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Experimental Investigation of Carbon Fiber reinforcement T-stiffened Composite Panel with Aluminum Panel

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Abstract - *T-stiffened composite panels are used extensively in thin walled structures such as aircraft fuselage and wings, with the skin carrying membrane loads and the stiffeners carrying bending loads and resisting skin buckling [8]. The comparative analysis was carried out between the Analytical and experimental results. After making the comparative analysis result and conclusion was drawn [6]. It is observed that T joint with reinforcement of composite layer have improved reaction force to 81 KN compared to existing T joint with aluminum material with 23 KN.*

Key Words: T-stiffened composite, walled structures, Skin buckling

1. LITERATURE REVIEW

Herszberg, H.C.H. Li et.al the research activities associated with the damage assessment of maritime structures, conducted within the Cooperative Research Centre for Advanced Composite Structures, which aims to develop the capability to predict the criticality of typical damage in a ship joint and to develop and test techniques for its structural health monitoring (SHM).

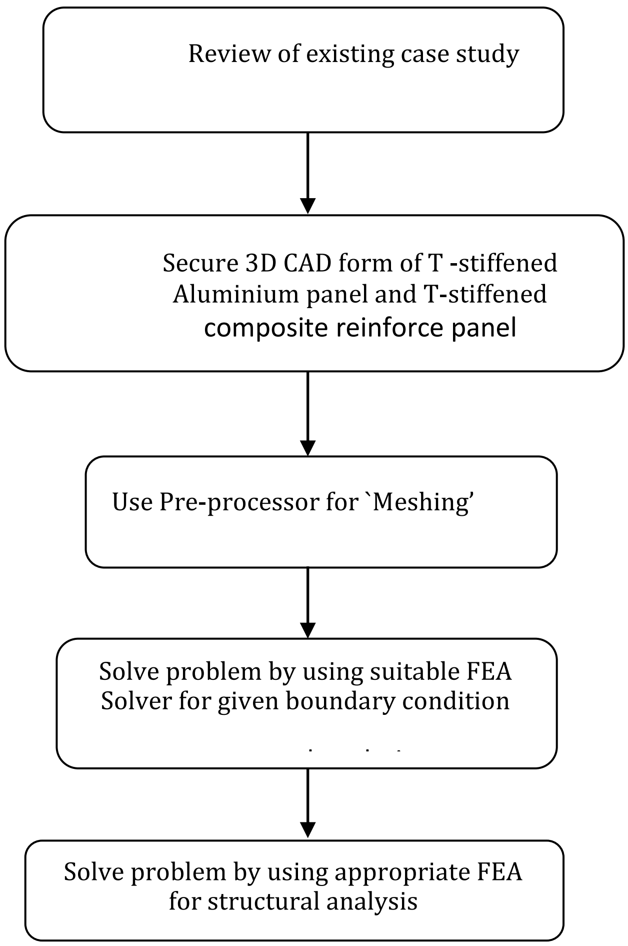
Shen Shang, Pizhong Qiao et.al. In this paper model-based damage detection strategy combining a higher-order finite element model with a continuum damage mechanics model is presented for delamination identification of laminate composite panels.

A.P. Herman, A.C. Orifici et.al. In which optimizing the structural response in service with regard to weight and safety is a recurrent objective. Currently, composite stiffened panels are employed in fuselage components and wing panels on aircrafts, among other applications. Nevertheless, viable success of these panels in real structures strongly depends on the ability to fully exploit their potential strength capacities under different loading scenarios

2. INTRODUCTION

The incorporation of carbon fibre reinforced polymer (CFRP) composites [1] for the construction of modern lightweight structures has been continuously increased over the last years [8]. At present, as a consequence of their superior behaviour in terms of specific stiffness and strength ratios, these materials are mainly being used for primary structural components in the aerospace and aeronautical industries, and in new car body designs. In a broad range of engineering applications, stiffened panels are one of the most commonly encountered structural concepts. This is motivated by the fact that such panels have the potential of producing highly efficient structures concerning their mechanical performance, allowing an adequate loading transfer and use of the load bearing capabilities.

