Flexural Properties of Kenaf Fibre Hybrid and Non-Hybrid Composite Materials

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***Abstract:**Natural fibre are well known for its properties where it has low density and it is also better in form of cost efficiency compared to synthetic fibre. There are not too much difference between specific properties of natural fibre and synthetic fibre although the natural fibre strength is significantly lower than synthetic fibre. This study discusses the flexural properties of a hybrid composite made from both natural fibre and synthetic fibre. In this research, kenaf fibre – non-treated and treated with NaOH solution – as well as x-ray film – non-treated and surface treated with consistent holes were chosen to investigate its flexural properties. The number of layers in this study is maintain throughout the research, which are seven layers of kenaf – treated and untreated – as well as alternating layers between kenaf fibre and x-ray films – also treated and untreated. The specimen were prepared using the normal hand lay-up process and it was tested by the three-point bending method using Instron 4204 at a speed of 15mm/min. Even though the test showed expected problems such as interfacial bonding issues, there are improvements due to treatment and the hybridization. The specimen showed results of flexural modulus of up to 8.83GPa for treated fully kenaf configuration and 3.36GPa for alternative configuration with treated kenaf. The higher flexural modulus is suitable for applications which desire a more rigid structure like a spall linear or car bumper, while the specimen with the lower flexural modulus is suitable for a more flexible structure like body armour.*

***Index Terms:** Kenaf fibre, x-ray film, hybrid composite, flexural properties.*

I. INTRODUCTION

Natural fibres are categorized in terms of source as animal based, vegeta-ble based which is mostly used in studies, & mineral based. Vegetable based natural fibres which are the most broadly used are further categorized as seed based like cotton, leaf based like jute, hemp, flax and also fruit based like coconut and coir [1-2]. The mechanical properties of natural fibres, especially kenaf, hemp, flax, sisal and jute, are great and may be comparable in specific strength and modulus with glass fibre. Numerous studies have been done on different types of natural fibres like kenaf, bamboo, flax, hemp, and jute to investigate how these fibres affect the mechanical performance of composite materials [3-5]. Even though it is known that in average natural fibre com-posites' strength is not on par to synthetic fibre reinforced composites even with optimal fibre-matrix interaction [6-8], they are still comparable in terms of specific and economic standpoint due to their lower density and lower cost. Hence, it gives a strong credit for the replacement of natural fibre composite as compared to existing materials.

Bharath et al. studied on the comparison in term of mechanical and thermal properties of natural fibres, and it was found that kenaf composite shown better performance, thus make it suitable for engineering applications [9-11]. It was also found that kenaf fibre is suitable for various applications because of its excellent properties hence it is applicable to replace normal reinforcement in composite such as glass fibre and other synthetic fibre [12-14].

However, to improve the bonding between natural fibre and matrix in a composite, surface treatment on the natural fibre is required. Previous study done on structural, thermal, and mechanical properties on kenaf fibre by Akhtar et al, proved that NaOH helps to improve the surface roughness of kenaf fibre and provides better bonding between fibres and polypropylene matrix [15-16]. Fiore et. al. has found that NaOH treatment gives better stress transfer between reinforcement and matrix because of improved interfacial bonding between fibre and matrix [17-18]. Yousif et. al. has performed flexural testing with fibre treated with NaOH, and it was found that treated composite performed better compared to untreated composites [19-20].

X-ray films are a polymeric based material that are commonly used in medical facilities to imprint radiographic images of the human body. These films are abundantly available due to the lack of method to dispose of it properly. Hence, this material is chosen to be used in this study due to their availability, good flexural properties, and as an approach towards turning waste to wealth.

Hybridizing two materials does not necessarily improve the properties of the product. Bajuri et. al. found that hybridizing kenaf fibre with hydrophobic silica

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nanoparticles showed a detrimental effect on the mechanical properties of the specimen [21-23]. Yusoff et. al. found that by hybridizing kenaf and coir fibres together using PLA matrix, high flexural properties were gained, showing flexural modulus 70% higher than other combinations they studied [24-26]. Kumar et. al. found that using longer fibres, the flexural properties of kenaf fibre hybridized with glass fibre is better than the base fibres [27]. Based on this trend, we can see that the flexural properties can be im-proved by applying chemical treatment to the natural fibre or hybridizing different fibres together.

II. METHODOLOGY

In this research, a hybrid composites made from kenaf fibre and x-ray films were chosen. The reinforcements, kenaf fibre was in the form of woven mat, and x-ray films in the form of ply while the matrix used in this research is epoxy resin. NaOH treatment were done on kenaf fibre, with 6% of concentration within 3 hours immersion time, in water bath with the temperature of 95°C. Normal hand-lay up fabrication process were used, and composites with different layers configurations were produced as shown in Table 1.

Table 1. Samples configurations for flexural testing

Configuration	Layers	Thickness
1	KF-KF-KF-KF-KF-KF-KF	8.15mm
2	TKF-TKF-TKF-TKF-TKF-TKF-TKF	8.15mm
3	KF-XF-KF-XF-KF-XF-KF	6.35mm
4	TKF-XF-TKF-XF-TKF-XF-TKF	6.35mm

KF – Kenaf; TKF – Treated kenaf; XF – X-ray Film

For flexural testing, samples were prepared according to ASTM D-790. Instron 4204 machine testing were used for the three point bending flexural testing process with speed of 15mm/min.

