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Studying Some Physical Properties of an Advanced Composite Material Using of ANSYS Program

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Abstract

Composite materials are known for their excellent combination structural rigidity and light weight. The main advantage of these materials of varying properties is their ability to be customized for specific application by optimizing design parameters such as the stacking sequence and orientation of the angles of the fiber layers. This paper presents the effect of the fiber orientation angle on the stress and deformation of the composite material prepared from Epoxy E-Glass under the influence of tensile load (300N) from one end and fixed from the other end. In the current work, using the ACP and Static Structural in Ansys, we designed a composite material consisting of three layers of the aforementioned matter, and we studied the effect of fiber orientation on the deformation and stress of the all layers in two cases of symmetry and asymmetry angles and in the x and y axes.

Keywords: Normal Stress, ACP (Pre), Deformation, Orientation Angle.

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Introduction

Composite materials have important and attractive mechanical and physical properties, and for this reason, the researchers sought to search for everything related to these materials in terms of fiber orientation of angles, stacking arrangement, filling and matrices. A number of researchers have presented two hybrid methods using FEA to simulate some two-layer woven fiber-reinforced materials that can be applied to some three-dimensional structures to obtain von-mieses stresses [1]. Ansys ACP post 16 has been used to simulate a number of models of carbon epoxy type UD230Gpa and then apply a constant tensile load on these models then calculate the results of deformation and induced stress energy[2]. The FEA was used to analyze the mechanical properties of the (CFRP) carbon fiber reinforced plastic tie bar, and based on the results of the analysis, the simulation results showed that the orientation of the fiber in (^{o}0) was greater than (^{o}45) [3]. A study was conducted and the frequency of the free vibration of a cantilever beam was determined for a campsite material of E-Glass epoxy[4] and steel as well as the calculation of the stress using ansys 17 and it was concluded that the values obtained from FEA agree well with the results obtained from analysis [5][6]. Commercial carbon fibers were used to manufacture composite materials, and then samples were manufactured to measure the tensile test with angles of (0, 45, 90). The experimental results were compared with the FEA results by using ansys [7] [8]. Michael et al studied and analyzed the effect of the distribution of the direction of angles (0, 22.5, 45, 67.5, 90) on the mechanical properties of properties of polypropylene reinforced with bio-lyocell, then study the models prepared under tensile strength tests and dynamic analyzes[9]. A study conducted to investigate the dynamic analysis of a cantilever beam composed of glass fibers and epoxy resin. Through this study, the longitudinal and transverse Young's modulus and the shear modulus were determined theoretically and analytically[10]. Natural fiber compounds are considered environmentally friendly, because they are cheaper than synthetic fibers, lighter in weight and bio degradability[11]. The Upendra and his group improved some compounds reinforced with natural fibers, such as, banana, jute, hemp, and pineapple fibers at different direction angles. A tensile, flexural and hardness test was conducted, and it showed all fibers have a minimum stress in the direction of (0, 90)[12]. Tymoshenko's beam theory was used to study the motion of composite beam and then obtain the fundamental equations of motion through Lagrange equations, that is, a theoretical study was presented to study the effect of fiber orientation on the mechanical response of the composite beam [13]. Stress, flextural, tensile and shear tests were performed on fiber reinforced epoxy compound at different orientation and all samples were tested according to the ASTM standard in hydraulic Machin[14]. A comparative study was conducted between FEM and the practical method for preparing a composite beam of jackets of steel sheets and concrete fibers in order to strengthen the RC beams with known dimension with different loads and it was concluded that the thickness of the jacket significantly affects the response of the beams reinforced with composite jackets[15]. The metal compound of aluminum and titanium were used with fibers and polymeric materials (Aramid/BSL-312-UL, S2-glass, carbon /epoxy, carbon/polyimide) and in the form of multiple layers and with different orientation angles using the analytical method. Then the analytical results were verified with the results of the FEM. The fiber metal beam of laminated gives good results compared to the steel beam under the same loading[16].

Method and Material

The material used in our work is Epoxy E-Glass its properties are shown in table (1).