3. METHODOLOGY



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3. ENGINEERING PROPERTIES – ALUMINIUM ALLOY

Properties of Outline Row 3: Aluminum Alloy NL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	2770	kg m^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Po...	
6	Young's Modulus	7.1E+10	Pa
7	Poisson's Ratio	0.33	
8	Bulk Modulus	6.9608E+10	Pa
9	Shear Modulus	2.6692E+10	Pa

Fig. 1: Details of engineering material

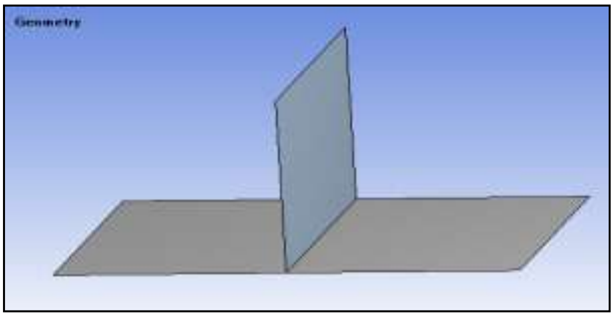
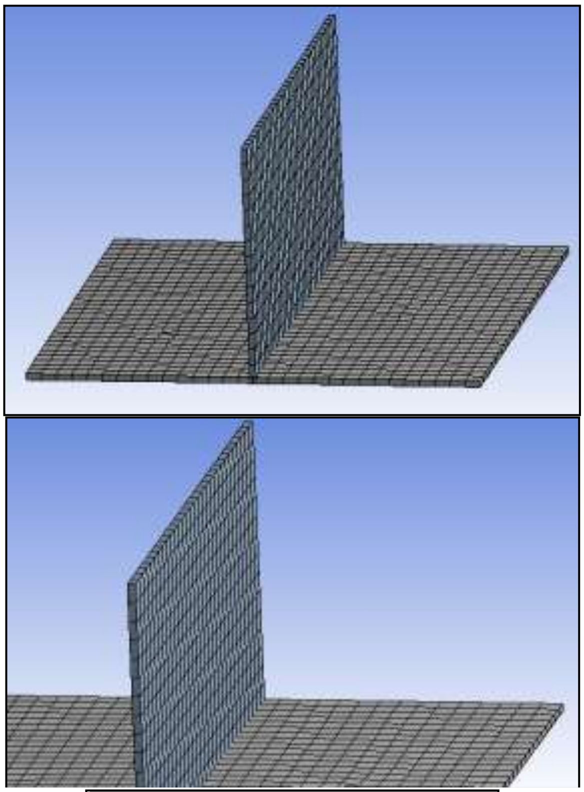


Fig. 2: T-stiffened panel geometry imported in ANSYS

4. MESHING

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.

Creating the most appropriate mesh is the foundation of engineering simulations. ANSYS Meshing is aware of the type of solutions that will be used in the project and has the appropriate criteria to create the best suited mesh. ANSYS Meshing is automatically integrated with each solver within the ANSYS Workbench environment. For a quick analysis or for the new and infrequent user, a usable mesh can be created with one click of the mouse. ANSYS Meshing chooses the most appropriate options based on the analysis type and the geometry of the model. Especially convenient is the ability of ANSYS Meshing to automatically take advantage of the available cores in the computer to use parallel processing and thus significantly reduce the time to create a mesh.



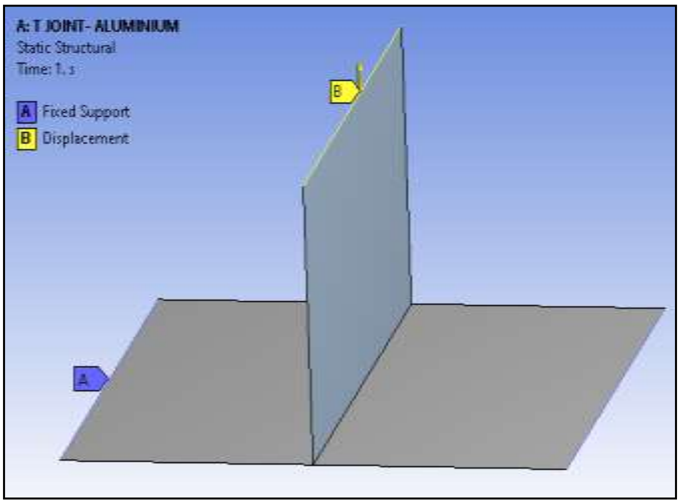
Statistics	
Nodes	1410
Elements	1336

Fig. 3: Details of meshing

5. BOUNDARY CONDITIONS

A boundary condition for the model is the setting of a known value for a displacement or an associated load. For a particular node you can set either the load or the displacement but not both[6].

