ANALYSIS OF COMPOSITE RIBS WITH FLANGED CUTOUTS

Nikitha D S[1], Bhaskar Raju S A[2], Karthik S B[3]

[1]*Assistant Professor in Department of Mechanical Engineering, Jain University- School of Engineering and Technology, Ramanagara, India.*

[2,3] *Assistant Professor in Department of Mechanical Engineering, Don Bosco Institute of Technology, Bengaluru,India.*

ABSTRACT

Carbon reinforced composites are extensively used in the structures like aircraft structures as there stiffness and strength are high with lower weight. Aircraft consists of different composite components they are empennage, parts of fuel and wings. Typical structures are wings ribs and intermediate spars, which can be built of CFC. Structures are introduced with the cut outs for lightening the components.

Stress concentrations are determined for the introduction of holes. Therefore it also leads to lowering of the buckling load carrying ability. To decrease the stresses in the vicinity of the hole and to enhance the buckling loads there is a requirement of reinforcement of the holes.

Here the consideration of the study containing a reinforced circular cutout in which a shear loaded square panel representing a segment of a composite (T300/976) rib. The effect of various reinforcement parameters is precisely included for both strength and stability.

Keyword:-*Carbon reinforced composites, Stress, Buckling loads, Shear load.*

1. INTRODUCTION

A typical aircraft wing consists of skin, longitudal spars which provide stiffness, transverse and bending ribs to with stand any transverse loads. Cutouts are very essential to save structural weight in many cases of minimum gauge thickness requirements, for the passage of hydraulic lines, wire bundles, control linkages etc. The most efficient structure only when the load path is direct. Invariably cutouts in structures decrease the structural weight because the structure adjacent to the cutout must be increased to carry the load which would have been carried in the cutout panel, plus the forces due to the redistribution of this load. In a loading plate stress concentration is formed around any of the cutout in a loaded plate. The area in which the problem occurs in fatigue strength and static strength. To overcome this effect it requires adaptation of different and various schemes of reinforcements.

2. METHODOLOGY

To determine the stress concentration factor and effect of providing reinforcement around the hole. To understand a study the effect of reinforcement is possessed on stability and strength of the plate.

Determination of stress concentration factor for reinforced holes under shear loading. Buckling analysis is carried out for different load cases like Shear, Compression and combination of both Shear and Compression.

3. RESULTS AND DISCUSSION

A plate of size of 300mm × 300 mm × 2mm with a cutout of diameter of 60mm is used in buckling analysis, buckling analysis is carried out for all three configurations of cutouts applying loads like Shear, Compression and combined loads of Compression and Shear.

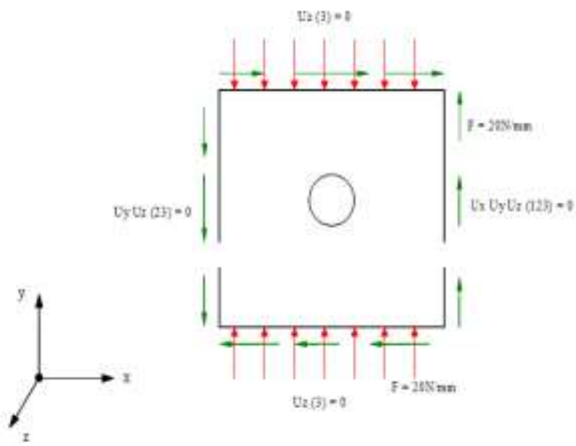


Fig 1 Showing Boundary conditions and loads

The lip width is 5mm and the flange angle is 45^o which is kept constant. The failure indices and BLF for plate with cutout diameter 60mm, 80mm and 100mm are calculated with flange height 'h' is varied and calculated for composite rib under a uniform shear load of 20 N/mm.
The Composite Material used is T300/976 and it has the following material properties;

E_{11}=135200Mpa; E_{22}=9240Mpa;
γ_{12}=0.32;
G_{12}=6280Mpa; G_{23}=5000Mpa; G_{13}=5000Mpa; Xt=1200Mpa; Xc=1000Mpa;
Yt=50Mpa; Yc=50Mpa;
S= 65Mpa; F= -0.5; ρ= 1.8g/cc.

