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Effect of orientation angle of elliptical hole in thermoplastic composite plate at different loads

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ABSTRACT:

Fiber-reinforced thermoplastic polymers are the primary reasons for their use in many structural components in the aircraft, automotive, marine, and other industries due to their low density, high strength, high stiffness to weight ratio, excellent durability and design flexibility. They are now used in applications ranging from space craft frames to ladder rails, from aircraft wings to automobile doors, from rocket motor cases to oxygen tanks, and from printed circuit boards to tennis rackets. Their use is increasing at such a rapid rate that they are no longer considered advanced materials. Residual stresses in the composite plates are particularly important. They can lead to premature failure. Therefore, the characterization of the elasto-plastic response of thermoplastic composite must be carried out along the credible design processes for composite structures involving plasticity effects in the nonlinear behavior.

In this thesis, residual stresses developed on Flouoro polymer laminated thermoplastic composite plates with central elliptical hole which is subjected to in-plane loading is determined by applying different loads. The effects of orientation angle of elliptical hole in the composite laminated plate under various in-plane loads, elliptical hole is rotated from 0° to 90° by 15° increments counterclockwise. Analysis is done in Ansys.

I. INTRODUCTION

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other.

- Natural composites
- Early composites
- Making composites

II. STRUCUTRAL ANALYSIS BYANSYS