Table 1: Material Properties

Density Kg m^{-3}	Young's Modulus		Poisson's Ratio		
	X-Direction	Y-Direction	XY	YZ	XZ
2000	45000	10000	0.3	0.4	0.3

The Ansys program (ACP (pre) & Static Structural) was used to prepare a composite material consisting of three layers as a Beam shaped as shown in Figure (1), where the nodes are (4420) & elements (3072) in the mesh.

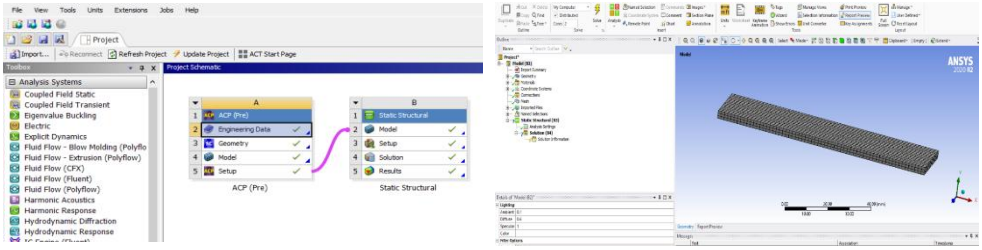


Fig. 1: Design the Composite Beam

The effect of fiber orientation of three values (30,0, ±30), (60,0, ±60), (90,0, ±90) of Symmetric and Asymmetric angles on deformation and normal stress was studied.

Result and Discussion

One of the most important physical factors that must be studied during the preparation of a composite material is the stress. In this work we study the effect of symmetric (sym.) and asymmetric (asym.) angles on the Deformation (D) and Normal Stress (σ) on the (X-axis and Y-axis) "each axis individually" by fixing the Beam on one end and applying a force of (300N) on the other end as shown in the following steps.

Table 2: Normal Stress and Deformation Results

Orientation	Normal Stress / Mpa (σ)						Deformation (D) Mm	
	Top Ply		Bottom Ply		Middle Ply			
	X	Y	X	Y	X	Y	X	Y
(30, 0, 30)	4.8258	0.91601	4.8258	0.91601	9.1457	0.96445	0.018087	0.018087
(30, 0, -30)	10.832	1.7134	10.832	1.7134	10.859	1.0668	0.069353	0.069353
(60, 0, 60)	4.1559	1.0775	4.1559	1.0775	10.492	1.1128	0.018596	0.018596
(60, 0, -60)	4.3734	1.3391	4.3734	1.3391	10.947	1.1221	0.026379	0.026379
(90, 0, 90)	4.0464	0.96644	4.0464	0.96644	8.9224	0.96902	0.018692	0.018692
(90, 0, -90)	4.0464	0.96644	4.0464	0.96644	8.9224	0.96902	0.018692	0.018692

In the case of the angle $(+30)_{sym}$ of vertical axis, the σ values for all three layers were close but, in the X-axis, the σ value of the middle layer was twice as compared to the upper and lower layers. It is certainly much larger than the vertical axis. In the case of asym. for angle (^{o}30), the stress values in the Y-axis increased by a noticeable amount from the previous one in the case of sym. and for the three layers, but in the horizontal axis, the resulting value of (σ) was large compared to the previously mentioned values and close to the three layers in the case of non-symmetry, we also found a clear bending in the prepared substrate in the case of asymmetry and for both axis's (X & Y). the values of deformations in the case of asym. was slightly greater than the case of sym. with the value constant in both axes for both cases as shown in the Figures (2,3).

