ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

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Maximum Flexural Stress Analysis of Hemp/Epoxy and Glass/Epoxy Polymer Composite via ANSYS Simulation

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Paper ID: 13A13B

Volume 13 Issue 13

Received 23 July 2022
Received in revised form 18 October 2022
Accepted 25 October 2022
Available online 01 November 2022

Keywords:
Fibre-reinforced polymers (FRP); Natural fibre; Numerical method; Fibre ply orientation; Staking sequence.

Abstract

One of the most widely utilised natural fibres for reinforcement in polymer composites is hemp fibre. It originated from the Cannabis sativa plant. The flexural properties of composite materials mainly depend on the properties of the fibre, fibre volume fraction, fibre orientation and its layer sequence architecture. In this study, the maximum flexural stress and deformation of the Hemp fibre-reinforced polymer (HFRP) composite were analysed using modelling and simulation techniques and compared to the conventional glass fibre-reinforced polymer (GFRP) composite. ANSYS software was used to determine the effect of fibre ply orientation, stacking ply sequence with and without supporting ply angle 0° and fibre volume fraction on the flexural response of the FRP composite. It was found that the HFRP composite with 0° supporting ply has a strength reduction index of 2.0, while the HFRP composite with no supporting ply has an index of 1.4.

Discipline: Mechanical Engineering.

Cite This Article:

Md Said, J., Jumahat, A., Sa'adan, A., Shah, R.M.R.A and Yusof, F.M. (2022). Maximum flexural stress analysis of Hemp/Epoxy and Glass/Epoxy polymer composite via ANSYS Simulation. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 13*(13), 13A13B, 1-10. http://TUENGR.COM/V13/13A13B.pdf DOI: 10.14456/ITJEMAST.2022.254

1 Introduction

Fibre-reinforced-polymer (FRP) composites are common engineering materials used in a variety of applications such as aircraft, spacecraft, ships, submarines, automobiles, and construction. FRP composites are popular in such applications because of their outstanding features, including high stiffness, strength, excellent fatigue, corrosion resistance, and low weight. In addition, FRP composites are also usually used to produce lightweight high-strength products with a specific required mechanical characteristic, low thermal expansion qualities, and excellent dimensional stability. When it comes to applications where thermal or mechanical qualities are critical, and weight management is required, glass fibre-reinforced polymer (GFRP) composites are frequently utilised (L. Mohammed et al., 2015). Currently, the utilisation of natural fibre-reinforced polymer (NFRP) composites is becoming increasingly popular. These composites are used as reinforcement materials that introduce matrix materials to replace synthetic fibre's utilisation. This is because NFRP possesses the unique quality of being biodegradable and abundant in sources.

The matrix binds the fibre reinforcement and transfers load between the fibres, giving the composite component its net shape and surface quality since natural FRP composites have high tensile and flexural modulus (Sanjay et al., 2016). Generally, the natural fibre-reinforced polymer composites industry is expanding rapidly. Natural fibre-reinforced polymer composites have largely replaced their synthetic counterparts in engineering applications. Due to the abundance of natural fibre resources, they are among the renewable and sustainable resources. Natural fibres are renowned for their low processing costs and desirable characteristics, such as high strength, high stiffness, corrosion resistance, and lightweight. Moreover, natural fibres have a minimal environmental impact (Gholampour & Ozbakkaloglu, 2020).

2 Literature Review

The rapid growth of composites can be attributed to the numerous advantages they offer in modern applications. Composites offer numerous advantages over conventional materials, including lightweight, high strength and stiffness, high toughness, high fatigue resistance, and corrosion resistance, while requiring minimal machining (Waghmare et al., 2022). Even though synthetic fibres are the preferred fibres for use in the production of composite materials, natural fibre is slowly gaining the attention of various industries as environmental consciousness grows. Natural fibres have advantageous properties and advantages over synthetic fibres, such as low cost, low weight, and less damage to production equipment (Prashanth et al., 2017).