2.1 Strucutral analysis of plate with different orientation angles of elliptical hole

2.1.1 Flouropolymer At Pressure – 5.5 (Orientation angle - 90^0)

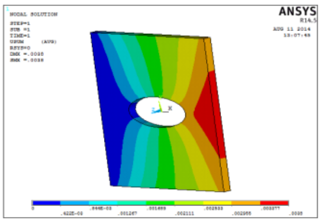

Figure 1.Displacement

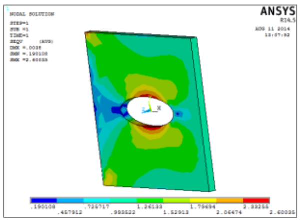

Figure 2.Stress

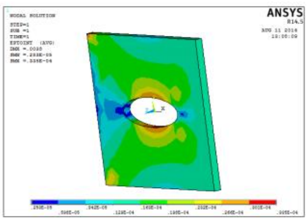

Figure 3.Strain

2.1.2 Orientation angle -45^0

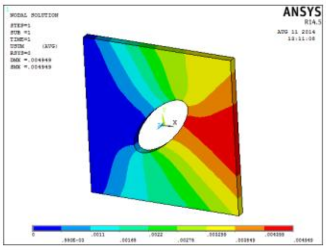

Figure 4.Displacement

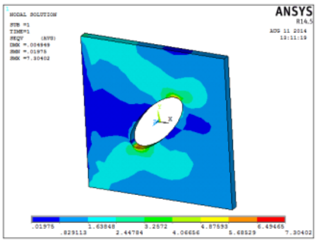

Figure 5.Stress

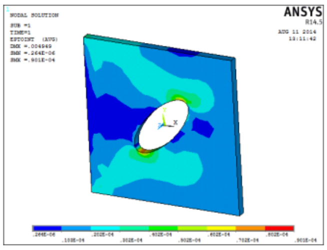

Figure 6.Strain

2.1.3 Orientation angle -30^0

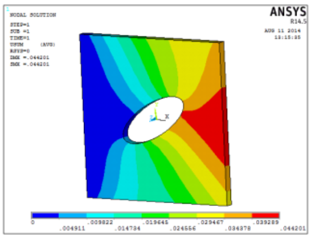

Figure 7.Displacement

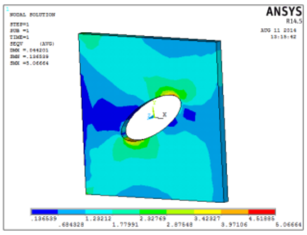

Figure 8.Stress

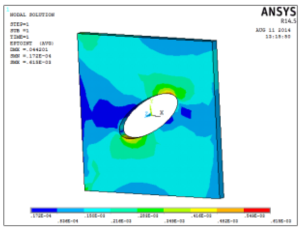

Figure 9.Strain

2.1.4 Orientation angle – (-45^0)

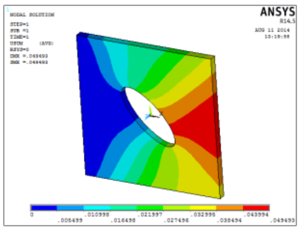

Figure 10.Displacement

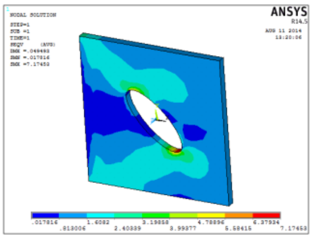

Figure 11.Stress

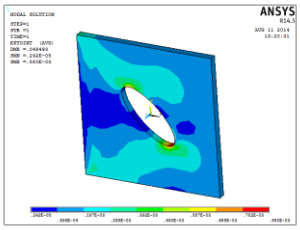

Figure 12.Strain

2.1.5 Orientation angle –(-30^0)

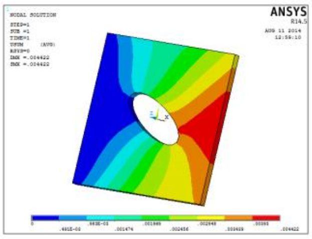

Figure 13.Displacement

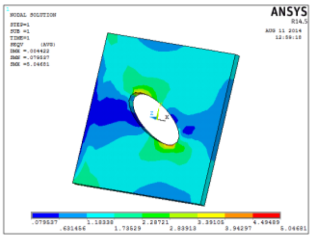

Figure 14.Stress

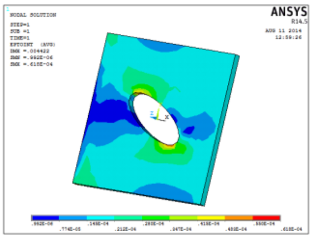

Figure 15.Strain

2.2 Pressure-6n/mm^2

2.2.1 Orientation angle - 90^0

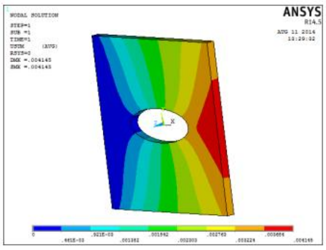

Figure 16.Displacement

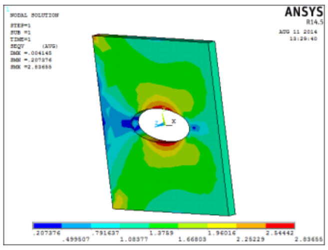

Figure 17.Stress

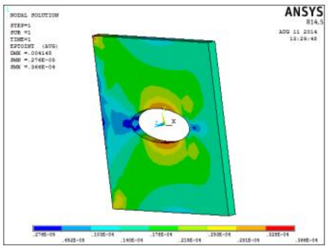

Figure 18.Strain

2.2.2 Orientation angle -45^0

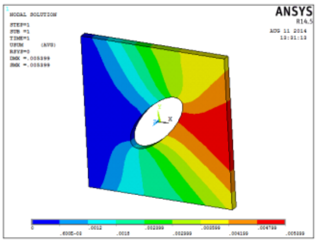

Figure 19.Displacement

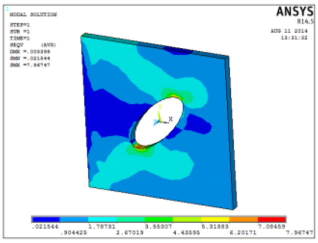

Figure 20.Stress

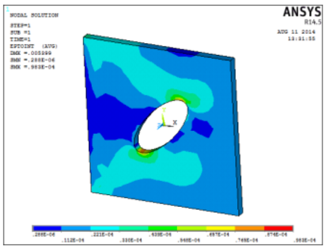

Figure 21.Strain

2.2.3 Orientation angle -30^0

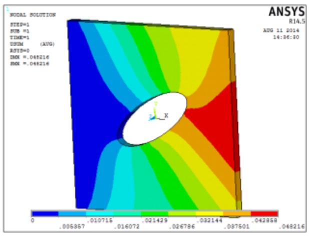

Figure 22.Displacement

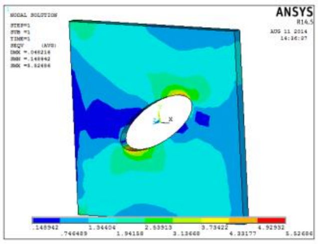

Figure 23.Stress