III. RESULTS AND DISCUSSION

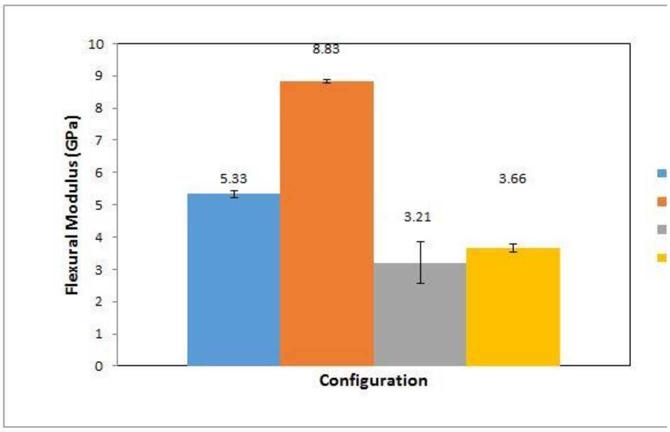

Fig 1. Water absorption behaviour of natural hybrid composites

Fig 1 shows that configuration 2 which is treated full kenaf configuration is the most rigid compared to the rest of the specimens with a flexural modulus of 8.83GPa. Comparing configuration 1 which is untreated full kenaf configuration to configuration 2, we can see significant raise in the flexural modulus which is 5.33GPa for configuration 1. This proves that chemical treatment improves the interfacial bond of kenaf fibre, hence making it more rigid. This is also true for configuration 3 and 4, where configuration 4 – alternative layers of treated kenaf fibre and x-ray films – shows slightly higher flexural modulus at 3.66GPa compared to configuration 3 – alternative layers of untreated kenaf fibre and x-ray films.

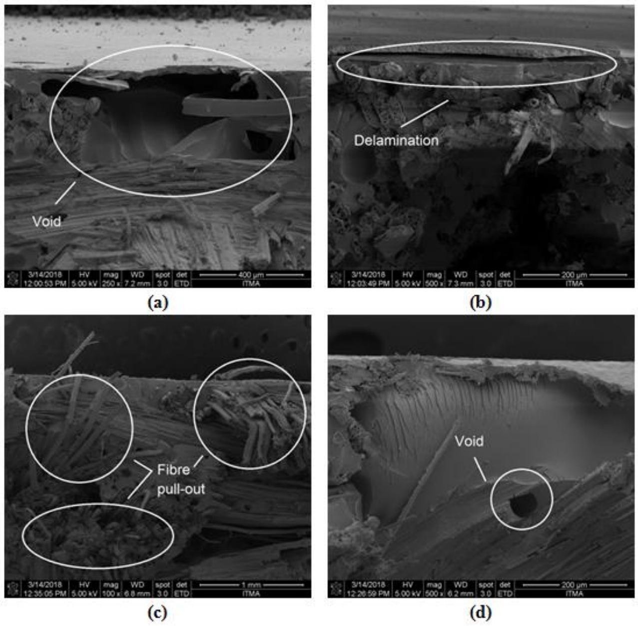

Fig 2. Microscopic Images of Specimen which includes; a and b) Untreated Kenaf, c and d) Treated Kenaf

Fig 2(a) reveals that there is an obvious void in the matrix, which is most likely caused by the weak bonding between the epoxy matrix and the untreated kenaf fibre. Because of the weak interfacial bonding, the epoxy matrix does not adhere to the fibre, hence producing a number of voids. We can also observe delamination between the layers of kenaf fibre and the layers of x-ray film in Fig 2(b). The delamination is very obvious as a wide gap between the two materials is easily observed. This is again most likely caused by the weak interfacial bonding between the kenaf fibre and the x-ray films.

Fig 2(c) reveals that a significant degree of fibre pull-out, which is most likely due to the kenaf fibre being degraded through the treatment process. Fig 2(d) shows that there is no gap between the kenaf fibre and x-ray film. This proves that the chemical treatment improved the interfacial bonding between the kenaf fibre with the epoxy resin, as well as with the x-ray film. Through manual lay-up method, the presence of void, as shown in Figure 2(d), is normally happen due to human error.

IV. CONCLUSION

From the results, it was found that the flexural properties of kenaf hybrid composites were affected by the layering configuration between kenaf and x-ray film. The results also show that kenaf and x-ray film did not stick well thus effects the performance of the hybrid composites as it experience delamination easily during the flexural testing. It is also proven that differences of the surface type between this two material affects the surface bonding thus effected the flexural properties. However, with chemical treatment there were signs of improvements. As mentioned, the more rigid specimens like configuration 1 and 2 which is fully consisting of kenaf fibres are more suitable for applications which require hard and stiff materials. On the other hand, configuration 3 and 4 which is softer are suitable for applications which require a more flexible material for example like applications in-volving impacts.

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