Effects of Fibre Orientation on Mechanical Properties of Glass/Kenaf Hybrid Composites

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Abstract*: Kenaf is produced into variety of new applications such as building materials, paper products, absorbents and livestock feed which is diverging from its old common role as a cordage crop. In this work, the hybrid composites are prepared through traditional way of layering glass fibre and kenaf fibre with epoxy matrix by using hand and left for cure at room temperature. Then, the effect of fibre orientation at 0/90°, 30° and 45° is investigate through tensile test and flexural test. The different weight ratio of 200gsm woven glass fibre and woven kenaf fibre and total fibre loading at 50% by weight. It is found out that 0/90° fibre orientation is superior in both tensile properties and flexural properties compared to others fibre orientation. While 45° fibre orientation is the lowest for both tensile properties and flexural properties.

Index Terms*: Fibre orientation, Hybrid composites, Kenaf fibre, Mechanical properties.

I. INTRODUCTION

Currently, kenaf fibre have been extensively studied by researcher as it is one of the highly-potential natural fibre to replace synthetic fibre[1]. Interesting fact about kenaf is about 40% of the stalk obtain are fibre that usable, almost double that of flax, jute or hemp. This yields percentage makes the fibre more economical to be planted and used [2]. Kenaf is proven as a good natural fibre, basic source for textiles and industrial applications [3][4].

The difference in strength between natural fibres and conventional reinforcing fibres is one the main reasons why natural fibres cannot fully replace the glass fibres. Therefore, hybrid composites, mainly natural-synthetic combination, were introduced to overcome the strength limitation of natural fibre as well as reduce the weight of synthetic fibres [5]–[9]. Other method such as fibre prestressing can also be applied[10][11]. Hybrid composite has 54% and 15% higher in tensile strength than pure banana composites and kenaf composites respectively as found by Alavudeen et al [8]. Woven kenaf bast fibre (KBFw) is hybridized with oil palm empty fruit bunches (EFB) as KBFw has higher tensile strength, thus can provide additional reinforcement to EFP as investigated by Khoshnava et al [12]. The addition of kenaf fibre to wood flour/PP system help to increases the tensile strength and tensile modulus of the composites is reported by Jamal et al [13]. Other than kenaf, banana, jute and flax, bamboo fibre are also being research as potential natural fibre [14]–[17].

Composites made up of woven fibre possess higher tensile strength when the fibre was oriented longitudinally to the load apply [9]. The flexural ,tensile and impact strength is found out to be at the highest when the fibre is at 90 orientations for both epoxy and polyester based composites as stated in studies done by Girisha et al [18]. Tensile and impact properties in composite can be monitored thoroughly for a set period of time[19][20]. This research used a smaller yarn size as compared to previous researches [21]–[24]. As to support the findings from the reported studies with a newly hybrid composites of glass/kenaf reinforced epoxy, this research was focused on examining the effects of orientation on their mechanical properties.

II. MATERIALS AND METHODOLOGY

Materials being used are 200 g/m² E-type woven glass fibre and woven kenaf fibre, both supplied by IndersenShamlal Pvt. Ltd. India. E-type glass fibre is more suitable for structure application compared to the other type [25]. Epoxy type Zeepoxy HL002TA cured with Zeepoxy HL002TB hardener was used as the matrix. The mixture of resin and hardener were prepared using the ratio of 2:1. A rectangular shaped panel was fabricated with 50 wt.% kenaf fibres, in a specific layering sequence as shown in Figure 1, through hand lay-up technique.

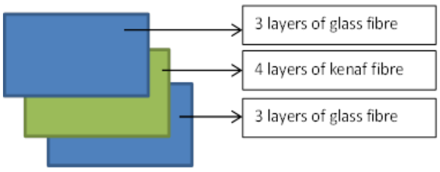

Fig. 1: Schematic diagram of kenaf/glass hybrid composites

The prepared samples were cut into four different orientations of 0/90°, 30° and 45° as shown in figure 2 until

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figure 5. The tensile test and flexural test were done to investigate the mechanical properties of the samples.

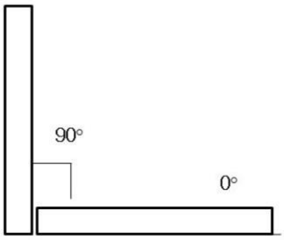

Fig. 2: Schematic drawing of specimen cut for 0/90° fibre orientation

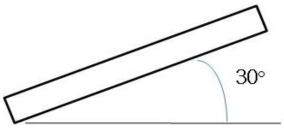

Fig. 3: Schematic drawing of specimen cut for 30° fibre orientation

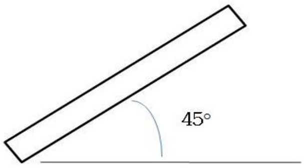

Fig. 4: Schematic drawing of specimen cut for 45° fibre orientation

Tensile tests were carry out using a floor model Universal Testing Machine; model Instron 3382 while the flexural test were accomplish using floor model Universal Testing Machine; model Instron 3365. All tests data was recorded by InstronBluehill software combine with PC data acquisition, that will automatically calculates the obtained data directly. Sample of all configurations were tested according to ASTM3039/D3039M and ASTM D790-03 standard for tensile and flexural properties respectively [26][27]. Five repetitions of all configurations were tested for the average value.