The main types of loading available in FEA include force, pressure and temperature. These can be applied to points, surfaces, edges, nodes and elements or remotely offset from a feature [8]. The way that the model is constrained can significantly affect the results and requires special consideration [1]. Over or under constrained models can give stress that is so inaccurate that it is worthless to the engineer. In an ideal world we could have massive assemblies of components all connected to each other with contact elements but this is beyond the budget and resource of most people [1]. We can however, use the computing hardware we have available to its full potential and this means understanding how to apply realistic boundary conditions.



Tabular Data

	Steps	Time [s]	Z [mm]
1	1	0.	0.
2	1	1.	2.
3	2	2.	4.
4	3	3.	6.
5	4	4.	8.
6	5	5.	10.

Fig.4: Details of boundary conditions for T-stiffened panel

Fixed supports are applied at edges of plate and displacement of 10 mm is provided at top edge in step of 5 with 2 mm each.

6. EQUIVALENT STRESS RESULT

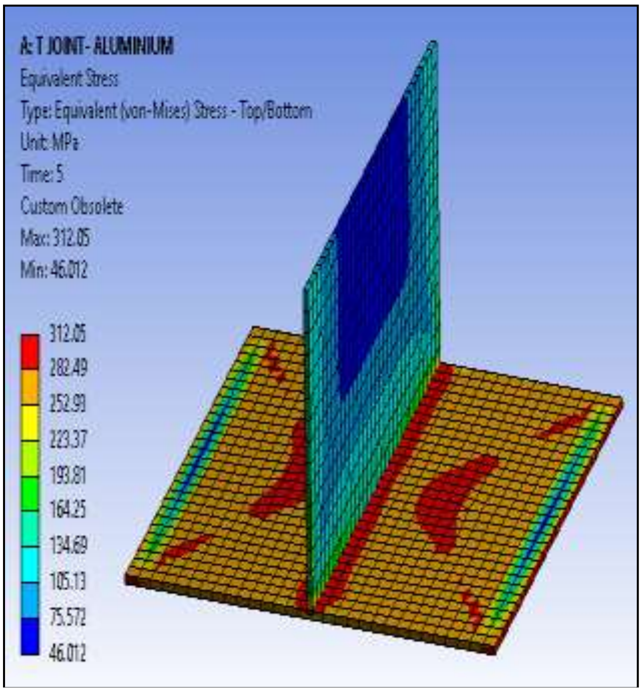


Fig. 5: Equivalent stress results of T-stiffened panel

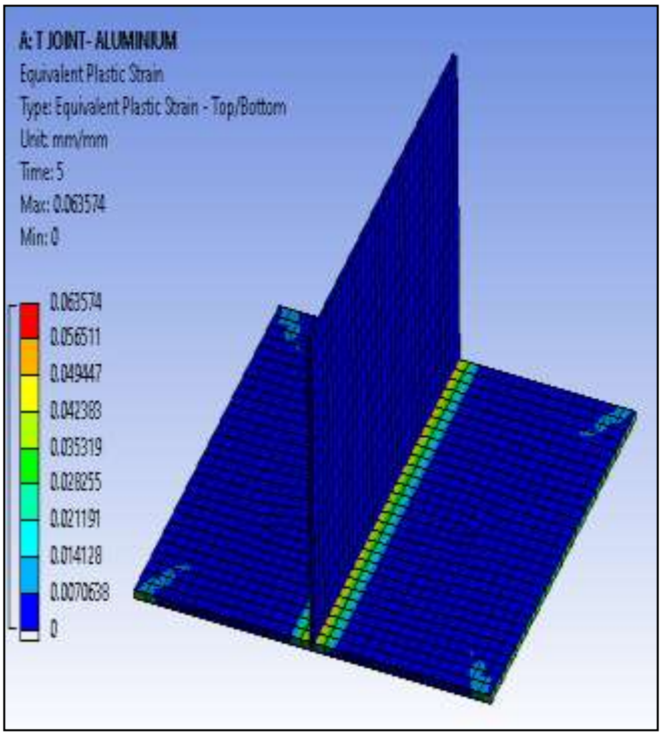


Fig.6: Equivalent plastic strain results

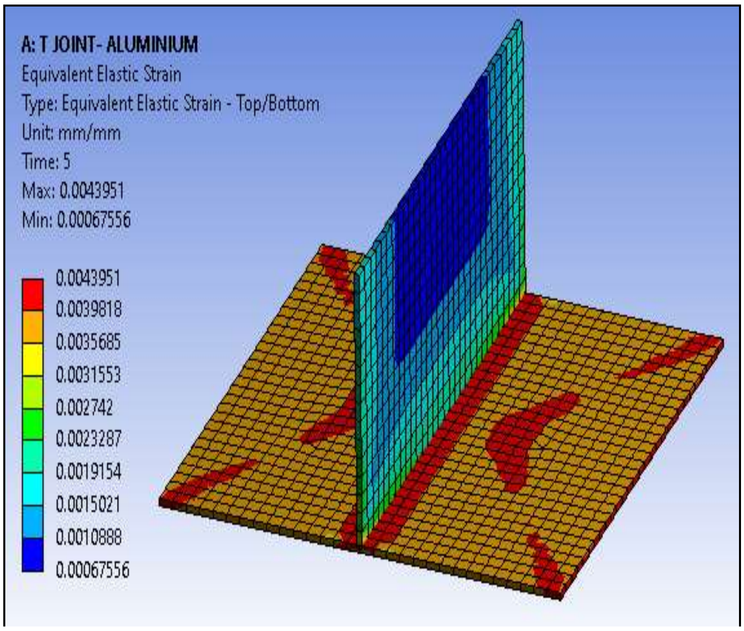


Fig.7: Equivalent elastic strain results

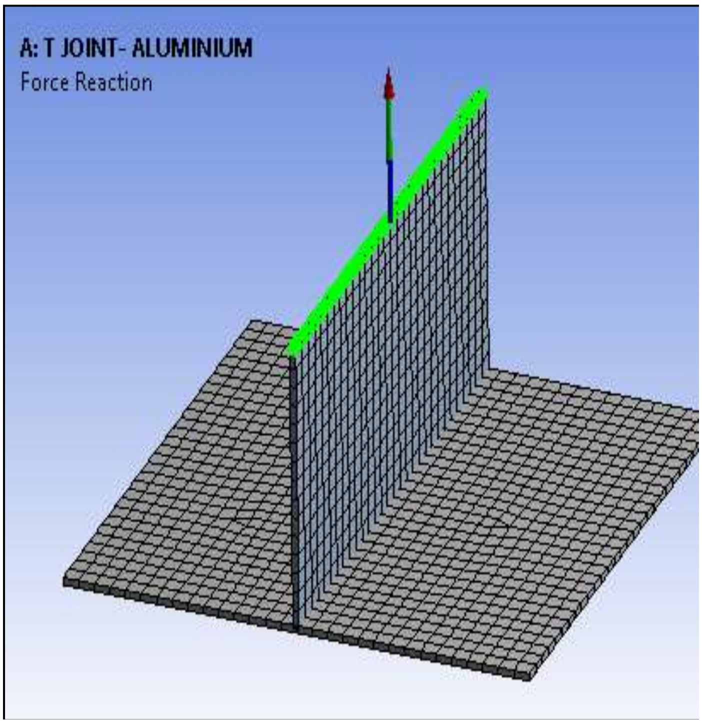


Fig. 8: Reaction force results

Maximum Value Over Time	
X Axis	0. N
Y Axis	0. N
Z Axis	23954 N
Total	23954 N

It is observed that reaction force of 23 KN is obtained for T joint with aluminum alloy with displacement of 10 mm.

