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PROPERTIES OF POLYURETHANE FOAM/COCONUT COIR FIBER AS A CORE MATERIAL AND AS A SANDWICH COMPOSITES COMPONENT

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ABSTRACT

This research focuses on the fabrication and characterization of the sandwich composites panel using glass fiber composite skin and polyurethane foam reinforced coconut coir fiber core. The main objectives are to characterize the physical and mechanical properties and to elucidate the effect of coconut coir fibers in polyurethane foam cores and sandwich composites panel. Coconut coir fibers were used as reinforcement in polyurethane foams in which later were applied as the core in sandwich composites ranged from 5 wt% to 20 wt%. The physical and mechanical properties found to be significant at 5 wt% coconut coir fiber in polyurethane foam cores as well as in sandwich composites. It was found that composites properties serve better in sandwich composites construction.

Keywords: Coconut Coir; Polyurethane Foam; Polyurethane Moulding; Sandwich Composites.

INTRODUCTION

Sandwich panels consist of two outer skins and core in the middle. The combination of these parts offer sandwich panels a relatively high strength and stiffness at low densities. Skins can be made of composite laminate panels, aluminium alloys, titanium steel or plywood. Core is the constituent that requires low density materials such as polymer foams, balsa wood, synthetic rubbers or inorganic cements (Mallick, 2008). Commonly sandwich composites were used in aerospace, automotive, sporting goods, marine, construction and civil structures. Various materials and structures were used to design the sandwich composites to meet the application requirement. Composite material that formed with natural fibers constitutes a current area of interest in composites research. A great development in this field has been noticed and currently applied in automotive industries (Pickering, 2008). Natural fibers are low priced and sustainable natural resources and have good mechanical properties (Chand and Fahim, 2008). Therefore, the used of this fiber reduce the materials cost of sandwich composites and in the same time improve its properties (Bledzki et. al. 2001). Furthermore the densities of natural fibers are close to the densities of thermoset polymer and glass fiber. On the other hand, polyurethane foam (PUF) resins are widely used in the engineering applications since exhibit its structural versatility as elastomer, thermoplastic, thermosetting, rigid and flexible foam. By combining the natural fiber with polyurethane foam (PUF) as a core, the sandwich construction development will enhance the properties of Polyurethane foam as well as sandwich composites panel (Silva, 2005).

EXPERIMENTAL

Panel Preparation

There are several stages in the construction of the sandwich composites panel of glass fiber and polyurethane/coconut coir foam core (GFRP - PUC):

(i) Coconut coir treatment: The coconut coir fibers were crushed using granulator machine with the fiber length ranging from 0.5-1cm. Later it has been treated by using alkaline treatment method. The treatment begins when the coir fibers treated with 5 wt.% Natrium Hydroxide (NaOH) and 95 wt.% water. The treatment with NaOH solutions were required to remove impurities from coconut fiber, such as hemi cellulose, lignin and aromatic acids, which could be reduced the adhesion between fiber and matrix. The duration for this treatment was 24 hours at room temperature. Lastly, the coir fibers were cleaned and dried up in oven for 12 hours at 80º (Herrera and Valadez, 2005).

(ii) Polyurethane foam: The polyurethane foam was produced by mixing the polyol and isocynates by using one shot process. When the mixing of polyol and isocynate were prepared, coir fibers ranging from 0 wt% to 20 wt% will be added and stirred to ensure the coir fiber was uniformly distributed. Lastly, these mixed components were poured into the mould and cured at a room temperature using rotational moulding method.

(iii) Skin preparation: Skins were prepared by using compression moulding technique with woven glass fiber mat and epoxy matrix with ratio of 2:1. Skin panels consist of three plies of fiber glass woven mat with panel dimension of 300 mm x 300 mm. These panels were then cured for 12 hours at room temperature.