Hemp is one of the most widely used natural fibres, as it increasingly replaces synthetic fibres. Hemp fibre is categorised as a bast fibre derived from Cannabis Sativa plants. Because it is the ingredient in the fibres that are both the most rigid and the most robust, cellulose is the primary factor responsible for the fibre's stiffness and strength (Shahzad, 2012). In contrast, the variations in the physical and mechanical properties of the elements are the result of the compositional variety of the constituents. The widths of the fibre as well as its qualities will differ based on a variety of criteria such as the age of the fibre, its geographic origin, constituent contents and source. Most of hemp's fibrous material is used in the production of materials for the construction industry, footwear, paper, and ropes. This plant, which is indigenous to Central Asia, is currently cultivated primarily in Europe, Central Asia, the Philippines, and China. Construction, textiles, paper, packaging, furniture, electrical, and pipe applications use FRP composites derived from hemp (Tanasă et al., 2020).

To investigate the properties of the hemp fibre, in addition to the experimental approach, the simulation methodology is another option for determining the characteristics of FRP composites, which is a method developed to predict the strength of composite materials without using conventional methods such as experimental work. The development of computer technology has made it possible to calculate and analyse a variety of engineering problems using the Finite Element Method (FEM) (Faizan & Gangwar, 2020). It is a highly effective computational method for approximating complex real-world engineering problems under specific boundary conditions. ANSYS Mechanical Ansys parametric design language (APDL) is a general-purpose finite element analysis software. The software includes a variety of general-purpose analysis tools, including pre-processing and post-processing solutions. This programme allows the measurement of the characteristics of fibres with a variety of shapes, sizes, and compositions, as well as directions (Dinesh Kumar & Mohanty, 2015).

3 Method

3.1 Numerical Validation

Numerical modelling (or numerical validation) is a crucial preliminary step in demonstrating that the initial Finite Element (FE) design and implementation are acceptable. The use of FE software is crucial, and the ANSYS-generated results are validated to ensure their consistency with the actual outcomes. Since certain research was previously performed, numerical validation is required to confirm that the produced result is acceptable. Analytical validation was performed on composite laminate plates with dimensions of 279 x 279 x 2.16 mm and a ply thickness of 5.55555×10^{-6} m. Eight nodes of the SHELL281 element type were utilised to mesh the plate. The current FE results from ANSYS have been validated according to the exact method of solution (Sony, 1983). The current model was validated by comparing its results to the exact answer provided by previous researchers. The results are acceptable because the margin of error is less than 2 %.

An evaluation of convergence is carried out to determine the most appropriate mesh size for the analysis. With a smaller mesh size, the accuracy of the analysis will increase, but the computer evaluation will take longer due to the increased computation time (Muhammad et al., 2016). For this convergence analysis, mesh sizes of 2×2, 4×4, 8×8, 16×16, 32×32, 32×32, 64×64, 128×128, and 256×256 were tested on unidirectional glass fibre-reinforced polymer (GFRP) at 0°, 50°, and 90° fibre angles under tensile load. Even when the mesh size was increased, the deformation values remained the same. Therefore, a mesh size of 8×8 was chosen for improved accuracy of results and faster data computation.

3.2 Modeling and Failure Analysis of Composite Laminates

A specimen measuring 13 mm in width, 60 mm in length, and 2.5 mm in thickness was utilised to simulate the flexural test utilising FEM in ANSYS software. This required considering implementing symmetric angle-ply sequences with and without supporting ply angle 0° across 16 layers of fibre-reinforced laminate. For the specimen without a supporting ply angle of 0°, the laminates were arranged as follows: $[0/0]_{4s}$, $[\pm15]_{4s}$, $[\pm30]_{4s}$, $[\pm45]_{4s}$, $[\pm60]_{4s}$, $[\pm75]_{4s}$, and $[90/90]_{4s}$ whereas specimens with a supporting ply angle of 0° were arranged in the sequences of $[0/0]_{4s}$, $[(\pm15)_2,0_4]_s$, $[(\pm30)_2,0_4]_s$, $[(\pm45)_2,0_4]_s$, $[(\pm60)_2,0_4]_s$, $[(\pm75)_2,0_4]_s$, and $[(90/90)_2,0_4]_s$. The mesh elements and boundary conditions utilised in this analysis are displayed in Figure 1.

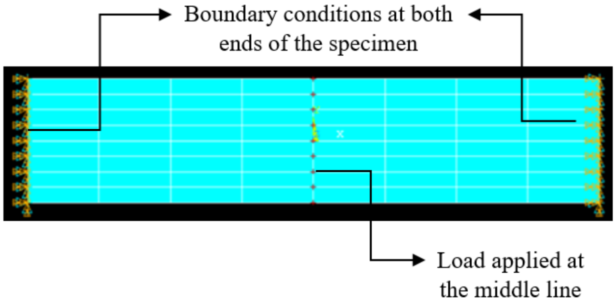


Figure 1: The modelled specimen with mesh element, boundary conditions, and load applied.

