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FINITE ELEMENT ANALYSIS OF COMPOSITE HEMISPHERICAL SHELL WITH CUT-OUT

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ABSTRACT

Lightweight structures are becoming increasingly popular globally because of their architectural and sustainability advantages, and engineering efficiencies. Use of composite materials for the construction of structural component can result in significant benefits on high strength and better performance. Cut-outs are passages used as access for electrical wires, control rods, hydraulic lines in aircraft structural design. Different cut-out shapes in structural elements are needed to reduce the self-weight of the elements and also provide access to other parts of the structure. In hemispherical shell, cut-outs are provided to decrease the self-weight, to provide access, services and even aesthetics. When the structures with cutouts are loaded, it will affect the buckling characteristics of the shell as well as on the ultimate load capacity. Thus, to know how this phenomenon occurs and to analyze the buckling behavior of this perforated shell has great importance for an efficient structural design. The cut-outs invariably reduce the frequency of the composite cylindrical shell and more specifically the ultimate load. Addition of stiffeners in in the structure will improve the strength and frequency value of cutout. In this study, we are planning to use the finite element analysis package, ANSYS to analyze the behavior of composite hemispherical shell with opening.
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Keywords—Finite element analysis, Composite materials, ANSYS

1. INTRODUCTION

Use of composite materials for the construction of structural component can result in significant benefits on high strength and performance. Application of such materials will leads to formation of light weight structure with a considerable cost reduction. And they have high design flexibility and corrosion resistance. They are generally used for the construction of Boat hull, swimming pool panel, bath tub, storage tank etc.. .

In recent years, the increasing need for lightweight structures has led to optimization of structural shape. Different cut-out shapes in structural elements are needed to reduce the self weight of the elements and also provide access to other parts of the structure. The presence of a cut-out in a stressed member creates highly localized stresses at the vicinity of the cut-out. The ratio of the maximum stress at the cut-out edge to the nominal stress is called the stress concentration factor (SCF). It is very necessary to understand the effects of cut-out on the ultimate load and stress concentration of structure is very important in designing of structures.

In this paper a study of behavior of composite hemispherical sell with cutout is done. Through this study we can understand the effect of cutout in a composite structure under loading. We can also determine the important parameters considered in this study and their effect on the analysis results. Like type of composite material, presence of cut-out, orientation of fiber, type of stiffener etc **.**

2. DESCRIPTION OF THE STRUCTURE

Hemispherical dome is selected as the main structure. Shell 181 is used for the modelling. Diameter of shell is selected as100 m and thickness is 50 mm. Circular cutout is selected for the study, whose diameter is taken as 20 mm. Here all the bottom of the hemispherical shell is assumed to be fixed. the service loads were uniformly distributed on the top of shell surface

3. FINITE ELEMENT MODELLING

Finite element analysis (FEA) is a computerized method for predicting how a structure reacts to different type of forces, vibration, heat, fluid flow, and other physical effects. Here finite analysis id performed using the software ANSYS. It is suitable for modelling, model analysis and static analysis and dynamic analysis of a structure. And is also very efficient for structural analysis, including linear, nonlinear, dynamic, hydrodynamic and explicit studies.

4. ANALYSIS OF SHELL FOR THE MATERIAL SELECTION

4.1 Model Analysis

Modal analysis in the ANSYS family of products is a linear analysis. It is used to determine the natural frequencies and mode shapes of a continuous structure. It is the most fundamental of all dynamic analysis types and is generally the starting point for other, more detailed dynamic analyses. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions. They are also needed if you want to do a spectrum analysis or a mode superposition harmonic or transient analysis

Three composite materials are selected, carbon Fiber epoxy, Glass fiber epoxy, and Aramid fiber epoxy. These are commonly used composite materials

4.1.1 Analysis of carbon fiber/ epoxy hemispherical shell

In analysis of hemispherical shell we are considering both model analysis and static analysis for composite materials. At first we are going to discuss Model analysis of hemispherical shell without cut-out for carbon epoxy composite.

