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A STUDY ON COMPARISION OF TESILE LOAD CARRYING CAPACITY OF COMPOSITE WINGS AND CUT-OUTS

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ABSTRACT

The utilization of composites in airplane structures is consistently expanded and presently become part of existence. In development of multi-cell airplane wing, patterns are usually given in the wing fights and ribs to work with the fuel move across cells. While the snare of the fight is relied upon to move shear loads under a general bowing burden, presence of such discontinuities are of extraordinary concern. Specifically, wing fights made of fiber built up composites, such discontinuities might bring about fiber tear and are notable areas of stress focus. Present work endeavors to investigate a carbon fiber composite (CFC) and Glass fiber composite wing fight, with patterns, under cantilever pillar conditions with the pressure load applied toward one side of the fight to initiate an unadulterated bowing pressure at the pattern, through FE examination. The information estimated broadly during the tests was utilized for changing thickness and measurement to recognize the pressure focuses, basic disappointment areas. This review is to set up the requirement for displaying the entire stacking get together to accomplish the outcomes.

Key words: FEA, Glass Fiber, Stress Concentration Factor, Composites.

1. INTRODUCTION

Laminated composite materials are increasingly being used in a large variety of structures including aerospace, marine and civil infrastructure owing to the many advantages: high strength/stiffness for lower weight, superior fatigue response characteristics, facility to vary fiber orientation, material and stacking pattern, resistance to electrochemical corrosion, and other superior material properties of composites. At the same time, the fabricated material poses new problems, such as failure due to delamination and pronounced transverse shear effects due to the high ratio of in-plane modulus to transverse shear modulus. Hence, a true understanding of their structural behavior is required, such as the deflections, buckling loads and modal characteristics, the through thickness distributions of stresses and strains, the large deflection behavior and, of extreme importance for obtaining strong, reliable multi layered structures. The finite element method is especially versatile and efficient for the analysis of complex structural behavior of the composite laminated Structures [1]. Cutout holes in such plate elements are necessary for inspection, maintenance, service purposes and weight reduction. The presence of cutouts (perforations) in a structural member often complicates the design process. In aerospace structures, cutouts are commonly used as access ports for mechanical and electrical systems or specially weight reduction. Structural panels with cutouts often experience compressive loads that are induced either mechanically or thermally and can result in panel buckling. Thus, the buckling behavior of structural panels with cutouts must be fully assigned in designing process [2]. Studies on buckling analysis of plates under non-linear compressive loads have been very few. Plate problems are often idealizations of portions of a much larger overall stiffened or built-up structure-an aircraft wing or a ship or a multistoried building, for instance, and hence the loads that cause buckling are those exerted by the adjoining free –body on the plate; thus, uniform loading is an exception rather than the rule because the elastic forces between the free bodies depend on their relative stiffness. It is necessary to analyze plates subjected to various types of simple, assumed edge load distributions so as to understand their qualitative and quantitative influence on the buckling behavior When the opening becomes inevitable for the plates under large working stress, the reduced buckling strength of the plate may be insufficient to meet the requirements of normal serviceability limits and structural safety. A design solution must be deduced to increase the structural stability of such perforated plate before it can be used to its best advantage. This always can be accomplished by selecting the thicker plate but the design solution may not be economical in terms of weight of material introduced by an adequate increase in the thickness of the plate [3]. In general, the analysis of composite laminated plates is more complicated due to their anisotropic and heterogeneous nature. Less attention has been paid on the buckling of rectangular composite plates with cutouts. Due to the practical requirements, cutouts are often required in structural components to produce lighter and more efficient structures. For example, cutouts in wing spars and cover panels of commercial transport wings and military fighter wings are needed to provide access for hydraulic lines, electrical lines and for damage inspection [4,5]. The present work deals with the analysis of a rectangular and circular cutouts being considered as under various boundary conditions and loadings are used to perform pull-out analysis using ANSYS. The effect of rectangular and circular cutouts on the varying thickness and diameter to identify the stress concentrations behavior of laminated rectangular composite plates subjected to various in-plane tensile loading is examined using FEM.