The pre-processor was the initial step in the ANSYS simulation process. The pre-processor was necessary for calculating model dimensions, element type, material attributes, failure criteria, layup sequence, and mesh size. To determine the maximum stress and deformation of the laminate composite, the specimen's material properties were recorded. Table 1 shows the mechanical properties of the fibre-reinforced composite that was parameterised in ANSYS APDL materials properties. Multiple stacking layup directions were utilised for the fibre. The boundary condition and load applied to the model were implemented with a maximum load that the material can withstand where SMX (maximum stress) was equal to one, and the enforced load was solved using this value. In this study, the mechanical characteristics of glass fibre with volume fractions (vf) of 60 % (vf=0.6) and 30 % (vf=0.3) were chosen as reference materials. The characteristics of hemp fibre, which contained approximately 30 % (vf=0.3) of the total volume of fibre reinforcement, were used as a comparison for this study.

Table 1: Mechanical properties of fibre-reinforced composite (Jones, 2015; Hashim et al., 2021; Fajrin et al., 2016).

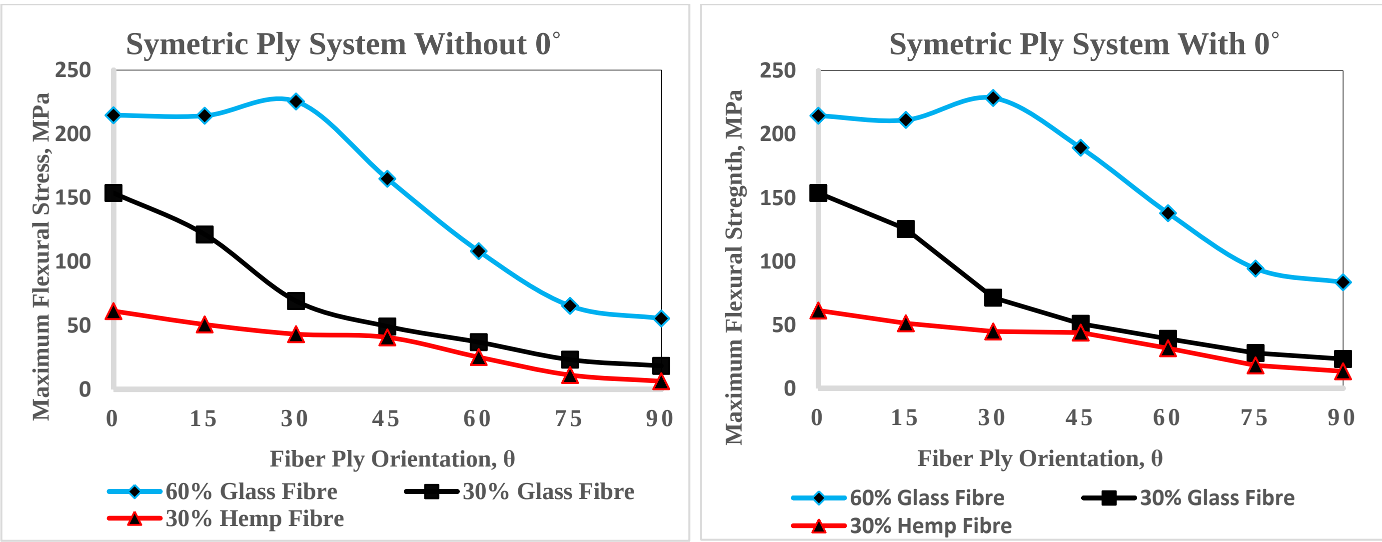
Mechanical Properties	Symbol	GlassFRPComposites vf = 0.6	Glass FRP Composites vf = 0.3	Hemp FRP Composites vf = 0.3
Longitudinal Modulus (0°)	E_1(GPa)	54.00	6.47	3.05
Transverse Modulus (90°)	E_2(GPa)	10.80	2.16	0.31
Shear Modulus	G_{12}(GPa)	9.00	2.59	1.10
Poisson's Ratio	V_{12}	0.25	0.25	0.39
Shear Strength	S_{12}(MPa)	41.00	41.00	23.45
Tensile Strength (0°)	X_T(MPa)	1035.00	342.56	31.37
Tensile Strength (90°)	Y_T(MPa)	28.00	9.25	3.20
Compression Strength (0°)	X_C(MPa)	621.00	77.29	31.69
Compression Strength (90°)	Y_C(MPa)	103.00	10.31	3.20