Table 1. Mechanical properties of carbon epoxy

PROPERTY	VALUE
Young's modulus(E)	2.09E11N/m^2
Density	1540 kg/m^3
Poisson ratio	0.27
In-plane shear modulus (G)	5.5E9N/m^2

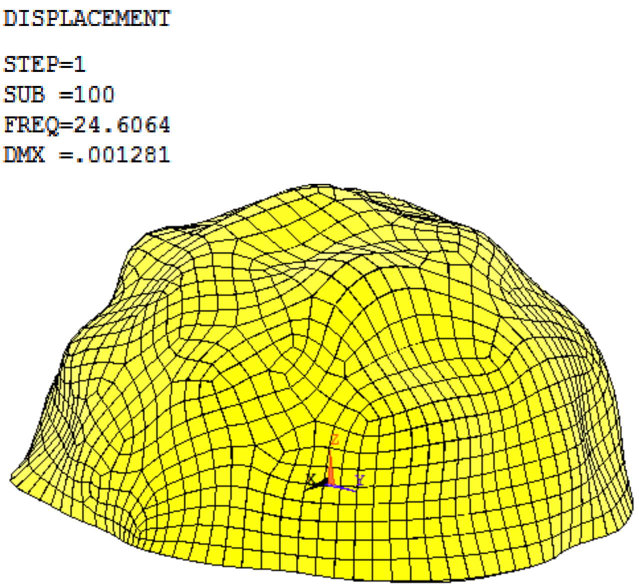


Fig 1: Displacement diagram of carbon fiber epoxy composite

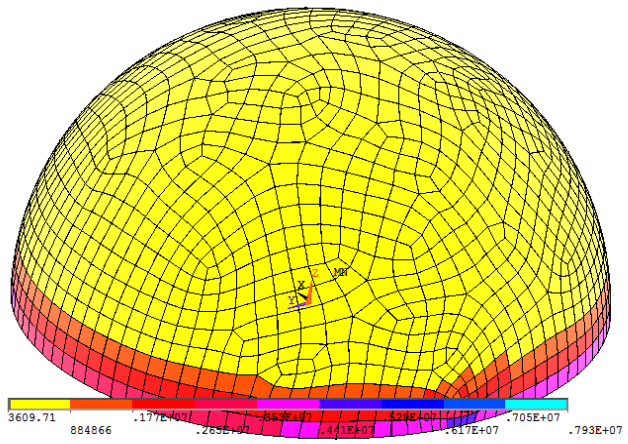


Fig 2: Vonmises Stress Diagram

4.1.2 Analysis of Glass fiber epoxy hemispherical shell

Table 2. Mechanical properties of carbon epoxy

PROPERTY	VALUE
Young's modulus(E)	4.5E10N/m^2
Density	2000 kg/m^3
Poisson ratio	0.3
In-plane shear modulus (G)	5E9N/m^2