2. METHOD OF ANALYSIS

The analysis is carried out using ANSYS modified for composite wing spar with circular and rectangular cutouts. The analysis consists of computing the stress concentrations and stresses in composite wings par under tensile load. This composite wings par with circular and rectangular cutouts was used in the current analysis. It is ability to produce the stresses in all nodes of composite wing spar. For comparative purposes, two composite wing spars were analyzed. The first one is carbon composite wing spar with increasing diameter of circular cutouts. The second is a glass composite wing spar with increasing diameter of circular cutouts but the same dimension of rectangular cutout is used in both composite wings pars. The Analysis is performed in the cantilever beam loading by using ANSYS. The each

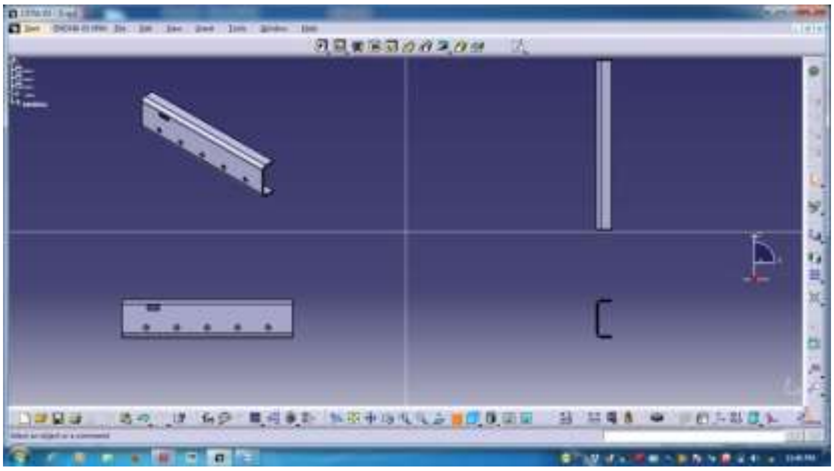

Figure1 Geometry configuration for C-spars

composite wing spar panels are exposed to different uniformly tensile loads: 15KN applied to free end of each panel another side kept fixed end as cantilever beam. The composite wings par (C- spar) was analyzed as dimensions of 337.5mm long, 3.5mm thick, with a fillet radius of 5mm, flange width of 30mm and height as 75mm having five holes of varying diameters of10mm, 15mm and 25mm.Isometric view of composite wing spar(C-Spar) designed by CATIAV5 has been shown in Fig.1. FEA modeling of the C-spars were carried out independently for carbon-epoxy and glass epoxy laminated beams considering as 0.175 ply thickness.

3. COMPOSITEPANELPROPERTIES

Various mechanical properties of the carbon fiber and glass fibers are required for the analysis and these inputs are shown in Table [1]

Table1 Composite panel properties for the analysis

S.NO	Property	Carbon Fiber	Glass Fiber
1	E_{11} &E_{22}	130 &10Gpa	36 &5 Gpa
2	G_{12}	5Gpa	2.7 Gpa
3	$X_{t,}X_c$	1200&1000 Mpa	465 &400 Mpa
4	$Y_{t,}Y_c$	40 &246Mpa	5.6 &5.6Mpa
5	V_{12}	0.35	0.25
6	Thickness	0.175 mm	0.175 mm
7	S	65 Mpa	19.2 Mpa
8	Density	1800kg/m^3	1540kg/m^3

4. RESULTS AND DISCUSSIONS

Two types of composite panels were analyzed, after the complete set of properties given to program as input. The output produces as stress concentration factor and maximum tensile stresses are increases with increase diameter of cutouts for glass and carbon fiber under the applied load.

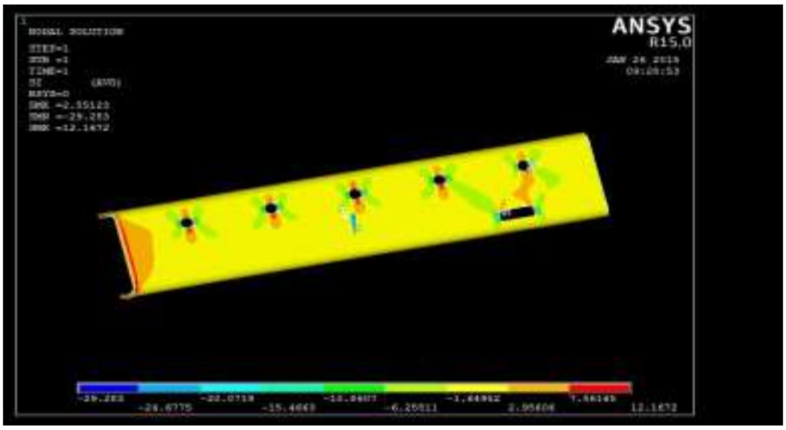

Figure2 Analysis of typical stress contour in glass epoxy fiber

A tensile load of 15kN was applied to the C- spar (beam) model at free end and another end is fixed. The C-spar will be considered for the analysis in the span-wise direction of the wing as shown in figure [2] and [3].