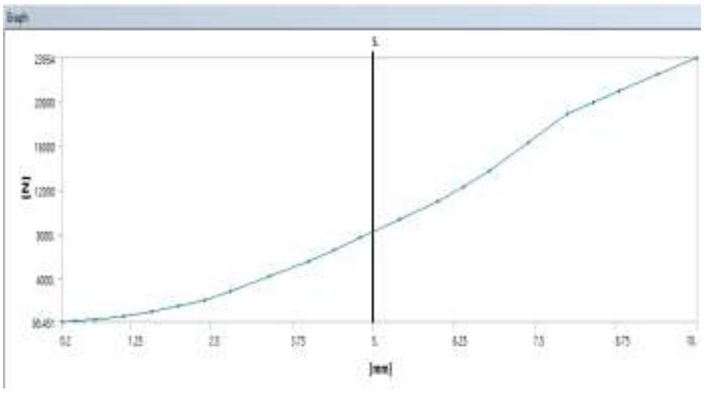


Fig.9: Variation of reaction force with deformation (displacement)

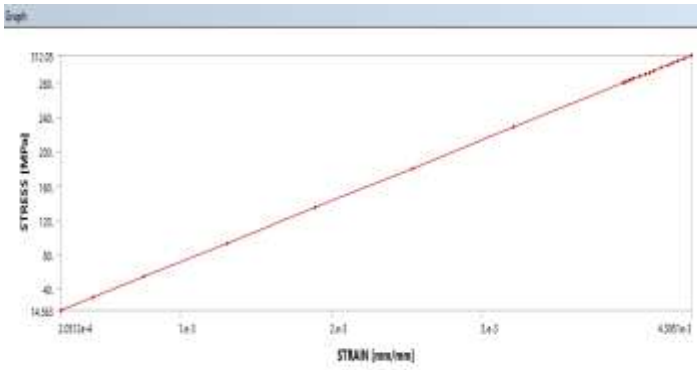


Fig.10: Variation of stress with strain

7. T-STIFFENED PANEL WITH ALUMINIUM AND CARBON EPOXY REINFORCEMENT ENGINEERING MATERIAL PROPERTIES

	A	B	C
1	Property	Value	Unit
2	Density	1.49E-09	mm^-3 t
3	Orthotropic Secant Coefficient of Thermal Expansion		
8	Orthotropic Elasticity		
9	Young's Modulus X direction	1.21E+05	MPa
10	Young's Modulus Y direction	8600	MPa
11	Young's Modulus Z direction	8600	MPa
12	Poisson's Ratio XY	0.27	
13	Poisson's Ratio YZ	0.4	
14	Poisson's Ratio XZ	0.27	
15	Shear Modulus XY	4700	MPa
16	Shear Modulus YZ	3100	MPa
17	Shear Modulus XZ	4700	MPa

Fig. 11: Details of epoxy carbon material properties

8. GEOMERTY IN ANSYS

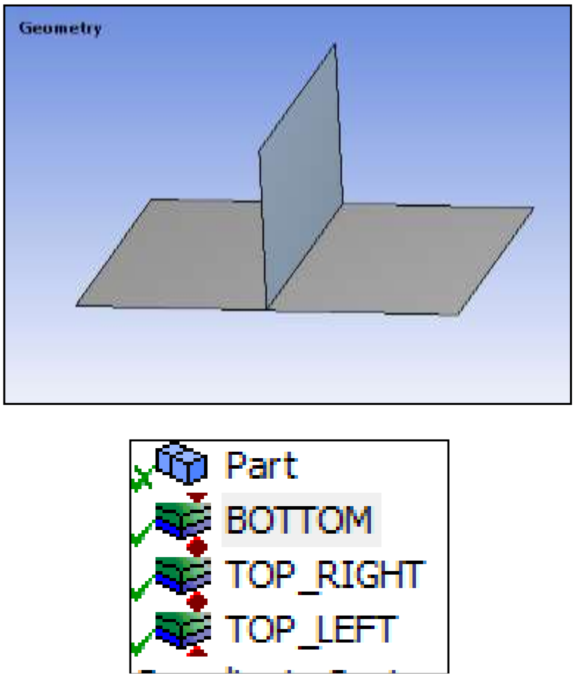


Fig. 12: T-stiffened panel geometry uploaded in ANSYS and layers pile up details

9. COMPOSITE LAYERS

In this T-stiffened panel it is made up of composite layers, which consist of 3 layers.