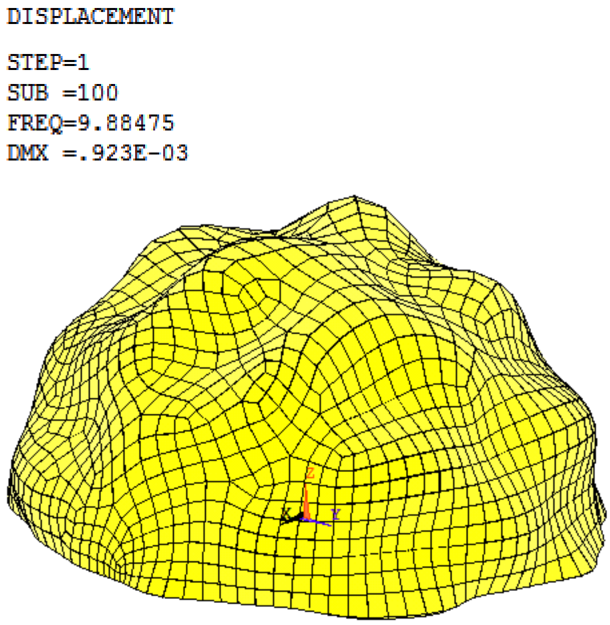


Fig 3: Displacement diagram of glass fiber epoxy composite

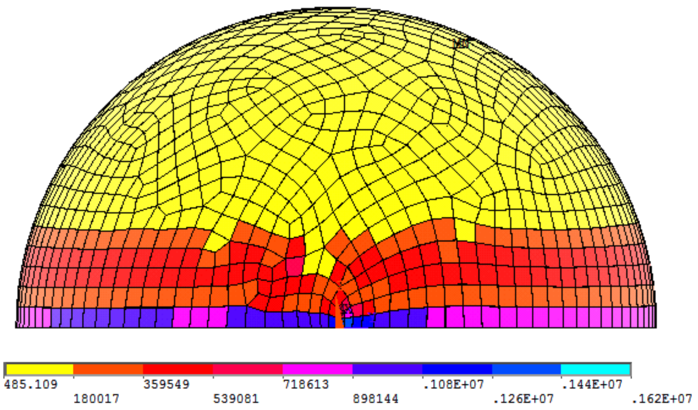


Fig 4: Vonmises Stress Diagram

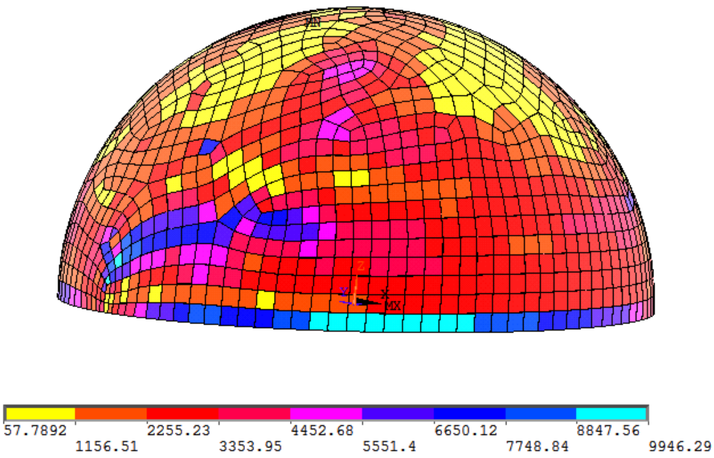


Fig 6: Vonmises Stress Diagram

4.1.3 Analysis of Honey comb epoxy hemispherical shell

Table 3. Mechanical properties of carbon epoxy

PROPERTY	VALUE
Young's modulus(E)	1E6N/m^2
Density	80 kg/m^3
Poisson ratio	0.49
In-plane shear modulus (G)	1N/m^2

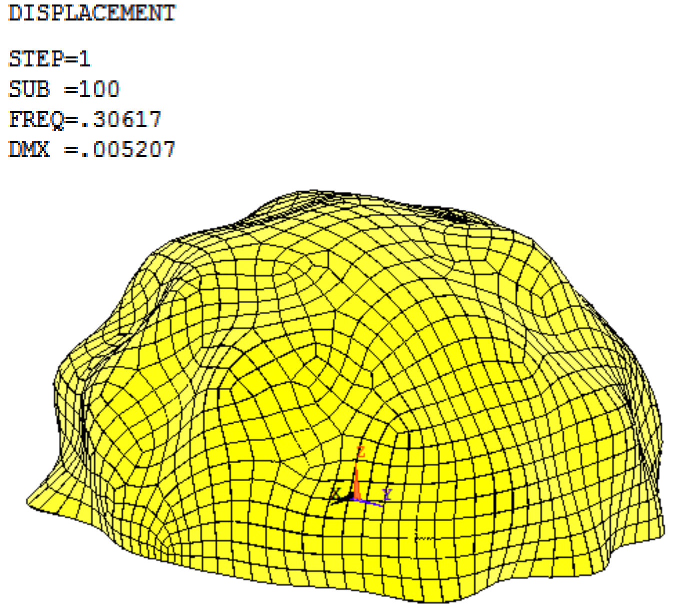
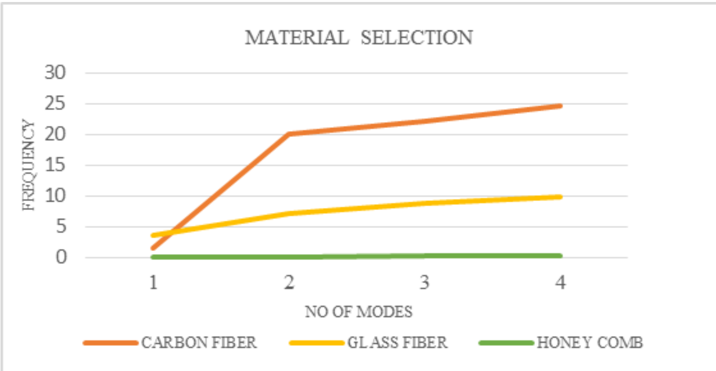


Fig 5: Displacement diagram Honeycomb epoxy composite

Table 4. Frequency modes for different composite material

NO OF MODES	CARBON FIBER /EPOXY COMPOSITE	GLASS FIBER/ EPOXY COMPOSITE	HONEYCOMB/ EPOXY COMPOSITE
1	**1.502**	**3.6**	**0.1065**
2	**20.02**	**7.12**	**0.203**
3	**22.1**	**8.74**	**0.3061**
4	**24.61**	**9.88**	**0.41**



Graph 1:Frequency modes of carbon fiber,glass fiber and honeycomb epoxy composites

From the above table the frequency value for different composite materials are obtained. The frequency values of carbon fiber Epoxy are higher than Glass Fiber Epoxy, honey comb whereas the glass fabric values are in between honey comb and carbon epoxy in case of cylinder without cutout.

