tensile strength of jute-epoxy laminates is influenced by the addition of MWCNT weight of percentage. Increase of nano material in jute-epoxy composite resulted in higher value of tensile behaviour of the laminate and peak at 3% wt. of MWCNT. Higher young modulus of jute-epoxy laminate was found, as compare with MWCNT-polymer system, suggested that introduce nano filler led to degrading of load transfer between matrices and fibre.

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## References
[1] A. K. Rana *et al.*, "Short Jute Fiber-Reinforced Polypropylene Composites : Effect of Compatibilizer," *J. Appl. Polym. Sci.*, vol. 69, no. 2, pp. 329–338, 1998.
[2] K. L. Pickering, M. G. A. Efendy, and T. M. Le, "A review of recent developments in natural fibre composites and their mechanical performance," *Compos. Part A Appl. Sci. Manuf.*, vol. 83, pp. 98–112, 2016.
[3] F. Abdalla, M. Megat, M. Sapuan, and S. Bb, "Determination of Volume Fraction Values Of Filament Wound Glass and Carbon Fiber Reinforced Composites," *ARPN J Eng Appl Sci*, vol. 3, no. 4, pp. 7–11, 2008.
[4] M. Tarfaoui, K. Lafdi, and A. El Moumen, "Mechanical properties of carbon nanotubes based polymer composites," vol. 103, pp. 113–121, 2016.
[5] G. Savage, "Composite Materials Technology in Formula 1 Motor Racing.pdf." 2008.

[6] R. K. Prusty, D. K. Rathore, and B. C. Ray, "CNT / polymer interface in polymeric composites and its sensitivity study at different environments," *Adv. Colloid Interface Sci.*, vol. 240, pp. 77–106, 2017.
[7] P. Shin, D. Kwon, J. Kim, S. Lee, K. L. Devries, and J. Park, "Interfacial properties and water resistance of epoxy and CNT-epoxy adhesives on GFRP composites," *Compos. Sci. Technol.*, vol. 142, pp. 98–106, 2017.
[8] K. T. Lau, "Interfacial bonding characteristics of nanotube/polymer composites," *Chem. Phys. Lett.*, vol. 370, no. 3–4, pp. 399–405, 2003.
[9] K. T. Lau, M. Chipara, H. Y. Ling, and D. Hui, "On the effective elastic moduli of carbon nanotubes for nanocomposite structures," *Compos. Part B Eng.*, vol. 35, no. 2, pp. 95–101, 2004.
[10] D. K. Rathore, R. K. Prusty, D. S. Kumar, and B. C. Ray, "Mechanical performance of CNT-filled glass fiber/epoxy composite in in-situ elevated temperature environments emphasizing the role of CNT content," *Compos. Part A Appl. Sci. Manuf.*, vol. 84, pp. 364–376, 2016.
[11] J. Du, J. Bai, and H. Cheng, "The present status and key problems of carbon nanotube," vol. 1, no. 5, pp. 253–273, 2007.