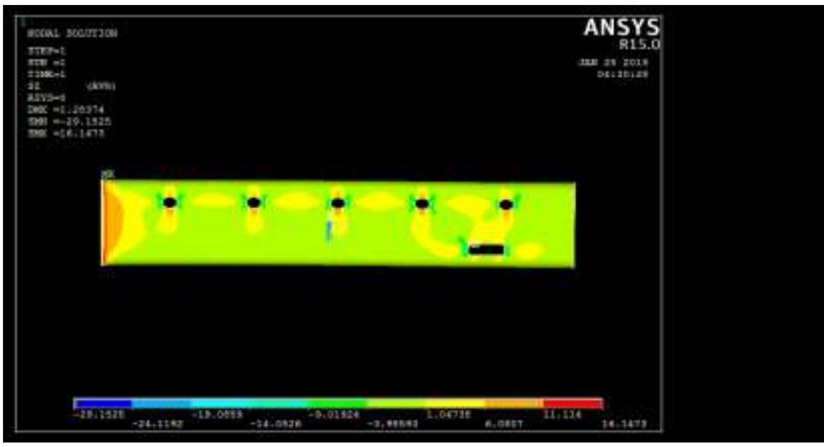

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Figure3 Analysis of typical stress contour in carbon epoxy fiber

Table 2 SCF for carbon and glass fiber

S.NO	Diameter (D)mm		Carbon Fiber	Glass Fiber
1	10	σ_{max}	16.14	11.48
		SCF	1.04	1.06
2	15	σ_{max}	19.42	17.88
		SCF	1.26	1.55
3	20	σ_{max}	19.03	17.04
		SCF	1.23	1.48

The maximum stress and stress concentration factor values are obtained for 10mm, 15mm, and 25mm diameter cut out beams of both carbon and glass fiber. Carbon fiber epoxy beam has maximum tensile stress and stress concentration factor than glass fiber epoxy beam with increase in diameter of the cutouts are shown in Table2. The displacement values are increases with increase in diameter of the cutouts and the carbon fiber epoxy beam resistance is higher than the glass fiber epoxy beam. The values of stress concentration factor and displacement for the C-spar beam of 10mm, 15mm, and 20mm diameter cutouts under the applied load is shown in Table 3.

Table 3 Displacement for carbon and glass fiber

S.NO	Diameter D(mm)	Carbon fiber	Glass fiber
		Displacements(mm)	
1	10	1.28	2.55
2	15	1.72	2.98
3	20	2.14	4.38

The analysis is used to determine the stress concentration on composite panel through using different cutouts in the panel. The comparison value of stress concentration factor for various diameter of C-Spar beam is subjected to under tensile load.

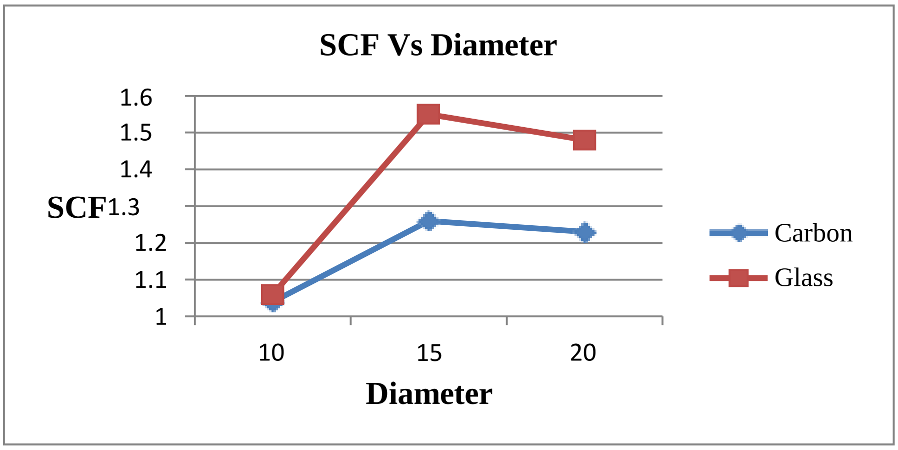

Figure4 Stress concentration factor Vs Diameter

The variation of stress concentration factor is increases with increase of diameter the composite panel cutouts. The carbon fiber epoxy beam has less stress concentration factor than glass fiber epoxy beam with increases of diameter in the composite panel cutouts is shown in Fig. 4. Carbon fiber epoxy beam has reduced the displacement than glass epoxy