4.2 Static Analysis

A static analysis calculates the effects of steady loading conditions on a structure, it is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. A static analysis can be either linear or nonlinear.

4.2.1 Analysis Of Hemispherical Shell With Cutout And Stiffeners

Here analysis of composite hemispherical shell with cutout are carried out by changing the cross section of stiffeners. Three type stiffeners are selected for the study. I section, rectangular section and square section. Static analysis is conducted for getting stress values and ultimate loads.

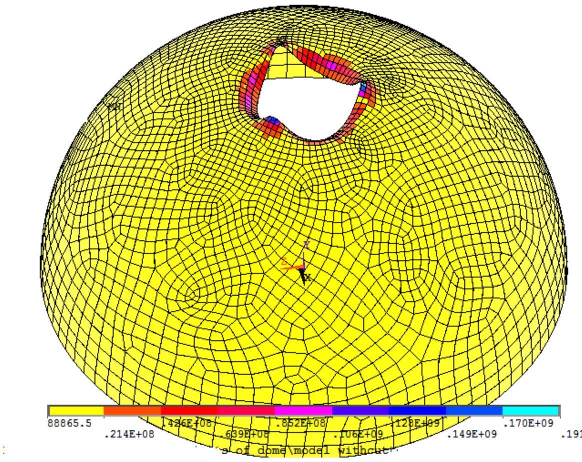


Fig 7: Von Mises Stresses of the hemispherical shell with cutout without stiffener

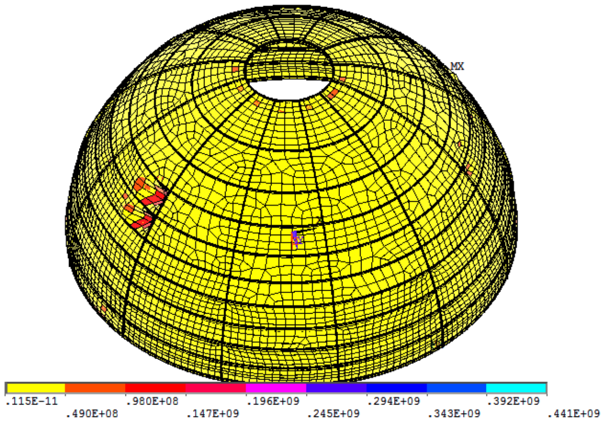


Fig 8: Von Mises Stresses of the hemispherical shell with I section as stiffener

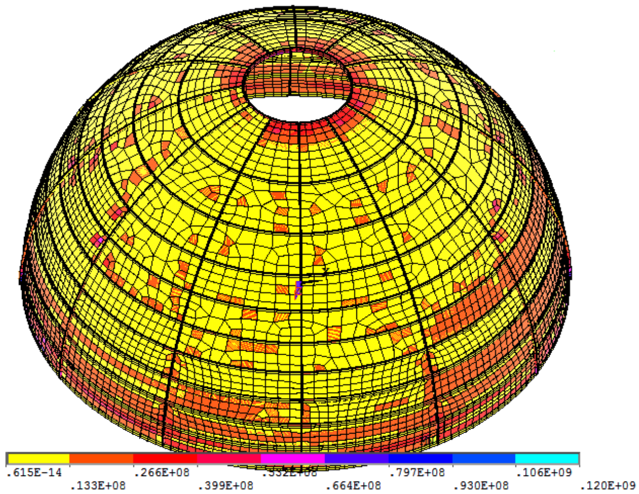


Fig 9: Von Mises Stresses of the hemispherical shell with rectangular rib as stiffener

