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# Buckling Behaviour Of Compression Loaded Composite Cylindrical Shells With Reinforced Cutouts

**Ramanatha Dash *, F.Anand Raju ****

*PG Student, CAD/CAM, Siddharth Institute of Engineering & Technology (SIETK), Puttur - 517583
** Department of Mechanical Engineering, SIETK College, Puttur, Chittoor Dist, Andhra Pradesh, INDIA.

## ABSTRACT

**In the recent times, Composite thin cylindrical shells are most widely used structural forms in Aerospace and Missile applications. In designing efficient and optimized shell structure, they become increasingly sensitive to buckling. It is well known that the experimental display is mainly attributed to geometrical imperfection like damage in the structure, or ovality or local thining of material etc. in missile and Airframe , the composite cylindrical shell structure is generally provided with cutouts for accessing internal components during integration. The cutouts invariably reduce the strength of the composite cylindrical shell and more specifically the buckling load. It has been a design practice to improve strength by addition of reinforcement around cutouts. The cutout not only introduces stress concentration but also significantly reduce buckling load. Which will results to eliminate the Interlaminar and intralaminar failure by change in material properties through dimensional computational analysis was carried out using ANSYS as the preprocessing software and FE as the solver and post processor.**

**Keywords**: Acoustic, reinforcement, FEA

## 1. INTRODUCTION:

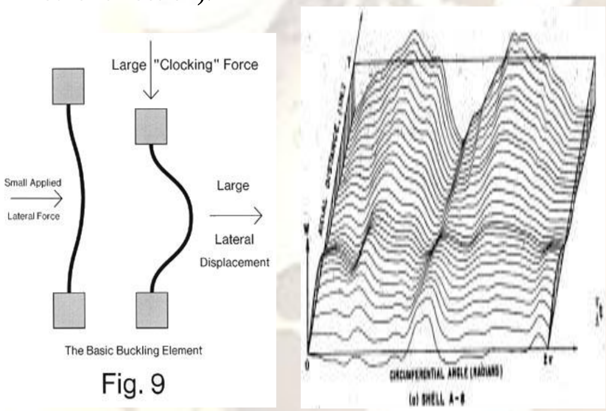
The composite is a combination of two or more materials combine on a microscopic scale to give superior properties than original materials include strength,fatigue life, stiffness ,temperature dependent behaviour,corrosion resistance,thermal insulation,wear resistance,thermal conductivity,attractiveness,acoustical insulation and weight. The composites find its application in Aerospace,Defence,Automobiles,Machine tool, Marine, Construction industry,chemical industry and biomedical equipments etc. In general structural discontiuities in the form of cutouts are inevitable in the design and construction particularly in the Aerospace industry.Thin-walled shell structures are a fundamental component found in Aircraft,spacecraft, and launch vehicles. In most applications,these structural components contain cutouts or openings that serve as doors,windows, or access ports, or used to reduce weight.often some type of reinforcement is used around a cutout to eliminate local deformations and stress concentrations that can cause local buckling or premature material failures. In addition it is important to understand performance enhancements that can be obtained by using light weight fibre-reinforced composite materials. Fuethermore these structures experience compression loads during vehicle operation and as a result, their buckling response and material failure characteristics must be understood and accurately predicted in order to devlop efficient,safe design.

Many numerical and experimental studies of the buckling behaviour of cylindrical shells have been conducted since the early 1900s.It took nearly 100 years to reach the point where robust,measurement technologies were available that could be used to conduct test-analysis correlations that include the effect of initial geometric,material, and manufacturing perfections and the effect of load introduction and support conditions.in addition ,the use of advanced composite materials allows the designer to tailor the stiffness properties of the structure to obtain a structurally efficient design. Thin walled cylindrical shells are found in many aerospace structural applications because of their high load carrying capacity and low structural weight.Many of these aerospace shell structures have cutouts or openings that serve as doors,windows, or access ports and thesr cutouts or openings often require some type of reinforcing structure to control local structural deformations and stress near the cutout.many studies have been conducted which shows that a cutout in an isotropic shell structure can have a significant effect on the response of the shell.Towards this objectives, numerically predicted results that shows the effect of change in material properties of graphite/Epoxy composite shell with reinforcement configuration on the response of these shell structures are presented. Results include the variation of Buckling factor, Deformation, Interlaminar shear stresses change in Et/El, Gxy/El, and Gyz/El.

Initially straight, then the direction of buckling will be very sensitive to any lateral force applied to the middle of the card. If you push gently to the left on the middle of the card and then squeeze it, it will buckle to the left. If you push gently to the right and then squeeze, it will buckle to the right. Once the card has begun to buckle in one direction it is difficult to force it in the other direction. In short, a small lateral force applied to the card as an "input signal" can control the direction of the large lateral displacement produced as an "output signal" when the card is buckled by a force applied from the top as a "clock signal"

## 2.BUCKLING OF CYLINDRICAL SHELL:

This buckling arrangement can be used to define logic operations. If one or more input forces are applied laterally to the midsection of the shell, then the midsection will be pushed either somewhat to the left or somewhat to the right, depending on the sum of the applied forces. When the large clocking force is applied, the initial direction of deformation will be continued, and with greater force. This can be viewed as a threshold device, for the output state is controlled by the sum of the input forces. Once buckled in one direction or the other, the shell will remain in that state and will be resistant to a change to the other stable state (in which it is buckled in the other direction).