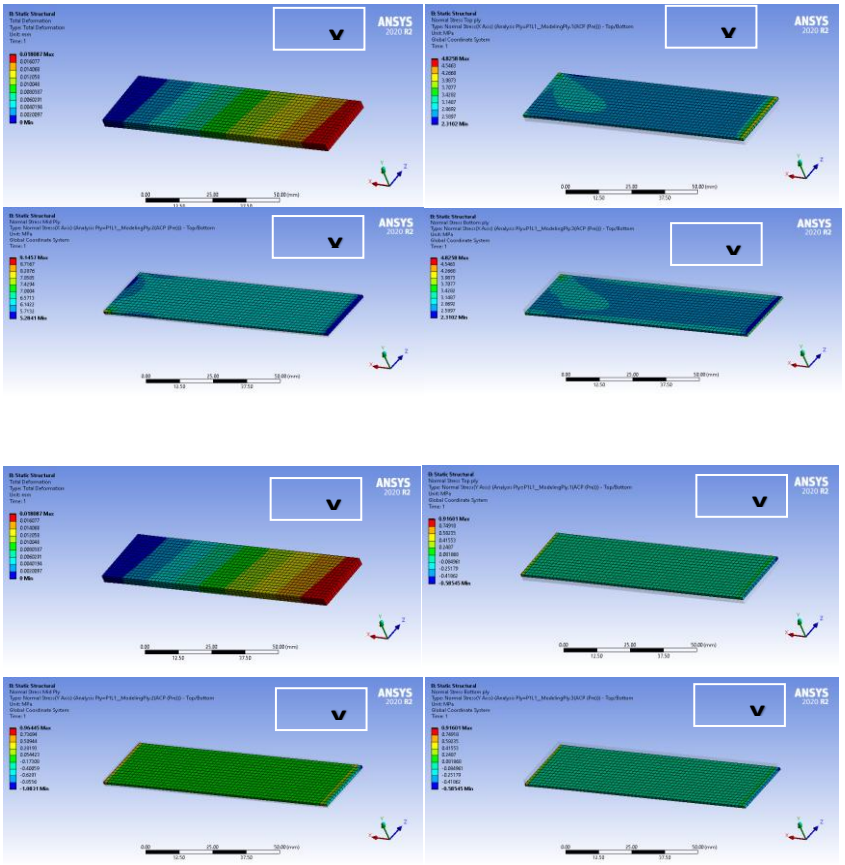


Fig. 2: Symmetric (^{o}30) in (X and Y)-axis

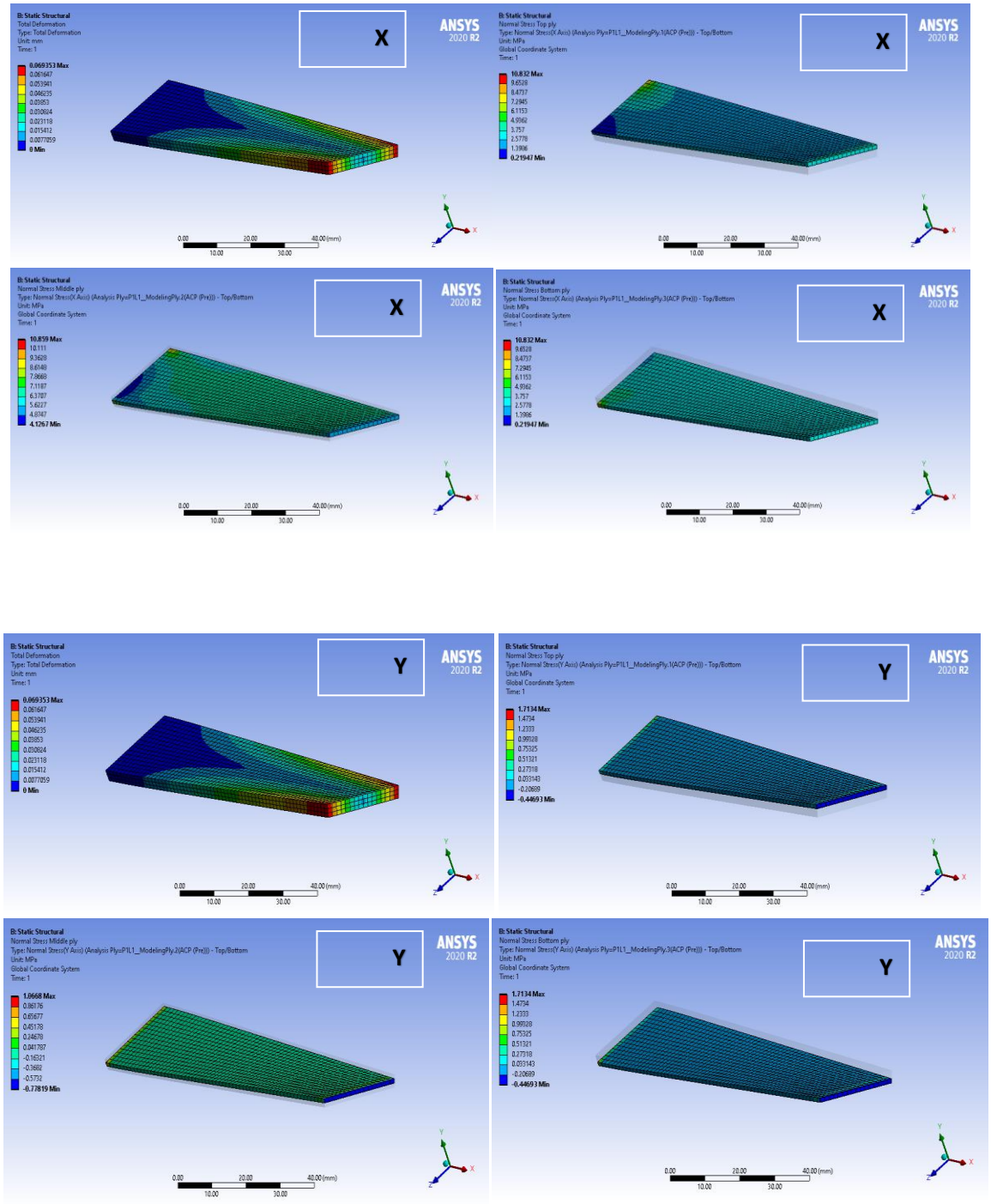


Fig. 3: Asymmetric (°30) in (X and Y)-axis

For the angle (°60), we find from figures (4,5) the following: the value of deformation in the (x and y) axis was the same in the cases of sym. and asym. with a small increase in the case of asym. than the previous one. In the cases of sym. and asym. with respect to the x direction, the effect of stress was clear on the prepared material, as we note that the stress values in the upper and lower layers have the same value in both cases with a small increase in the case of asym., but for the middle layer and in both cases the stress value was twice of the upper and lower layers, with a greater value appearing in the case of asym. compared to the previous values. Now in the y-axis, the stress had an effect on the beam, but not as strongly as the x-axis, as we note from table (2) that the stress values in the case of asymmetry are greater than in the case of symmetry, especially in the upper and lower layers, also a bend occurred in the prepared beam but it is less than what happened in the case of the angle (30) as shown in figures (4,5).