(iv) Sandwich composite construction: Glass fiber skins were ground with 120 grid abrasive paper to provide rough surface with polyurethane foam core. Moreover epoxy adhesive was placed between skins and cores. Sandwich composites cured using compression moulding method at 100 KPa for 8 hours to ensure excellent bonding between them. Figure 1 shows the sandwich composites with two skins placed at the outer surface and foam core located between them**.** Figure 2 (a) and (b) show the polyurethane foam core and sandwich panels at 0 wt.% coir fibers.

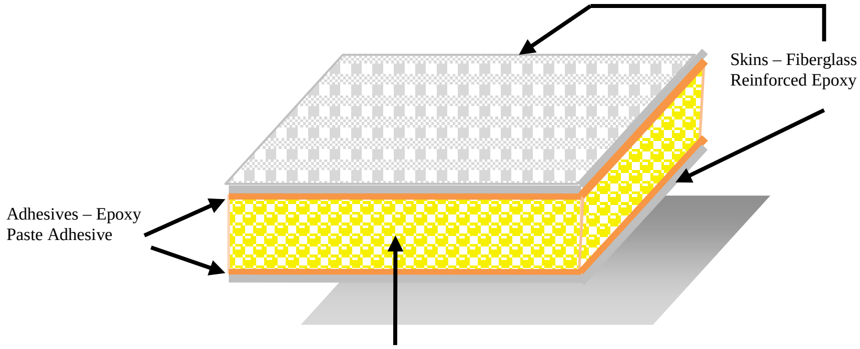
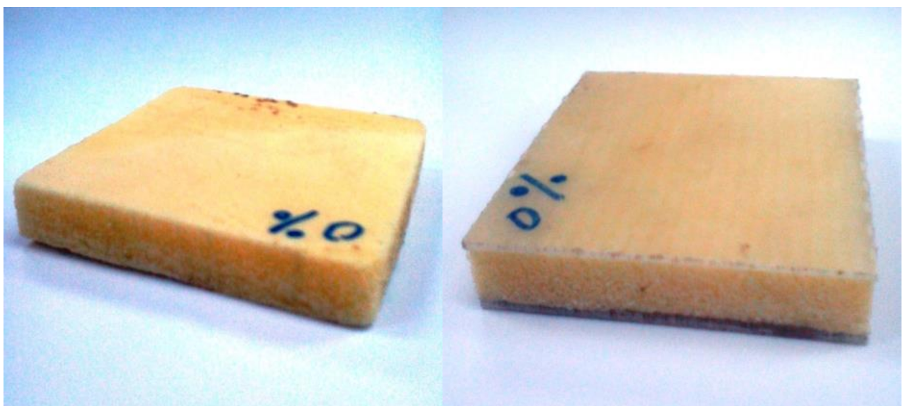


Figure 1. Sandwich composites panel of glass fiber and polyurethane/coconut coir foam core (GFRP - PUC).



(a) (b)

Figure 2. (a) Polyurethane foam core at 0 wt.% coir fibers
(b) Sandwich Panel at 0 wt.% coir fibers.

TEST METHODS

Density Test

The objective of this test is to determine the density of core materials. The density test was conducted under ASTM C 271. The samples dimensions were 300 mm x300 mm x18 mm. In this test, panels were tested to determine the effect of coir fiber to the panel's density. The density was measured as the mass of the panel divided by its volume (ASTM C271, 2002).

Flexural Test

The flexural test conducted by using three point bending test (ASTM C 393) using universal testing machine. The objectives of this test are to determine the flexural strength and stiffness properties of sandwich composites panels. For this test, the specimen dimensions were 350mm x75mm and the test velocity was 2mm/min (ASTM C393, 2002).

RESULT AND DISCUSSION

The physical and mechanical properties evaluated to analyze the comparison of between polyurethane foam cores and sandwich composites. The purpose of this analysis is to determine the ability of sandwich composites in enhancing the material properties. Sandwich composites offer excellent properties due to the way of skin and core deal with load applied.