The cylindrical shell is uniformly compressed in the axial directions,buckling symmetrical with respect to the axis of cylinder. The critical value of compressive force Ncr per unit length of the edge of the shell can be obtained by using the energy method.

### 2.1 FINITE ELEMENT MODEL:

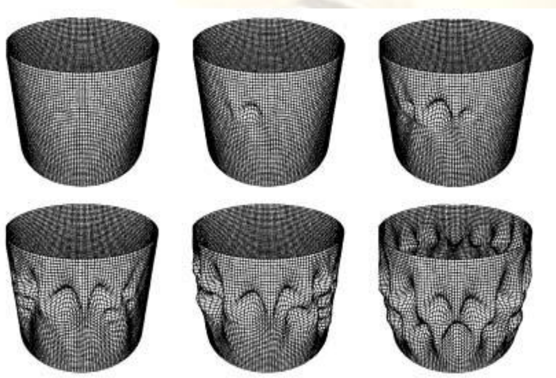


**Fig.** shows the structural analysis of shells.

**2D-DRAWINGS**

Fig 1, Fig 2 , Fig 3 & fig 4 shown below the finite element model of a composite shell with centrally located square cutouts dimensions of a 1*1mm.

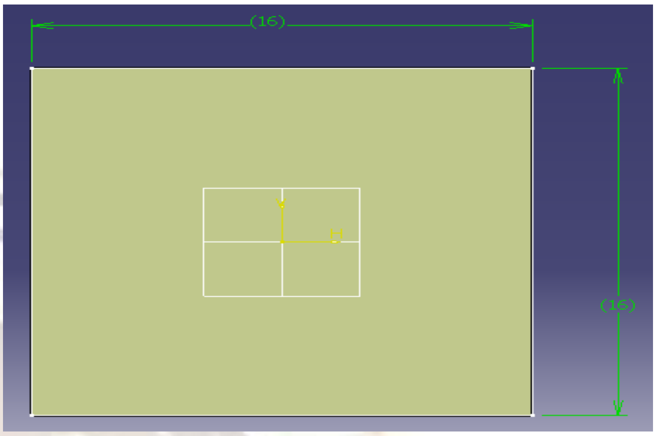



**Fig1**:.Front view of composite shell

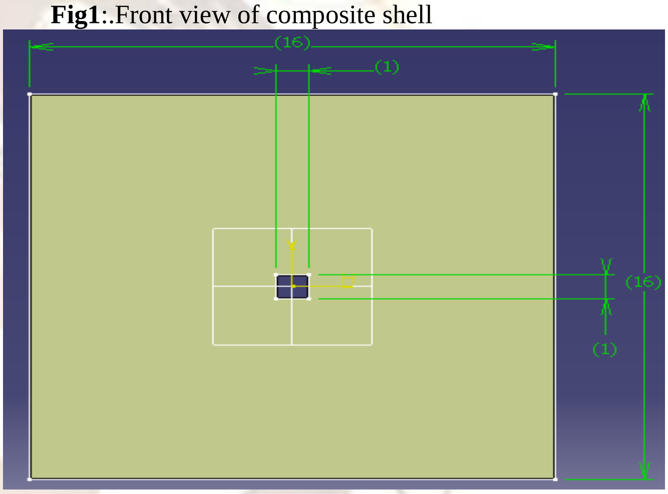



**Fig2:** Composite shell with hole

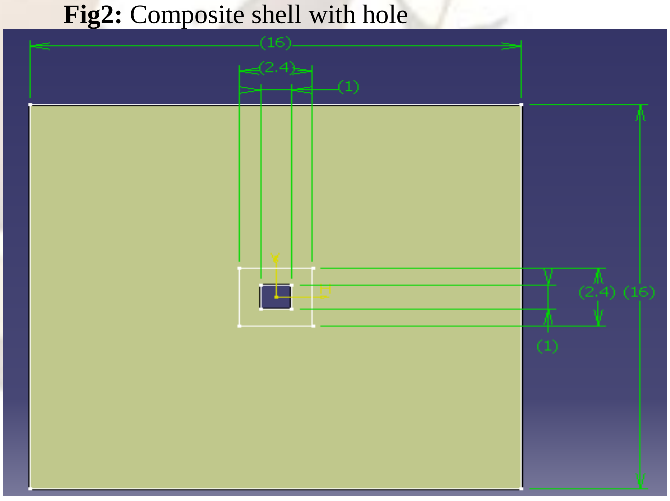



**Fig3**.Composite shell with reinforced hole

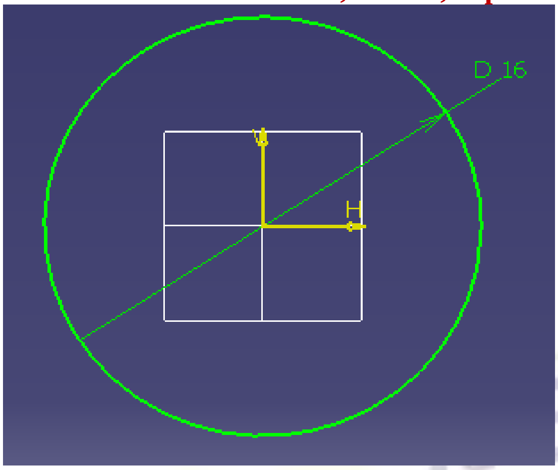



**Fig4.**Top view of composite shell

### 2.2 DIMENSIONS OF A MODEL:

Length of the shell =16 mm
Radius of the shell =8mm
Thickness of shell =0.04mm
No. of plies =8
Dimension of cutout =1mm*1mm

## 3. BOUNDARY CONDITIONS:

The one end of the shell constrained all Degree of freedom( Bottom ) and other end of the shell is applied compressive load of 2000N(Top).

### 3.1 SPECIFY MATERIAL PROPERTIES: (GRAPHITE/EPOXY)

Longitudinal modulus,El = 127.46Gpa