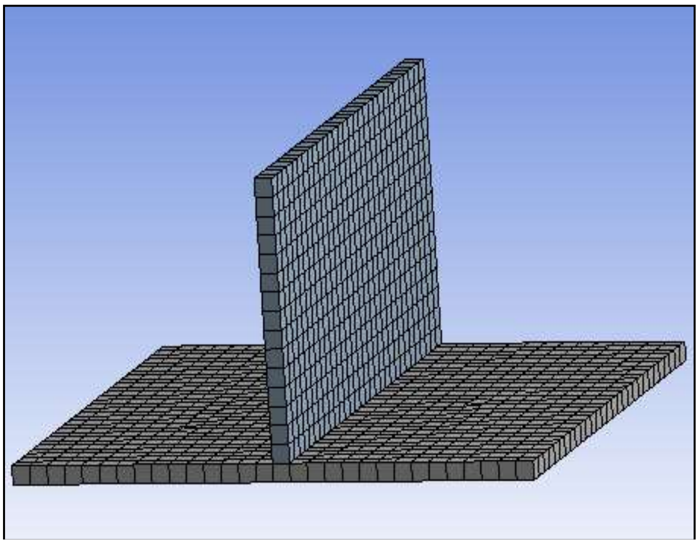
Total thickness is 5 mm so, aluminum alloy – 2 mm, epoxy carbon (1 mm) with 0 Deg, epoxy carbon (1 mm) with 45 Deg and epoxy carbon (1 mm) with 90 Deg.

[0˚, 45˚, 90˚] are ply orientation angle which are the optimum fiber angle orientation in composite layer concept[6].

So, these orientation of fiber are provided layer by layer and reinforcement is done.

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
4	Epoxy Carbon UD (230 GPa) Prepreg	1	90
3	Epoxy Carbon UD (230 GPa) Prepreg	1	45
2	Epoxy Carbon UD (230 GPa) Prepreg	1	0
1	Aluminum Alloy NL	2	0
(-Z)			