4 Result and Discussion

The results show the stress measured using the ANSYS APDL software for various layup stacking and fibre orientations of varying volume fractions of synthetic glass and natural hemp fibre. Figure 2 shows the results of maximum flexural stress with different angles of fibre orientation. Figures 2 (a) and (b) show the effect of 0° of angle ply that affected the value of flexural stress of the fibre. When comparing volume fractions of 60 % (vf=0.6) and 30 % (vf=0.3), the greatest value of flexural stress was obtained from the GFRP composite. However, the graph's trend proved that the declining trend coincided with the increasing number of fibre ply orientations. The trend of the graph indicated that a greater volume percentage (vf) delivered a greater stress value and the trend of the graph decreased with the increase of ply angle. It demonstrated that greater volume fractions were much more effective in terms of performance (Elkazaz et al., 2020).

The mechanical properties of fibre-reinforced composites varied depending on the angle that it was viewed. FRP composites with 0° fibre orientation have the highest strength compared to composites with 90° fibre orientation. This result depends on the direction of the fibre; when the direction of the fibre was parallel to the load, the result has greater strength than when it was perpendicular to it as proven by (Lasikun et al., 2018). However, in consideration of the flexural strength, as seen in Figure 2, when the direction of the fibres was perpendicular to the direction of the load, the material offered the greatest amount of resistance and yield the highest value.

The results also indicated the varying volume fractions of synthetic GFRP and Natural HFRC fibres (vf = 30%) with different stacking sequences. Since synthetic fibres have greater mechanical properties, they were assigned a higher value in the weakest point; 90° fibre ply orientations with 18.39 MPa for GFRP compared to 6.34 MPa for HFRP without 0° stacking sequences. Meanwhile, for the study of 0° stacking sequence layups, the value of stress was 23.04 MPa for GFRP and 13.42 MPa for HFRP.

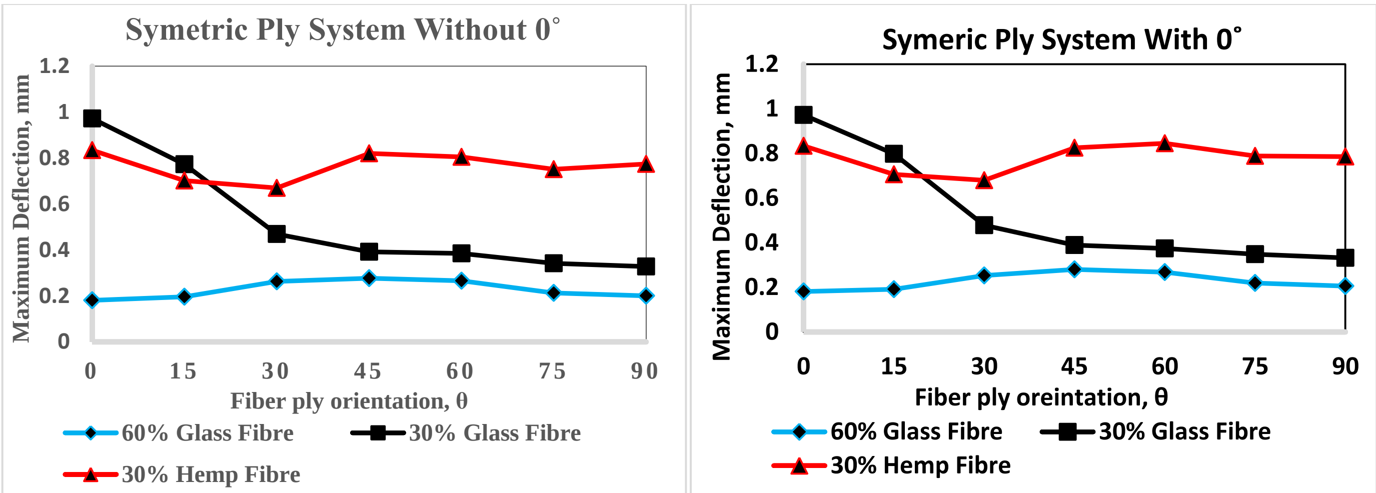


(a) (b)

Figure 2: Maximum flexural stress of fibre-reinforced polymer composite with different ply orientations (a) symmetric ply system $[(\pm\theta)_4]_s$ and (b) symmetric ply system with 0° $[(\pm\theta)_2,(0)_4]_s$.