The laminate of 16 layers each of 0.125mm and is laid with a stacking sequence of [45/45/45/45/45/45] s is used which is a uni-directional composite material.

Tab-1: Percentage of decrease in SCF w.r.t normal cutout

Cutout size (mm)	Flange height (mm)	SCF	% of decrease in SCF w.r.t normal cutout
60	0	3.344	0
60	4	2.28	31.81
60	6	2.37	29.12
60	8	2.42	27.63
80	0	3.916	0
80	4	2.514	35.8
80	6	2.686	31.4
80	8	2.656	32.17
100	0	4.426	0
100	4	2.913	34.18
100	6	2.923	33.95
100	8	2.983	32.6

Tab-2:BLF for Compressio, Shear and also effect of reinforcement around the cutout.

Cutout diameter (mm)	Flange height	BLF for Compr	BLF for Shear	BLF for Compression + Shear

	(mm)	ession		
Plate without cutout	0	1.443	2.58	1.16
60	0	1.2309	1.9604	0.9358
60	4	1.364	2.432	1.089
60	6	1.367	2.499	1.099
60	8	1.37	2.54	1.105
80	0	1.142	1.786	0.865
80	4	1.401	2.393	1.095
80	6	1.41	2.483	1.117
80	8	1.42	2.552	1.129
100	0	1.028	1.565	0.767
100	4	1.38	2.25	1.059
100	6	1.419	2.353	1.093
100	8	1.429	2.42	1.11

The following are the configurations;

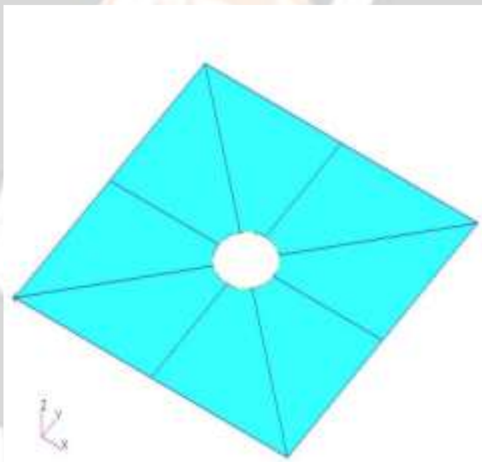


Fig (A)

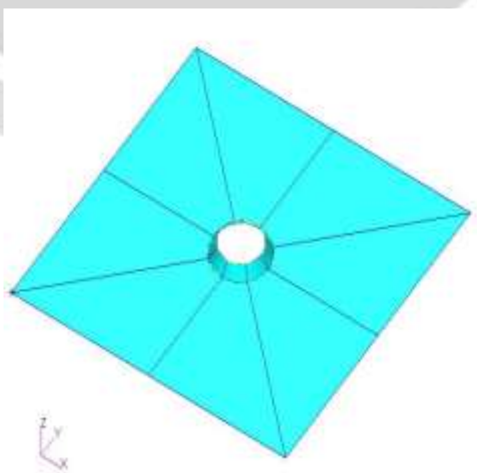
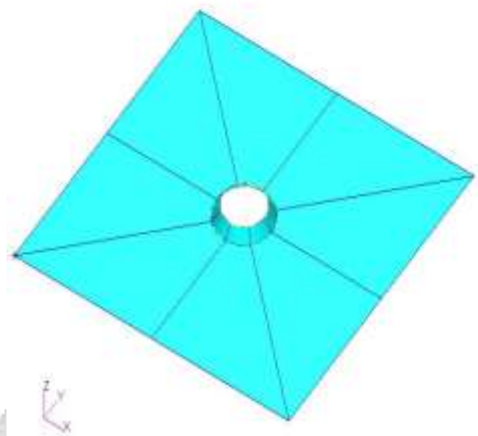