Fig.13: Details of composite layer pile up conditions



Statistics	
Nodes	1410
Elements	1336

Fig.14: Details of meshing

10. BOUNDARY CONDITIONS

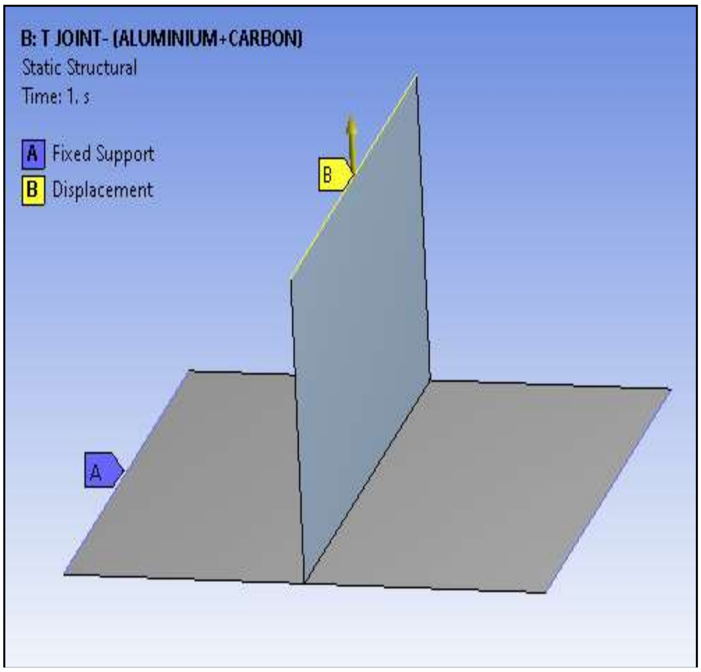


Fig. 15; Details of Boundary condition

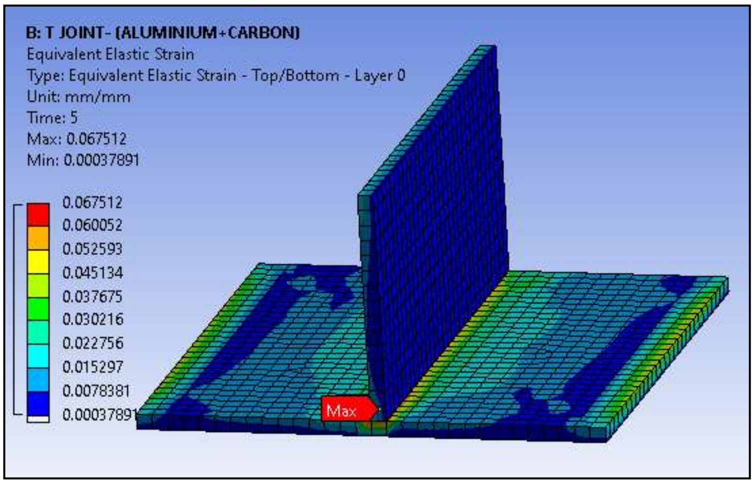


Fig. 16: Equivalent elastic strain results

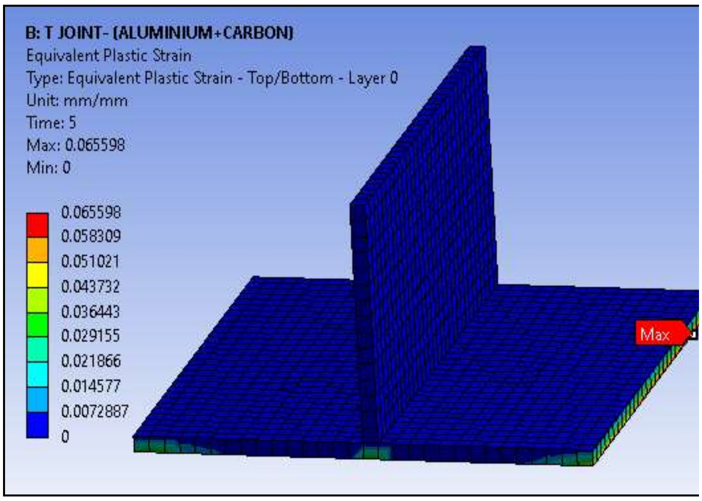


Fig. 17: Equivalent plastic strain results

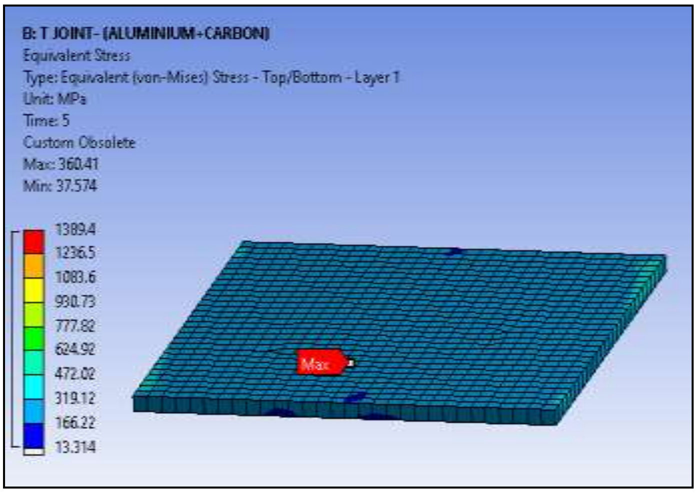
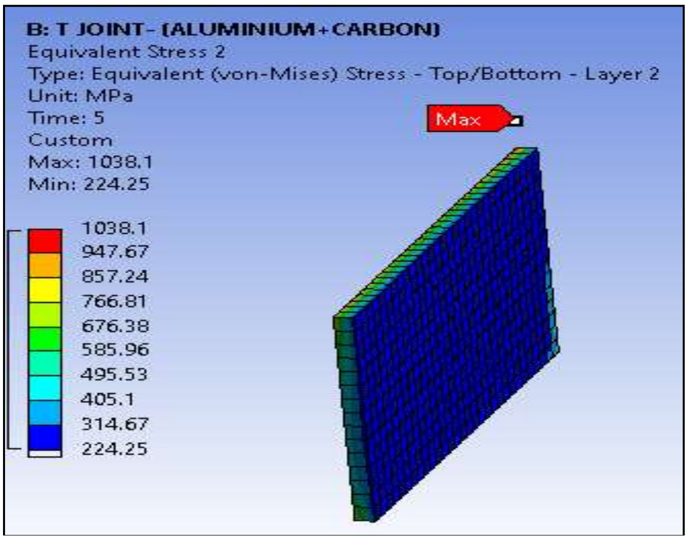