The results also indicated that employing 0° stacking sequences in the middle of the fibre enhanced the composites' characteristics. The value of synthetic fibre was greater than the value of natural fibre because synthetic fibre has better mechanical behaviour in terms of strength, impact resistance, thermal conductivity, and other characteristics than natural fibre (Andrew & Dhakal, 2022). Furthermore, while the decreasing trend for the glass fibre was not significantly different from the decreasing trend for the natural fibre when comparing the two layups with and without 0° stacking sequences, the decreasing trend for the natural fibre was significantly different when comparing the two layups with and without 0° stacking sequences. When the fibres carried the load, the load was distributed between the fibres, which stabilised and prevented the failure of the composites.

The numerical value of stress was parallel to the value of deformation and the results are shown in Figure 3. It shows the value of maximum deflection against the maximum flexural stress applied. The results show that the highest value was stated for GFRP (vf = 0.3) at 0° ply orientations, but HFRP composites were also given a higher value at 90° ply orientations compared to others. Both specimens with and without 0° stacking sequences have the same pattern since the maximum flexural stress provided the same value. The GFRP and HRFP composites (vf = 0.3) have a higher value of deflection compared to GFRP composites (vf = 0.6). The higher the maximum stress, the smaller the deflection value, since the material tends to resist the applied force. Meanwhile, the value of HFRP provided a stagnant pattern with stress and deflection since it did not give much different value starting from 0° to 90° ply orientations. Generally, the supporting ply angle 0° in the lamination scheme of $[(\pm\theta)_2, (0)_4]_s$ have better resistance towards deformation, thus having a higher value of maximum flexural stress compared to the lamination scheme of $[(\pm\theta)_4]_s$.



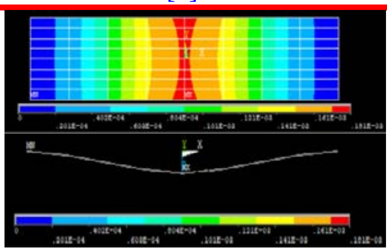
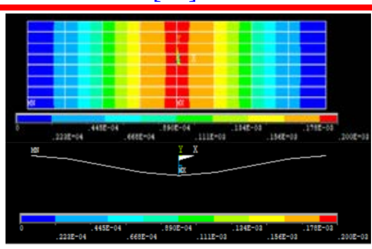
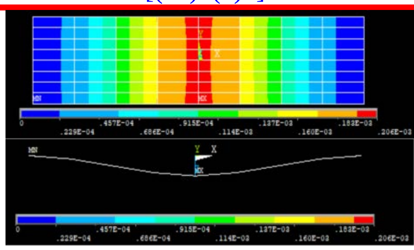
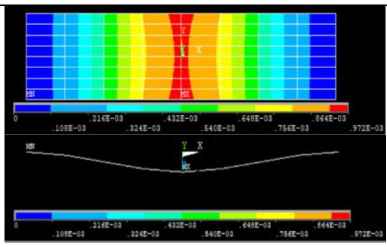
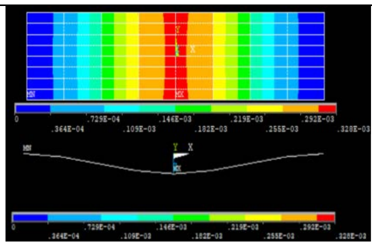
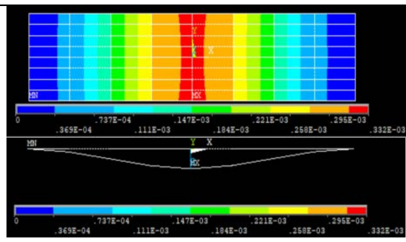
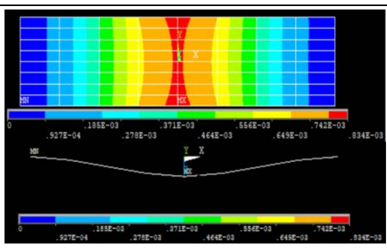
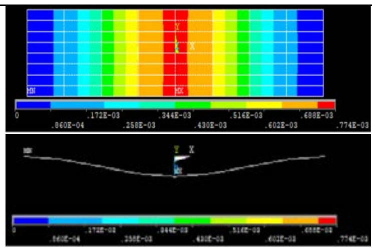
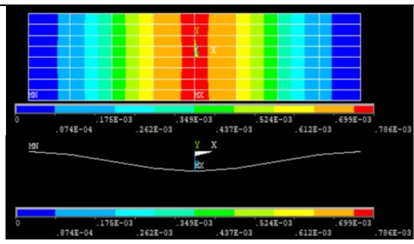
(a) (b)