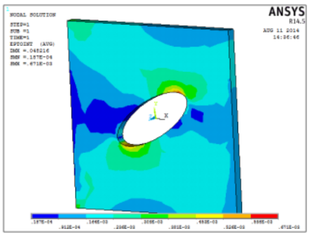

Figure 24.Strain

2.2.4 Orientation angle – (-45^0)

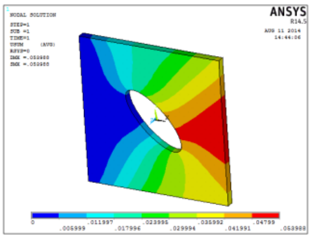

Figure 25.Displacement

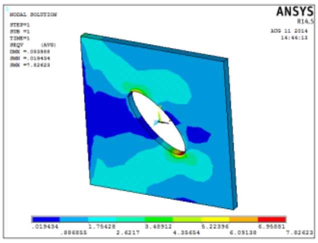

Figure 26.Stress

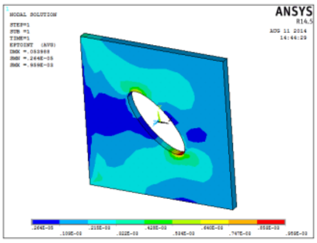

Figure 27.Strain

2.2.5 Orientation angle –(-30^0)

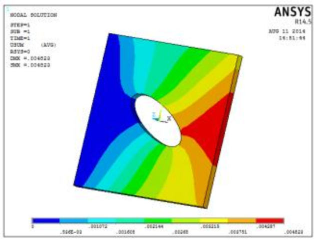

Figure 28.Displacement

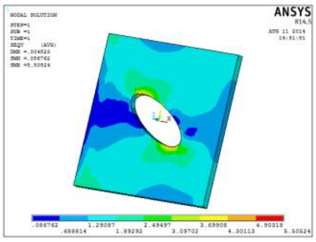

Figure 29.Stress

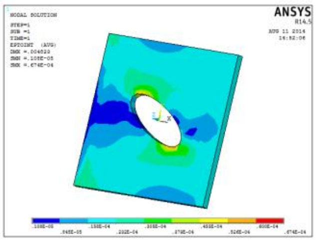

Figure 30.Strain

2.3 Pressure – 6.5n/mm^2

2.3.1 Orientation angle – 90^0

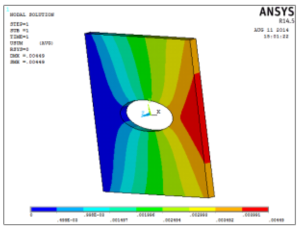

Figure 31.Displacement

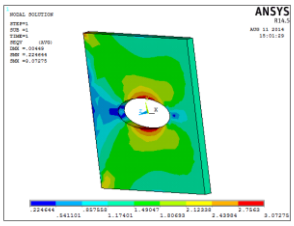

Figure 32.Stress

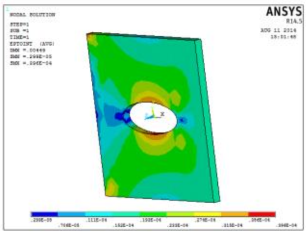

Figure 33.Strain

2.3.2 Orientation angle – 45^0

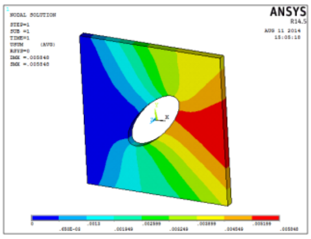

Figure 34.Displacement

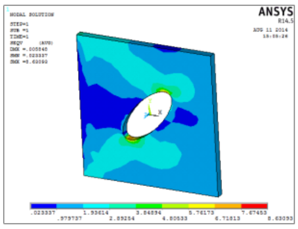

Figure 35.Stress

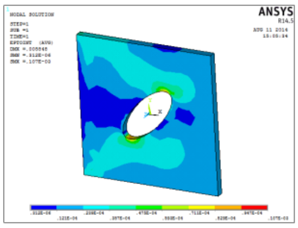

Figure 36.Strain

2.3.3 Orientation angle – 30^0

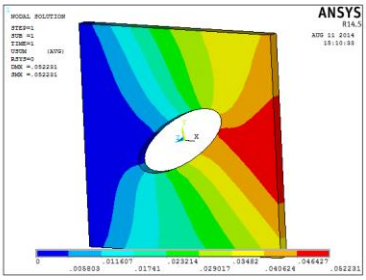

Figure 37.Displacement

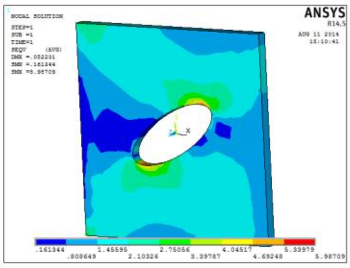

Figure 38.Stress

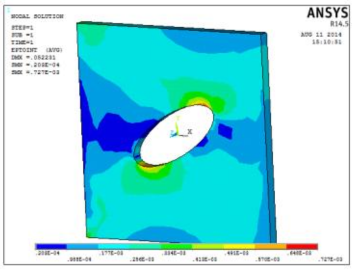

Figure 39.Strain

2.3.4 Orientation angle – (-45^0)

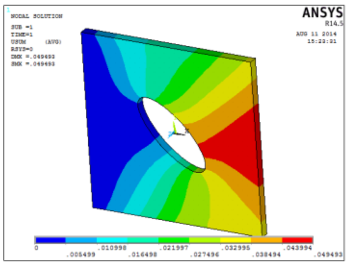

Figure 40.Displacement

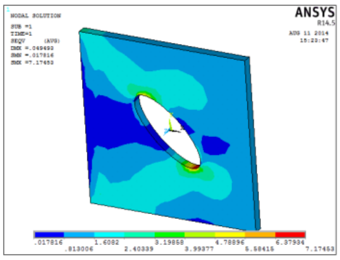

Figure 41.Stress

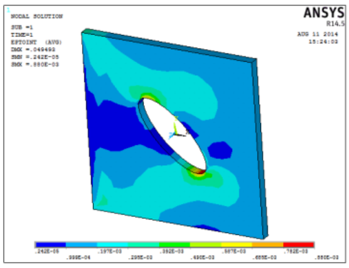

Figure 42.Strain

2.3.5 Orientation angle – (-30^0)

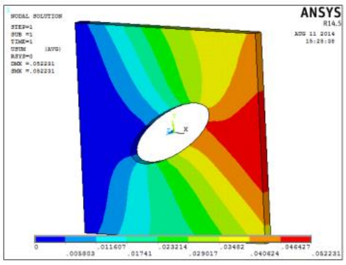

Figure 43.Displacement

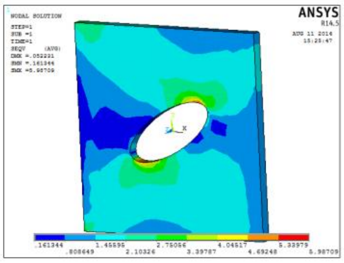

Figure 44.Stress

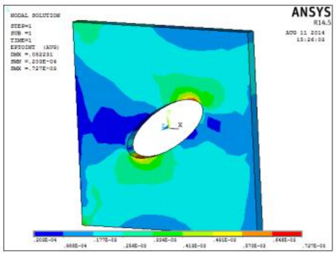

Figure 45.Strain

III. RESULTS TABLE

3.1 Pressure -5.5n/mm^2

	Angle 90	Angle 45	Angle 30	Angle -45	Angle -30
Displacement (mm)	0.0038	0.00949	0.44201	0.049493	0.004422
Stress (N/mm^2)	2.60035	7.30402	5.06664	7.17453	5.04681