Physical Properties

Physical properties of sandwich composites and polyurethane foam cores were determined by conducting density test. Figure 3 shows the differences between sandwich composites and cores. Polyurethane foam offered better density with lowest average value at 84.6 g/cm^3 compared to sandwich composite that have higher average density which is 382.45 g/cm^3. Sandwich composites density was increased to 352% compared to polyurethane foam cores. This increment is due to sandwich composite cores attachment to fiberglass composite skins. However the excellent properties contribution offered by the role of fiberglass composites skins in sandwich composites, make the density increment worth.

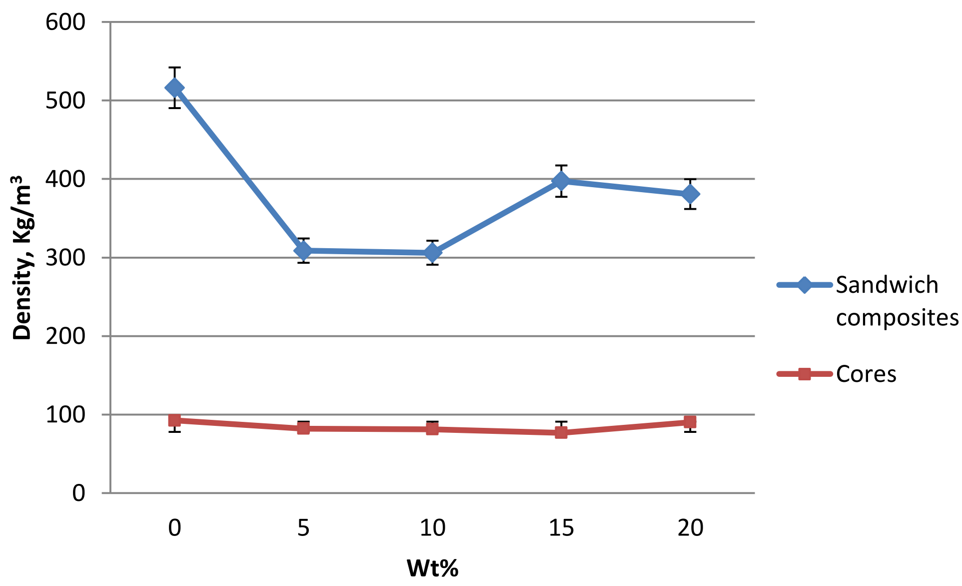


Figure 3. Density comparison of polyurethane foam cores and sandwich composites.

Mechanical Properties

Figure 4 shows the flexural shear stress comparison between cores and sandwich composites. The average flexural shear stress of sandwich composites is 190.95 KPa and cores flexural stress 31.46 KPa. The percent of shear stress increment for sandwich composites is 506.95% compared to cores. The maximum force of sandwich composites shows an increment 1145.42% compared to cores with the sandwich composites and cores maximum force are 587.04 N and 47.14 N respectively (Refer Figure 5). While for flexural modulus of sandwich composites and cores, the average flexural modulus are 362.76 MPa and 11.39 MPa respectively. Sandwich composites offer flexural modulus 3084% higher compared to cores. Figure 6 shows the flexural modulus comparison of polyurethane foam cores and sandwich composites.