Fig (B)



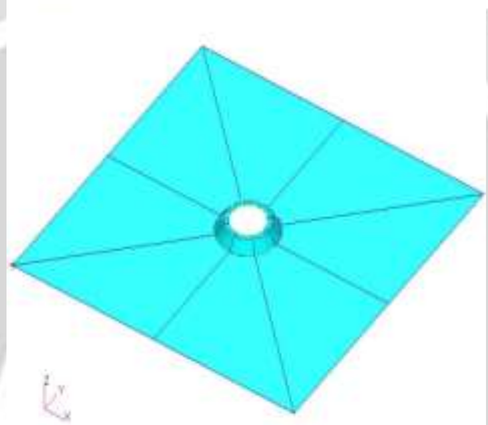


Fig (C)

Fig 2(A,B,C) Rib Configurations

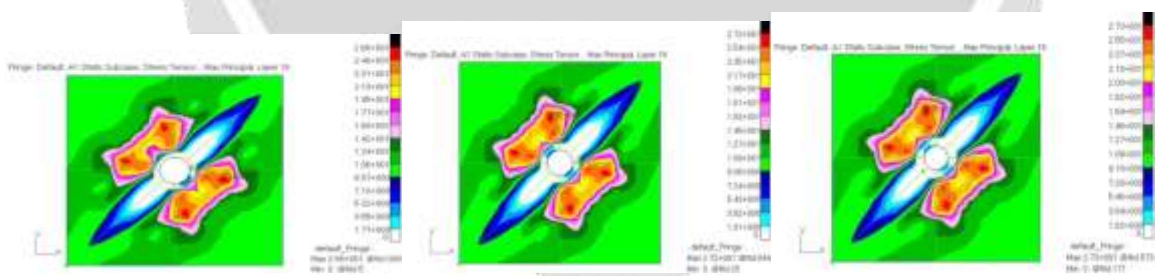
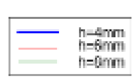