Figure 3: Maximum Deflection of fibre-reinforced polymer composite with different ply orientations (a) symmetric ply system $[(\pm\theta)_4]_s$ and (b) symmetric ply system with 0° $[(\pm\theta)_2,(0)_4]_s$.

For $[(\pm\theta)_4]_s$ lamination scheme, Figure 4(a) illustrates the graphs of maximum flexural stress against fibre ply orientation for GFRP composites (vf=0.6 and vf=0.3) while Figure 4(b) shows GFRP and HFRP composites (vf=0.3) with the strength decrease index of FRP composites under flexural loadings. Figure 4(a) demonstrates that the higher value of fibre volume fraction, the lower the strength reduction index. GFRP composite with 60% fibre volume fraction has a strength reduction index of 1.3 when compared to 2.4 for GFRP composite with 30% fibre volume fraction. Based on the results in Figure 4(b), GFRP composites vf=0.3 have the highest strength reduction index when compared to the HFRP composites vf=0.3 and GFRP composites vf=0.6. This signified that the strength reduction of GFRP composites vf=0.6 from fibre orientation 0° to 90° was lower. On the other hand, the lamination scheme of a symmetric ply system with 0° $[(\pm\theta)_2,(0)_4]_s$, as shown in Figure 4(c) and 4(d), has a higher strength reduction index when compared to those of lamination scheme $[(\pm\theta),(0)_2]_s$, as shown in Figure 4(a) and 4(b). This is due to the supporting ply angle 0 which improved the performance of the FRP composites. As the fibre orientation increased from 0° to 90°, the results indicated that the trendlines for all graphs decreased exponentially.

Table 2 shows the diagram of the analysis results of a maximum deformation contour at a maximum stress value (SMX) of 1. When the modelling results were analysed, the red colour represented the biggest deviation that occurred in the middle of the sample. Since it was fixed at the end of the sample and the force was applied at the centre of the sample surface area, it has been reflected in this figure. The parameters were like those used in experimental methods where the load was applied in a perpendicular direction to the sample's surface area. The value of a sample's displacement can be figured out by comparing how much its length has changed from the original length. The value of displacement was taken from the maximum stress, and it demonstrated that the trend was increasing for 0° and 90° fibre orientations because the fibre in 0° ply orientation has higher resistance compared to 90° ply orientation for both with and without 0° stacking sequences.

Table 2: Maximum deformation contour of fibre-reinforced polymer composite under flexural load for ply stacking sequence of $[(\pm\theta)_4]_s$ and $[(\pm\theta)_2,(0)_4]_s$.

Composite	[0]16	[90]16	[(90)4(0)4]s
Glass FRP Composite vf = 0.6	 Δ = 0.181 mm	 Δ = 0.200 mm	 Δ = 0.206 mm
Glass FRP Composite vf = 0.3	 Δ = 0.972 mm	 Δ = 0.328 mm	 Δ = 0.332 mm
Hemp FRP Composite vf = 0.3	 Δ = 0.834 mm	 Δ = 0.774 mm	 Δ = 0.786 mm