Strain	0.335E^{-04}	0.901E^{-04}	0.615E^{-03}	0.880E^{-03}	0.618E^{-04}

3.2 Pressure - 6n/mm^2

	Angle 90	**Angle 45**	**Angle 30**	**Angle -45**	**Angle -30**
Displacement (mm)	0.004145	0.005399	0.048216	0.053988	0.004823
Stress (N/mm^2)	2.83655	7.96747	5.52686	7.82623	5.50524
Strain	0.366E^{-04}	0.983E^{-04}	0.671E^{-03}	0.959E^{-03}	0.674E^{-04}

3.3 Pressure – 6.5n/mm^2

	Angle 90	**Angle 45**	**Angle 30**	**Angle -45**	**Angle -30**
Displacement (mm)	0.00449	0.005848	0.052231	0.049493	0.52231
Stress (N/mm^2)	3.07275	8.63093	5.98709	7.17453	5.98709
Strain	0.396E^{-04}	0.107E^{-03}	0.727E^{-03}	0.880E^{-03}	0.727E^{-03}

IV. CONCLUSION

In this thesis, stresses developed on Flouoro polymer laminated thermoplastic composite plates with central elliptical hole which is subjected to in-plane loading is determined by applying different loads. The effects of orientation angle of elliptical hole in the composite laminated plate under various in-plane loads, elliptical hole is rotated from 0° to 90° by 15° increments counterclockwise. The orientation angles are 90^0, 45^0, 30^0, -45^0 and -30^0. Analysis is done in Ansys.By observing the analysis results, the stress concentration is more at the hole and is reducing towards the end of the plate. The stresses are increasing from 90^0 orientation angle to the 45^0 orientation angle and then reducing to 30^0 orientation angles.

When the hole is oriented at counter clockwise directions, the stress values are less with respective to the positive angles. The stress concentration is more when the hole is oriented at 45^0. The better orientation angle of hole is 90^0 since the stresses are less when compared with other orientation angles.

1. References

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