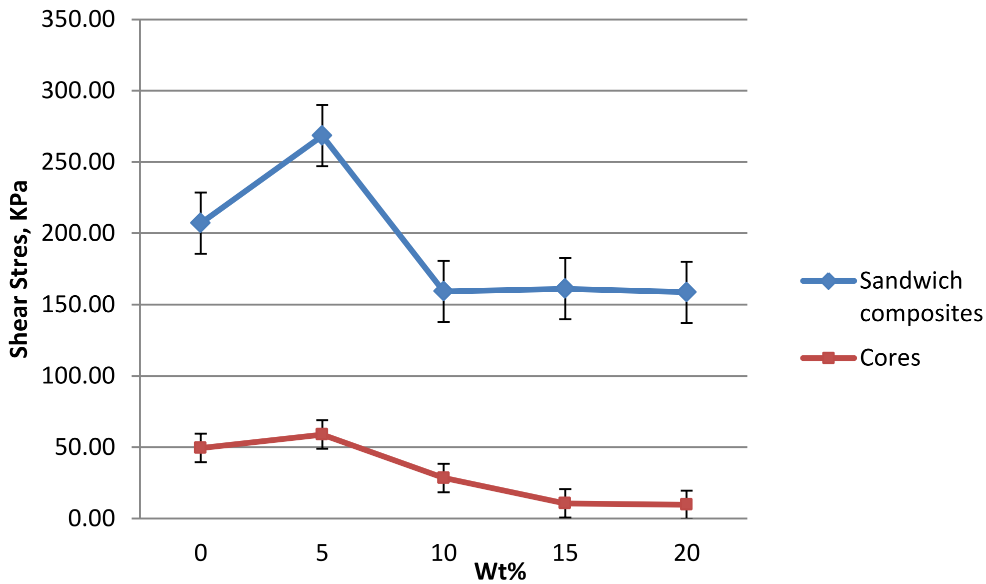


Figure 4. Flexural shear stress comparison of polyurethane foam cores and sandwich composites.

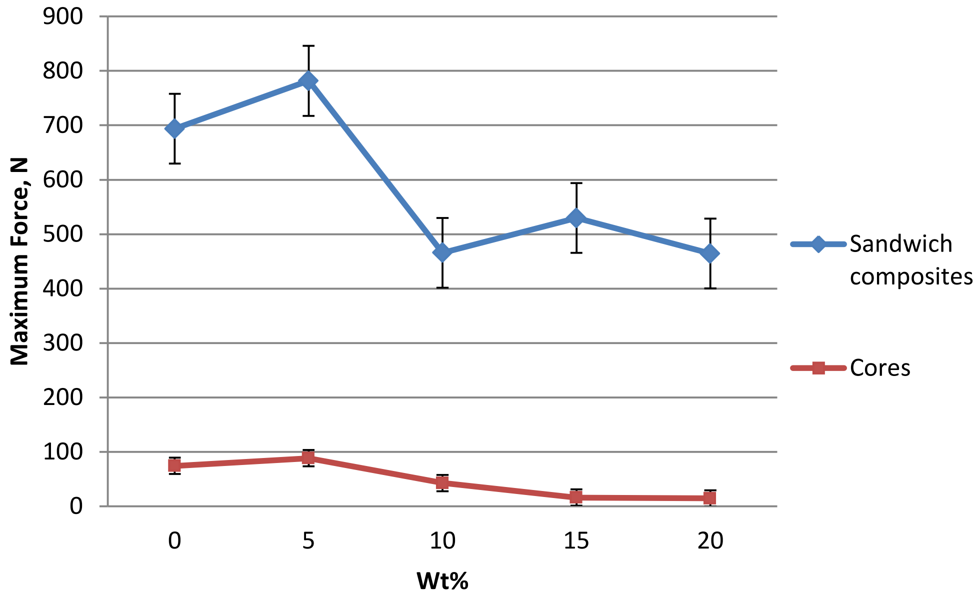


Figure 5. Maximum force comparison of polyurethane foam cores and sandwich composites.