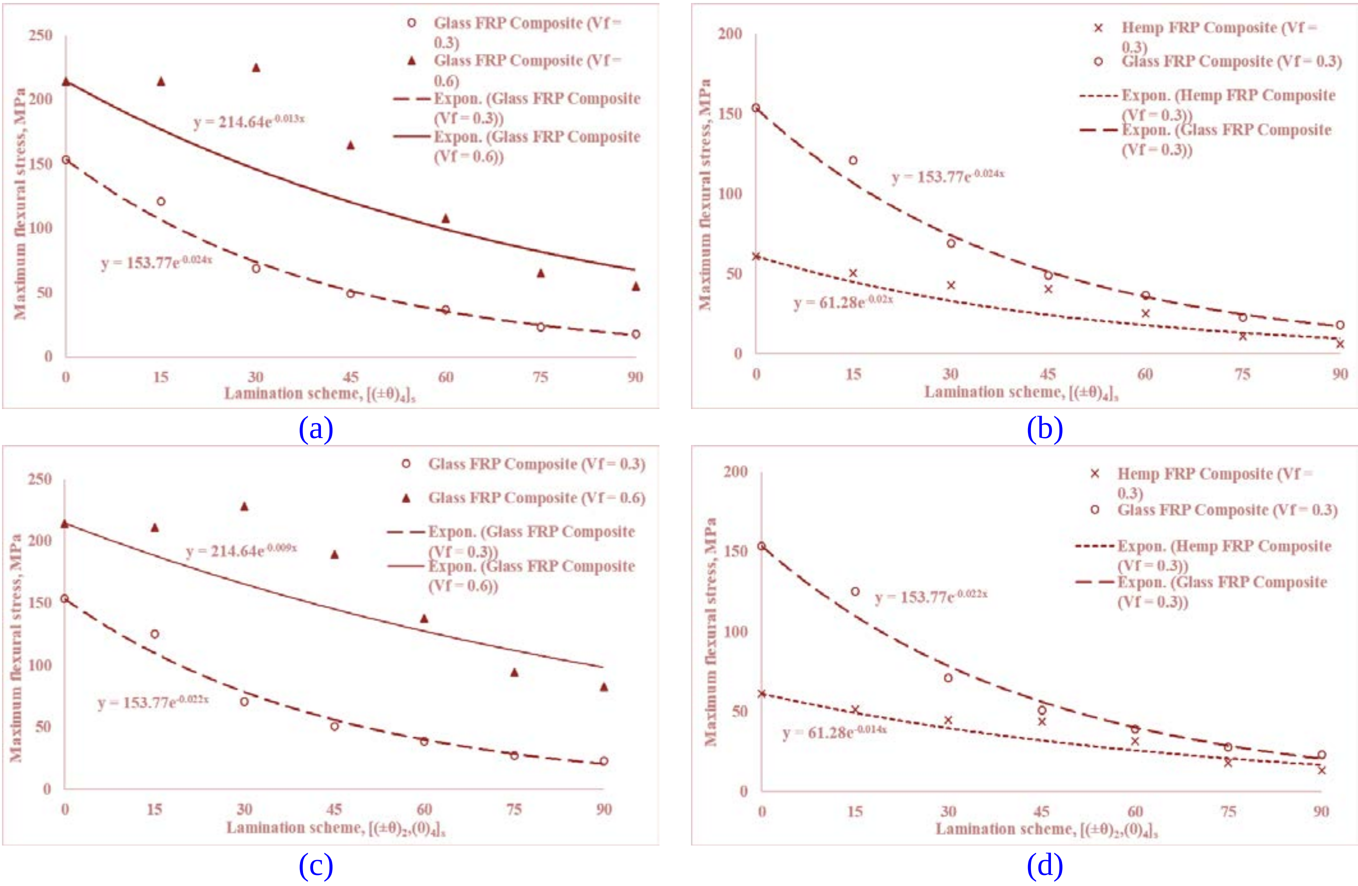


Figure 4: Graphs of maximum flexural stress against fibre ply orientation for: (a) GFRP composites (vf = 0.6 and 0.3) with lamination scheme of $[(\pm\theta)_4]_s$, (b) GFRP and HFRP composites (vf = 0.3) with lamination scheme of $[(\pm\theta)_4]_s$, (c) GFRP composites (vf = 0.6 and 0.3) with lamination scheme of $[(\pm\theta)_2/0_4]_s$ and (d) GFRP and HFRP composites (vf = 0.3) with lamination scheme of $[(\pm\theta)_2,(0)_4]_s$.