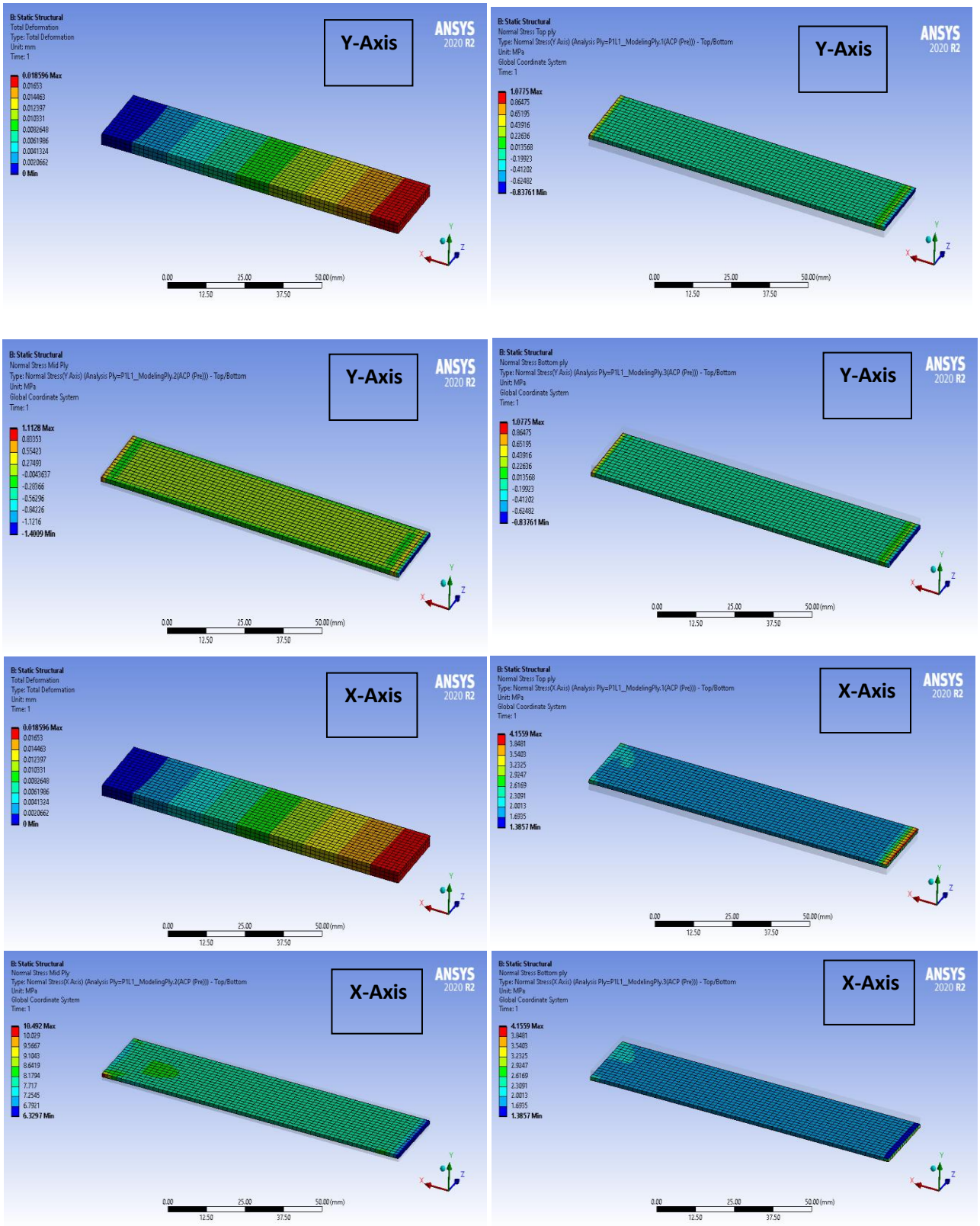


Fig. 4: Symmetric (º60) in (X and Y)-axis

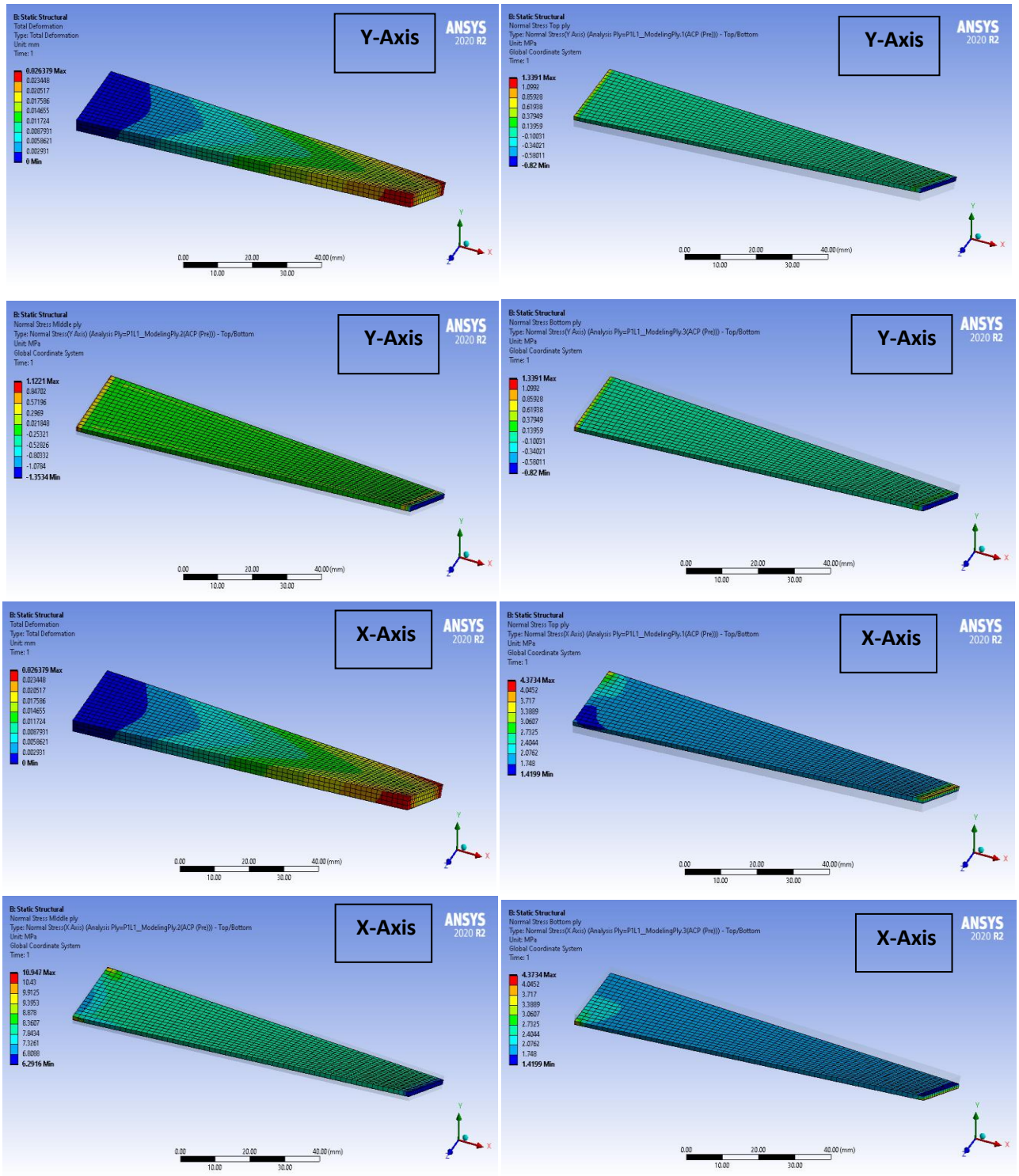


Fig. 5: Asymmetric (º60) in (X and Y)-axis

Finally, at the 90th angle, we examined the results more than once, where we noticed in the case of sym. and asym. that the results are identical for the vertical axis as well as the horizontal, as shown in table 2, but the values of the effect of stress on the middle layer in the x-axis were twice the values that appeared on the two upper layers and bottom for both sym. and asym. cases, while the stress values in the y-axis were much lower than the x-axis and have a convergent effect on the values of sym. and asym. and for both axis as shown in figure (5,6).