Fig 3 Maximum stress values for h=4mm, h=6mm and h=8mm respectively



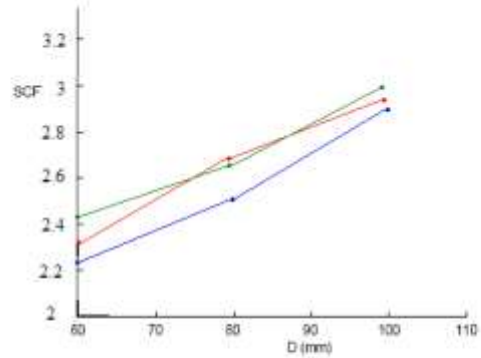


Fig 4 Variation of SCF with D and h for Flanged cutouts

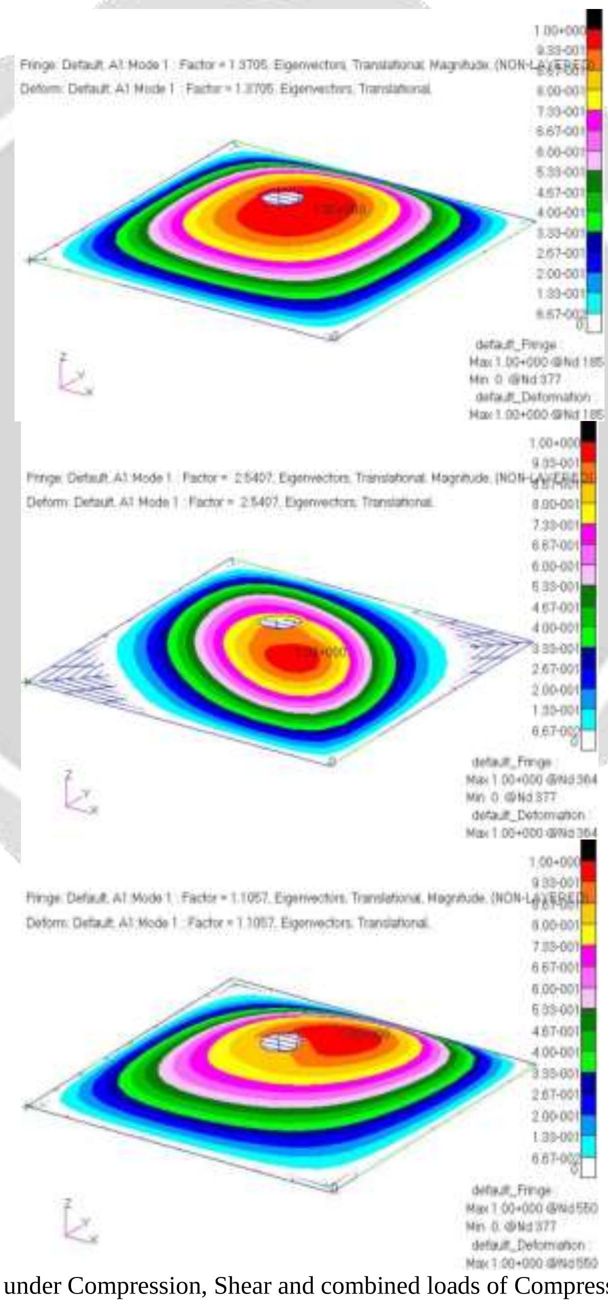


Fig 5 Buckling load factor under Compression, Shear and combined loads of Compression and Shear respectively

4. CONCLUSION

The analysis carried out in present project work and in present project the following conclusions may be made; Thecutout size and SCF are directly proportional as cutout size increases, SCF also increases. Introduction of flange leads to reduction in SCF but larger flange height leads in higher SCF but increase is not too high compared to less flange height.

The flange height and buckling loads are also directly proportional to each other if flange height is increased it leads to increase the buckling loads.If the selected flange height is around 8mm, the BLF then it remains high for all the hole sizes. Therefore BLF determined from the addition of lip is very advantageous.

Substantial gains in buckling loads can be a addition of flanges with the holes included in it. It is required to select composite ribs with flanged cutouts which leads to the weight savings.

5. REFERENCES

1. **William L. Ko** "Stress Concentration around a small Circular hole in HiMAT Composite Plate", NASA TM 86038.
2. **Cheng Yu and Benjamin W.Schafer** " Stress Gradient Effect on the Buckling of Thin Plates", 2002.
3. **S. Dash, A.V.Asha and S. K. Sahu** "Stability of Laminated composite curved panels with cutout using Finite element method", 2004.
4. **A. I. Zirka, M. P. Malezhik,** and **I. S. Chernyshenko**"Stress concentration in an Orthotropic plate with a circular hole under dynamic loading", 2004
5. **N.D. Mittal and N.K. Jain** "Finite element analysis for effect of fibre orientation on stress concentration factor in a laminated composite plate with central hole under in-plane static loading",2005.
6. **M. YasarKaltakci**and **H. M. Arslan** "Stress concentrations of symmetrically Laminated composite plates contain circular holes", 2006.
7. **S.J. Guo** “Stress concentration and buckling behaviour of shear loadedComposite panels with reinforced cutouts", 2006.
8. **S. Guo, R. Morishima, X. Zhang** and **A. Mills** "Stress concentration around cutout edges in a composite C-section beam under the in-plane shear load", 2008.
9. **Dr. Jan Gou**, Macromechanical Analysis of a Lamina, AL 36688.
10. **Dr. S. Li**, Failure Criteria of Composites, 2002.
11. **Michael P. Nemeth**, Buckling Behavior of Long Anisotropic Plates Subjected to Combined Loads, Hampton, Virginia 23681-0001.
12. **Nitin S Gokhale, Sanjay S Deshpande, Sanjeev V Bedekar, Anand N Thite,**Practial Finite Elament Analysis, **2008**.