5 Conclusion

ANSYS APDL simulation has been successfully implemented to study the effect of fibre ply orientation and plies stacking sequence on the maximum flexural stress and deformation analysis of GFRP composite (vf=0.6 and vf=0.3) and HFRP composite (vf=0.3). For both glass FRP composite (vf=0.3) and hemp FRP composite (vf=0.3), it was found that the value of maximum flexural stress decreased as the fibre angle was increased from 0° to 90°. However, for glass FRP composite (vf=0.6), the highest value of maximum flexural stress was observed when the fibre was oriented at 30°, with the value of 225.43 MPa for fibre ply orientation $[(+\theta, -\theta)_4]$s and 228.56 MPa for ply stacking sequence $[(+\theta,-\theta)_2,(0)_4]$s. When the laminate was stacked with a supporting ply angle of 0° at the middle, the maximum flexural stress of the FRP composite was higher than the FRP composite with no supporting ply angle of 0°. The strength reduction index was also higher when the laminate was stacked with supporting ply 0° in the middle. Fibre volume fraction also affected the behaviour of FRP composite in which a higher fibre volume fraction possessed a lower strength reduction index. This means it has greater resistance when subjected to transverse loading.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

7 Acknowledgement

The authors would like to acknowledge Universiti Teknologi MARA (UiTM) Malaysia for internal grant funding (LESTARI Grant No: 600-RMC/MyRA 5/3/LESTARI (054/2020)).

8 References

Mohammed, L. Ansari, M. N. M. Pua, G. Jawaid, M. & Islam. M. S. (2015). A Review on Natural Fiber Reinforced Polymer Composite and Its Applications. *International Journal of Polymer Science*, 2015, 1-15.

Sanjay, M. R. Arpitha, G. R. Naik, L. L. Gopalakrishna, K. & Yogesha. B. (2016). Applications of Natural Fibers and Its Composites: An Overview. *Natural Resources*, 7(03), 108–114.

Gholampour A. & Ozbakkaloglu. T. (2020). A review of natural fibre composites: properties, modification and processing techniques, characterization, applications. *Journal of Materials Science*, 55(03), 1-64.

Waghmare, S. Shelare, S. Aglawe, K. & Khope. P. (2022). A mini review on fibre reinforced polymer composites. *Materials Today Proceedings*, 54(03), 682–689.

Prashanth, S. Subbaya, K.M. Nithin, K. & Sachhidananda, S. (2017). Fibre Reinforced Composites - A Review. *Journal of Material Science & Engineering*, 06(03), 2-6.

Shahzad, A. Hemp fibre and its composites - A review. (2012). *Journal of Composite Materials*, 46(08), 973–986.

Tanasă, F. Zănoagă, M. Teacă, C. A. Nechifor, M. & Shahzad, A. (2020). Modified hemp fibres intended for fiber-reinforced polymer composites used in structural applications—A review. I. Methods of modification. *Polymer Composite*, 41(1), 5–31.

Faizan, M. & Gangwar, S. (2020). Tensile behaviour of carbon fibre reinforced polymer composite using ANSYS 21. *Materials Today: Proceedings*, 46(15), 6519–6526.

Dinesh Kumar. A, & Mohanty, A. (2015). Finite Element Analysis to Study the Mechanical Behaviour of Particulate / Fiber Reinforced Hybrid Composites Using Ansys. *International Conference on Advances in Construction, Manufacturing and Automation Research*, 1(6), 200–205.

Soni, S. (1983) A new look at commonly used failure theories in composite laminates. *American Institute of Aeronautics and Astronautics*, lnc.

Muhammad, A. Ali, M. A. H. and Shanono. I. H. (2019). ANSYS - A bibliometric study. *Materials Today: Proceedings*, 26(2), 1005–1009.

Robert M. Jones. (2015). Mechanics of Composite Materials., 2nd Edition, ISBN 9781560327127, Published February 4.

Hashim, U. R. Jumahat, A. and Jawaid, M. (2021). Mechanical properties of hybrid graphene nanoplatelet-nanosilica filled unidirectional basalt fibre composites. *Nanomaterials (Basel)*,11(6), PMC8226757.

Fajrin, J. Zhuge, Y. Bullen, F. and Wang, H. (2016). Flexural behaviour of hybrid sandwich panel with natural fibre composites as the intermediate layer. *Journal of Mechanical Engineering and Sciences*, 10(2), 1968–1983.

Elkazaz, E. Crosby, W. A. Ollick, A. M. and Elhadary, M. (2020). Effect of fibre volume fraction on the mechanical properties of randomly oriented glass fibre reinforced polyurethane elastomer with crosshead speeds. *Alexandria Engineering Journal*, 59(1), 209–216.

Lasikun, Ariawan, D. Surojo, E. and Triyono. J. (2018). Effect of fibre orientation on tensile and impact properties of Zalacca Midrib fiber-HDPE composites by compression molding. *AIP Conference Proceedings*, 1931(1).

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