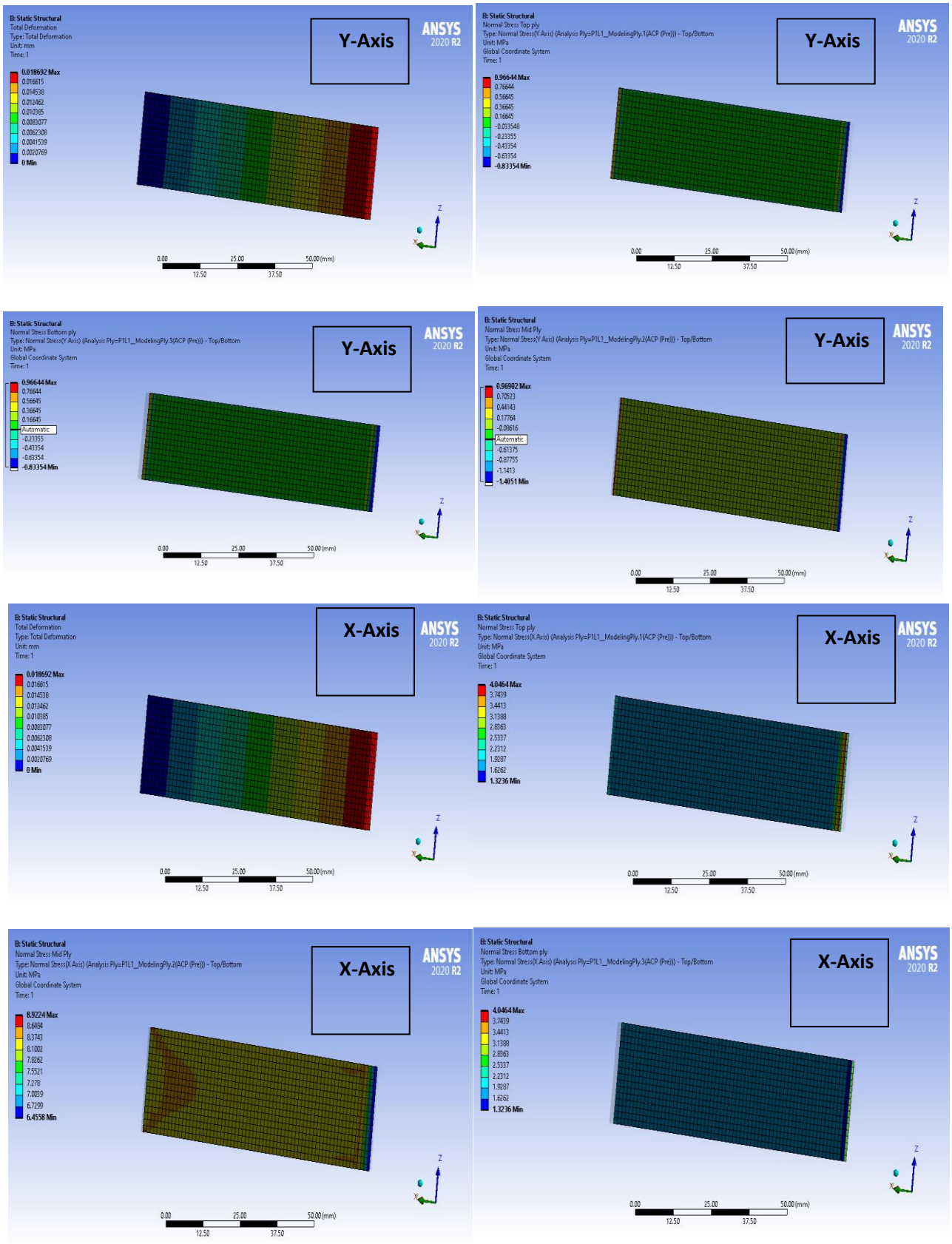


Fig. 6: Symmetric (º90) in (X and Y) axis

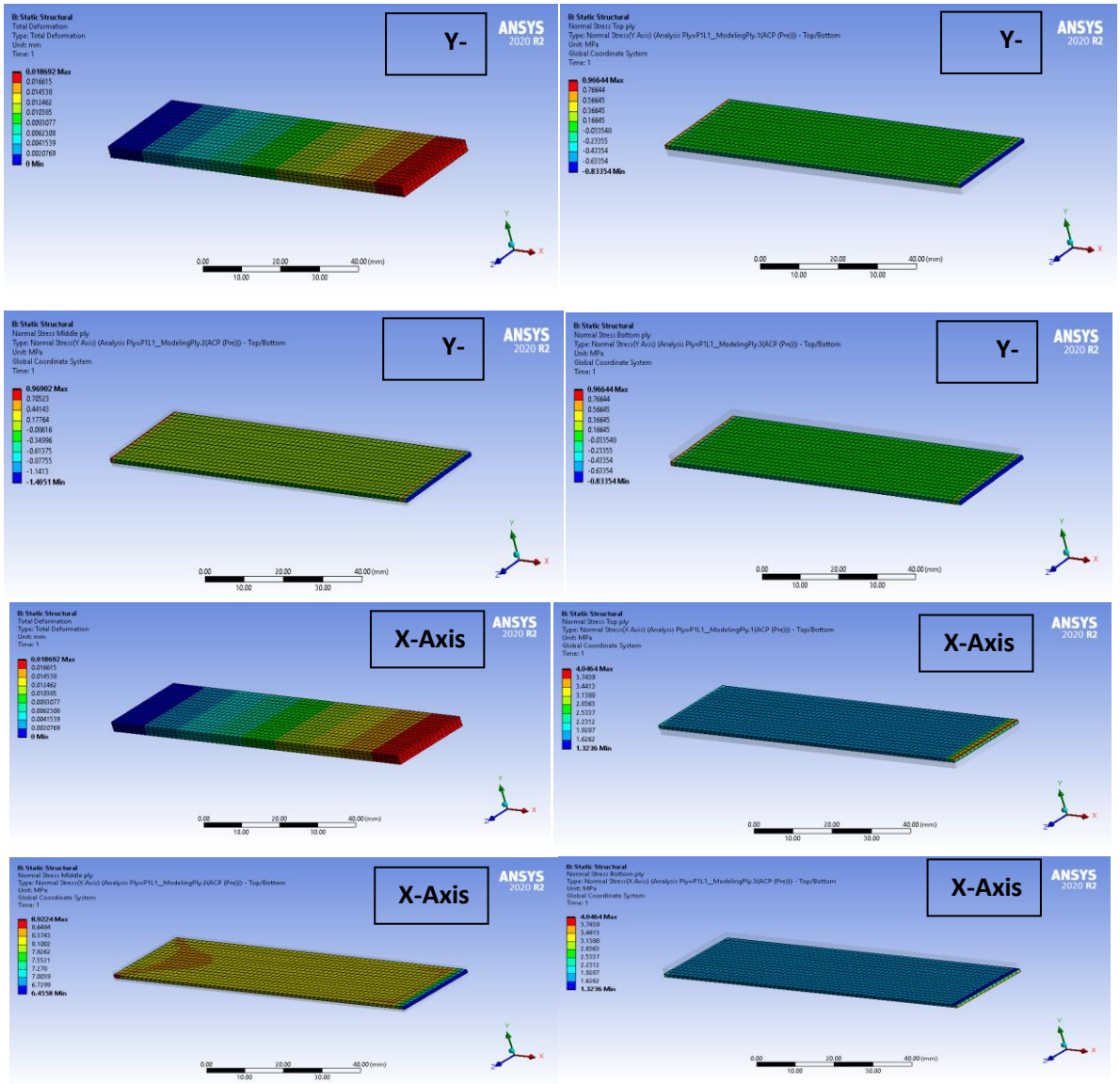


Fig. 7: Asymmetric (º90) in (x and y) axis

Conclusion

In this work, we designed a composite material consisting of three layers of (Epoxy E-Glass UD) with dimension (25, 100, 3) mm using (ACP pre.) and Static structural in Ansys and we conducted some tests on it by changing the angles of the fibers for three values (0, ±30, ±60, ±90) that are in two symmetric & asymmetric cases and in two dimensions (x,y), then determine the effect of angle distribution on the deformation and stress by fixing the prepared composite beam from one end and applying a uniaxial load from the other end. The outcomes we obtained led to the following conclusions:

1. The deformation values showed very close results in the cases of angle orientation of fibers at symmetrical of (30,60,90) and (90) asymmetrical for both axes.
2. The deformation outcomes of the two asymmetric cases (30,60) showed values greater than the previous cases with a clear curvature on the prepared composite material as shown in figures (3&5).
3. For the angle 30 and for both cases at y-axis, we got results for stress that are somewhat close in sym. with double values in the case of asym. But in the case of symmetry (30), the effect of stress on the middle layer was double its effect on the other layers. Also, in the case of asym., the stress values appeared large and close for the three layers.

4. In the x-axis for angle (60), we obtained close values of stress in the upper and lower layers, and for both cases, sym & asym. with the appearance of double the value on the middle layer and for both cases. But in the case of the vertical axis, the stress values were much lower than the x-axis and appeared close to the three layers in the case of symmetry, but in the case of asymmetry, they appeared slightly greater than the previous case.
5. In the case of the angle (90), the stress values in the x-axis of the middle layer appeared large and double the value of the upper and lower layers, for both sym. and asym. cases. But for the y-axis, the values of the obtained results were all few and close regularly, and in both cases, sym. and asym. with no bending appearing in the prepared material.

Future Scope

Our ambition is to study different polymeric materials with fibers and adhesives with layers that may be four or more in cases of angles other than those used in this work.

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