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beam due to increasing the load. When the diameter is increases, the displacement of glass fiber epoxy beam is increased shows in fig 5.

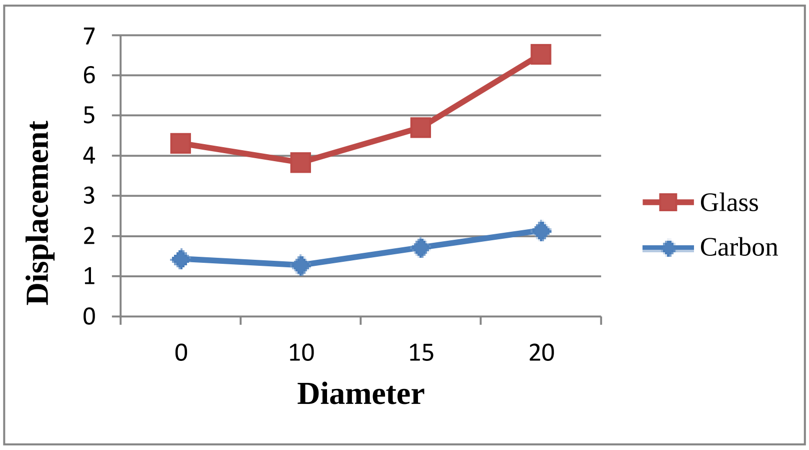

Figure 5 Displacement Vs Diameter

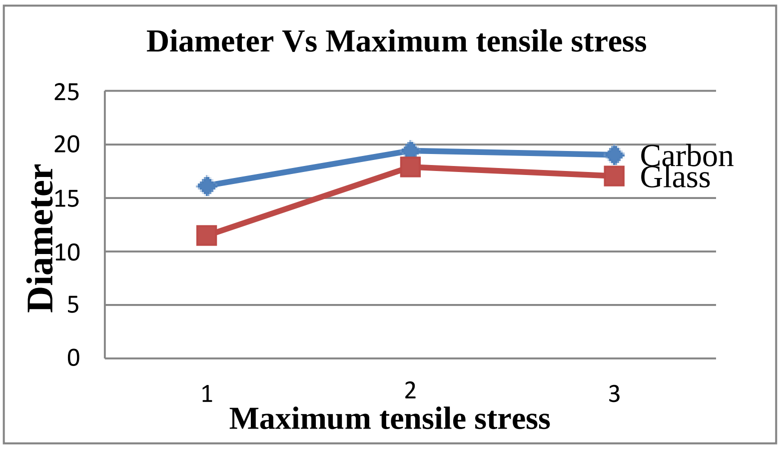

Figure6 Diameter Vs Maximum tensile stress

When the diameter of cutouts is increases in composite panel, the carbon fiber epoxy beam has maximum tensile stress (which is reaches to 19.43N/mm^2) than glass fiber epoxy beam (which is reaches to 17.88N/mm^2). The glass epoxy fiber has less tensile stress and higher displacement than carbon epoxy fiber due to increases of cutouts diameter in the panels shown in figure6.

5. CONCLUSIONS

The analyzed result shown that for a composite plate with rectangular and circular cutout, the theoretical carbon epoxy fiber has clearly demonstrates the advantages than glass epoxy fiber under the applied of tensile load. The tensile stress and stress concentration factor is maximum in carbon epoxy fiber with increase in diameter of the rectangular and circular cutouts. The displacement is reduced in carbon epoxy fiber than glass epoxy fiber with increase in diameter of the cutouts under the applied of tensile load, which is shown in table [3]. From this investigation it was observed that the maximum stress concentration and the failure stress are reduced in the carbon fiber epoxy from the load direction. It was also

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observed that the material with the higher stiffness ratio also had the higher stress concentration factor.

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