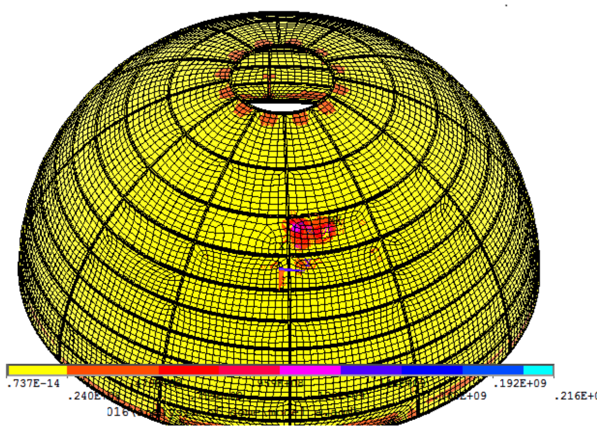


Fig 10: Von Mises Stresses of the hemispherical shell with square rib as stiffener

Table 5. stress, deformation, ultimate values of shell with stiffeners

STIFFNERS(C/S)	VONMISES STRESS (kN/mm^2)	DEFORMATION (mm)	ULTIMATE LOAD (N)
With cutout without stiffener	**0.191E9**	**0.5665**	**3.5E6**
I Section	**0.441E9**	**0.289**	**1.1153E8**
Rectangular Section	**0.120E 9**	**0.037**	**9.8555E7**
Square section	**0.216E9**	**0.269**	**8.3632E7**

It is clear that from above table the ultimate load value of hemispherical shell with cutout at the apex can be improved by the provision of stiffeners. From the three stiffeners hemispherical shell with I section rib gave maximum ultimate load as compared to other two sections.

5. CONCLUSION

This study deals with the selection of best material and cross section of stiffeners for the hemispherical shell with and without cutout. Based on the result following conclusions are drawn

- Concept of composite material, different hemispherical structure, and cutout are studied.
- Factors influencing structural behaviour are studied.
- Among the three different composite material carbon epoxy gave higher frequency value and less deflection so carbon epoxy is the best composite material in this study
- Presence of stiffeners in the hemispherical shell will affect the strength and deflection value
- Stiffener having cross section" **I** "gave maximum ultimate load value

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7. REFERENCES

[1] K. Anusha Reddy, and G. Eason, B Ravi Katukam "Relative Comparison of Geometrical Shapes for Cutouts" Volume 5 Issue 3 June 2015, ISSN: 2319 – 1058

[2] Sudhir Sastry Y B, Sindhura .G, Sarwade A. G R. Model Analysis of Composite Fuselage like Structures with Cutouts "Vol. 2 Issue 11, November - 2013 , ISSN: 2278-0181

[3] M Mohan Kumar, Rajesh S, Yogesh H, " Study on the Effect of Stress Concentration on Cutout Orientation of Plates with Various Cutouts and Bluntness" Vol.3, Issue.3, May-June. 2013 pp-1295-1303 ISSN: 2249-6645

[4] Dinu Paulose, Dipu V.S "Behaviour Of Plates With Circular Cutout" Volume 5, Issue 12, December (2014), pp. 134-142

[5] Sudhir Sastry Y B, Sindhura .G, Sarwade A. G R. "Model Analysis of Composite Fuselage xzlike Structures with Cutouts "Vol. 2 Issue 11, November - 2013 , ISSN: 2278-0181

[6] M Mohan Kumar, Rajesh S, Yogesh H, " Study on the Effect of Stress Concentration on Cutout Orientation of Plates with Various Cutouts and Bluntness" Vol.3, Issue.3, May-June. 2013 pp-1295-1303 ISSN: 2249-6645

[7] J.Ramaniah, K.Jagan Mahon Rao" Buckling Analysis of Orthotropic Composite Shell With and Without Cutouts Using Fem" ISSN: 2278-0181 Vol. 2 Issue 8, August – 2013

[8] M.S Ismail, a, B.T.H.T Baharudin, b, S.A. Yahya1and H.A. Kahar "Finite Element Analysis of Composite Cylinder with Centre Cutout under Axial Load and Internal Pressure" Vol. 701 (2013) pp 425-429

[9] B. Sidda Reddy, A. Ramanjaneya Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy" Bending Analysis Of Laminated Composite Plates Using Finite Element Method" Vol. 4, No. 2, 2012, pp. 177-190

[10] Ravikiran Kadoli- " Linear Thermoelastic Buckling Of Composite Hemispherical Shells With A Cut-Out At The Apex" Composite Structures 68 (2005) 87–101