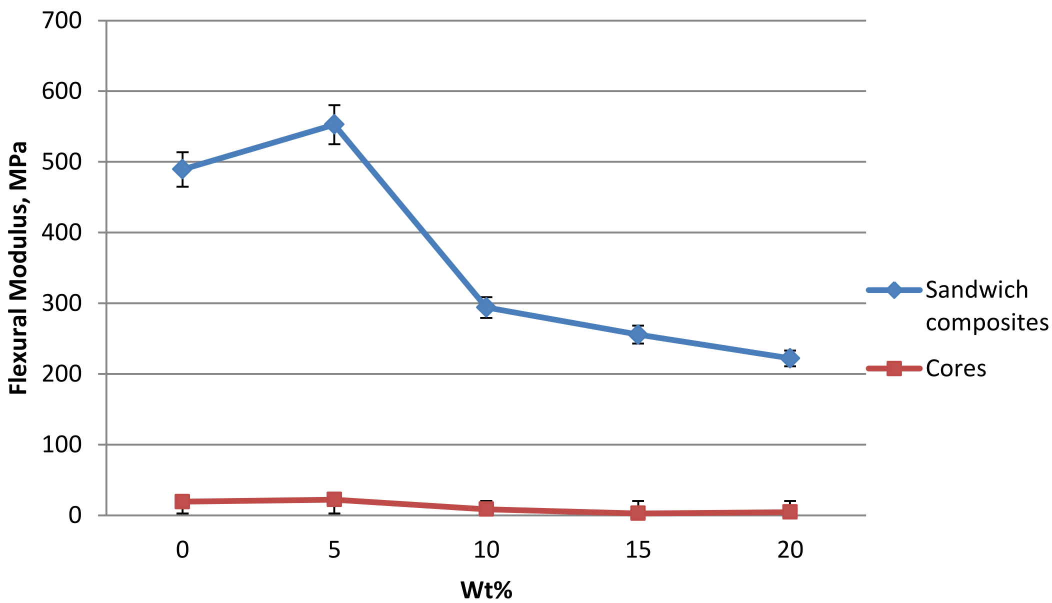


Figure 6. Flexural modulus comparison of polyurethane foam cores and sandwich composites.

The excellent increment in sandwich composites material properties compared to polyurethane foam cores is due to because of the sandwich composites structure itself. Sandwich composites structures contain skins and cores that resist each others from buckling during load application (Papa et. al., 2001). Cores of sandwich composite act as a web to stabilize the skins by carrying lateral forces applied. Most of in-plane loading and transverse bending stresses beared by the sandwich composite skins helped cores to be in compression and shear or tension and shear (Zheng et. al., 2008). The combinations of skins and cores properties lead sandwich composites to have better properties. Compared to polyurethane foam cores, they were found not to assist by any material in resisting the load applied. The polyurethane foam cores resist the load and buckling due to its own properties.

CONCLUSION

This study shows that by reinforcing polyurethane foam cores with coconut coir fibers, physical and mechanical properties of cores and sandwich composites had increased. The optimum performance was achieved by reinforced cores and sandwich composites with 5 wt% of coconut coir fibers. The polyurethane foam cores offered better properties as sandwich composites in resists bending stress to avoid panel buckling.

REFERENCES

American Society for Testing and Materials (2002). Standard test method for core shear properties of sandwich constructions by beam flexure. Philadelphia:ASTM C393

American Society for Testing and Materials (2002). Standard test method for density of sandwich core materials. Philadelphia:ASTM C 271.

Bledzki, A. K., Zhang, W, and Chate, A. (2001). Natural-fibre reinforced polyurethane microfoams. Composites Science and Technology, 61(16): 2405-2411.

Chand, N. and Fahim, M. (2008). Tribology of natural fiber polymer composites, Cambridge : Woodhead Publishing.

Herrera P. J. and Valadez-González A. Fiber-matrix adhesion in natural fiber composites. In A. K. Mohanty, M. Misra, and L. T. Drzal. (2005). Natural fibers, Biopolymers, and Biocomposites. Florida: CRC Press. 187: 196-197.

Mallick, P. K. (2008). Fibre reinforced composite (material, manufacturing and design). 3st Ed. Boca Raton : CRC Press.

Pickering, K., L. (2008). Properties and perfomances of natural-fibre composites. Cambridge: Woodhead Publishing.

Papa, E., Corigliano, A. and Rizzi, E. (2001). Mechanical behaviour of a syntactic foam/glass fibre composite sandwich: experimental results. Structural Engineering and Mechanics. 12(2): 169-188.

Silva R.V. (2005). Fracture toughness of natural fibers/castor oil polyurethane composites. Composites Science and TechnologY. 66(10): 1328-1335.

Zheng, X. T., Zhang, J. F.; Yang, F., Chai, Y. N., and Li, Y. (2008). Experimental and analytical study on the mechanical behavior of stitched sandwich composite panel with a foam core. Seventh

International Conference on Fracture and Strength of Solids (FEOFS2007). Xi'an: Northwestern Polytechnical University. pp. 477-482.