III. RESULTS AND DISCUSSIONS

The fiber orientation, weave style and the bonding between the fiber and matrix will determined the strength of woven fibre composites as stated by Shibata et al. [28]. In this study, 0°/90° fibre orientation is found out having the best tensile strength of 134.15 MPa and the highest tensile modulus of 5.61 GPa. These are followed by 30° fibre orientation with ten-sile strength of 59.72MPa. The lowest tensile strength is from 45° fibre orientation with only 51.01 MPa. 45° fibre orienta-tion has tensile modulus of 3.64 GPa which is higher than 30° fibre orientation with tensile modulus of 3.24 GPa. The rea-son that 0°/90° fibre orientation having better tensile strength and tensile modulus compare to 30° and 45° fibre orientation is because the fibre orientation is in the same direction as the direction of force being applied to the specimen [9].

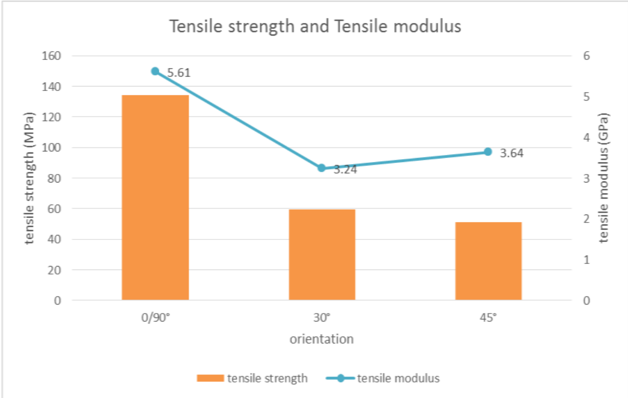

Fig. 5: Tensile strength (MPa) and tensile modulus (GPa) for all orientation

In flexural properties as shown in figure 7, there is two types of condition occur which is compressive mode on the top lay-er while tensile force on the bottom layer of specimen being tested [29]. The orientation that has the highest value of flex-ural strength and flexural modulus is the best orientation that can withstand compressive force and tensile force simultane-ously which is the 0°/90° fibre orientation that has flexural strength of 229.21 MPa and flexural modulus of 11.21 GPa. Other than that, 30° and 45° fibre orientation have the flexural strength of 143.05 MPa, 134.18 MPa and flexural modulus of 6.41 GPa, 5.69 GPa respectively. The different on flexural strength is believe due to 0°/90° fibre orientation have better force distribution thus manage to withstand higher force compare to 30°and 45° fibre orientation.

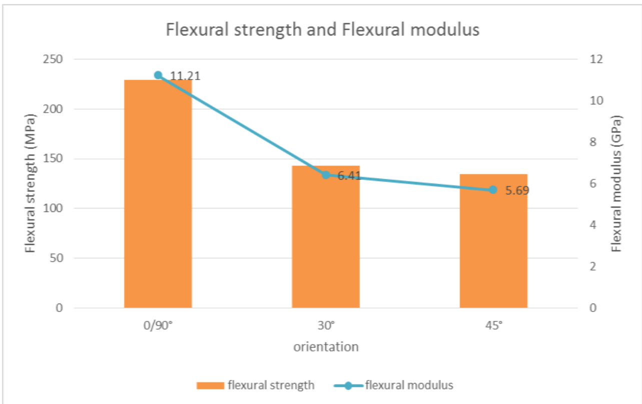

Fig. 6: Flexural strength (MPa) vs flexural modulus (GPa) for all orientation

IV. CONCLUSIONS

Based on the tensile properties, the 0/90° fibre orientation gives the best properties as show in the figure 5 which present the obtain value of tensile strength and tensile modulus. 0°/90° fibre orientation having the best value of tensile strength and tensile modulus is consistent as found in previous work [18]. 0/90° fibre orientation also has the highest young's modulus of 5.61 GPa follow by 45° fibre orientation with 3.64 GPa and 30° fibre orientation with 3.24 GPa. Other than that the 45° fibre orientation is the lowest in tensile strength with only 51.01 MPa.

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orientation has 229.21 MPa and 11.21 GPa which gives the highest value for both average flexural strength and average flexural modulus respectively. Figure 6 shows that the 30° fibre orientation with flexural strength of 143.05 MPa and flexural modulus of 6.41 GPa exhibit better flexural properties than 45° fibre orientation with flexural strength of 134.18 MPa and flexural modulus of 5.69 GPa.

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