Fig.18: Equivalent stress on bottom layer results



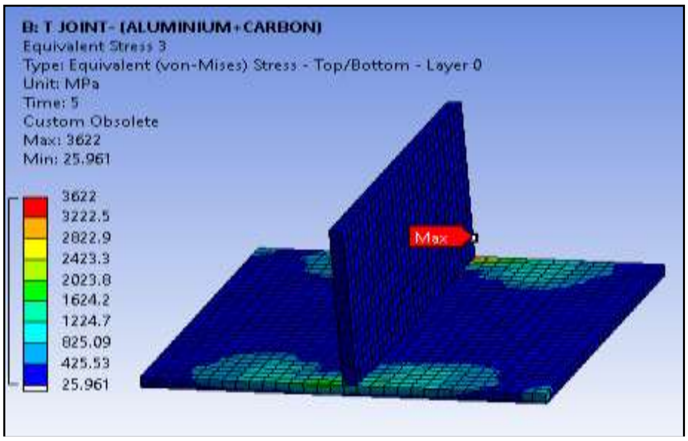


Fig. 19: Equivalent stress results for different layers

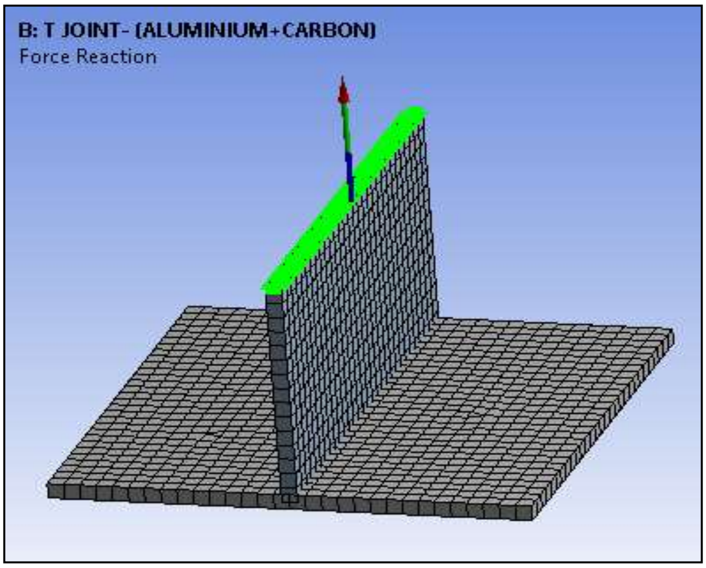


Fig. 20: Reaction force results for composite material

Maximum Value Over Time	
X Axis	0. N
Y Axis	0. N
Z Axis	81308 N
Total	81308 N

11. CONCLUSION

It is observed that T joint with reinforcement of composite layer have improved reaction force to 81 KN compared to existing T joint with aluminum material with 23 KN. The comparison is given in tabular format.

Table 1: Comparison of reaction forces & Elongation

Sr. No.	Parameters	Material without coating			Material with coating		
1	Elongation (mm)	0	5	10	0	5	10
2	Reaction forces(KN)	0	8	23	0	12.5	81

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REFERENCES

1] "Damage assessment and monitoring of composite ship joints." by I. Herszberg a, , H.C.H. Li b, F. Dharmawan b, A.P. Mouritz b, M. Nguyen b, J. Bayandor b

2] "Delamination identification of laminated composite plates using a continuum damage mechanics model and subset selection technique." by Shen Shang1, Gun Jin Yun1,3 and Pizhong Qiao

3] "Experimental failure investigation of pull–off tests of single T-stiffened composite specimens." J. Justoa, J. Reinosoa,_, A. Bl´azqueza

4] "Vibration modal analysis of defects in composite T-stiffened panels by A.P. Herman, A.C. Orifici, A.P. Mouritz

5] "Failure prediction of T-stiffened composite panels subjected to compression after edge impact" by Nian Li, Puhui Chen

6] "Impact of Composite Manufacturing Constraints On Aerospace Stiffened Panel Design." D. Quinn1*, A. Murphy1, M.A. Price1 and M. Mullan.

7] "A Review Of Structural Health Monitoring Techniques As Applied To Composite Structures." by Amafabia, Daerefa-a Mitsheal, 2Montalvão, Diogo, 1David-West, Opukuro, 1Haritos, George.

8] "Stability of composite stringer stiffened panels." by Richard Degenhardt