Transverse modulus, Et = 11.3Gpa
In-plane shear modulus,Gxy = 6Gpa
In-plane shear modulus,Gyz = 3.514Gpa
Major Possions ratio,v =0.30

### 3.2 SHELL99 ELEMENT DESCRIPTION:

SHELL99 may be used for layered applications of a structural shell model. While SHELL99 does not havsome of the nonlinear capabilities of SHELL91, it usually has a smaller element formulation time. SHELL99 allows up to 250 layers. If more than 250 layers are required, a user-input constitutive matrix is available.

The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes.

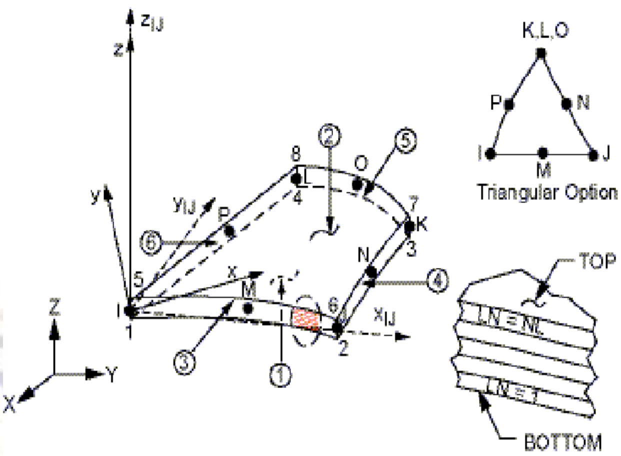


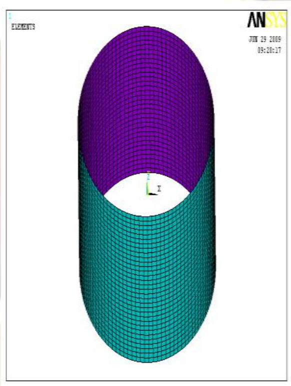

**Fig** Shell99 element geometry
Xij = Element x-axis if ESYS is applied.
X=Element x-axis if ESYS is supplied.
LN= layer Number
NL=Total number of Layers.

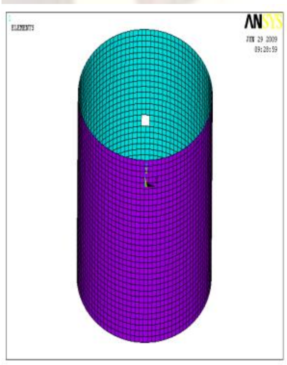
## 4.0 MESHING:

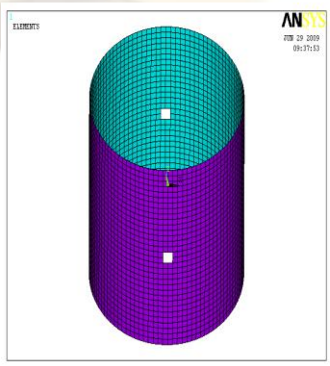
The results are studied to understand the influence of cutouts on buckling strength of shell of same material and also the extent of improvement by providing reinforcement around cutouts.

### 4.1 WITHOUT REINFORCEMENT

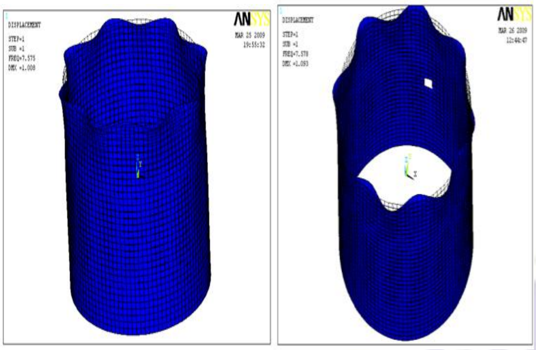
Composite shell without hole Composite shell with one hole





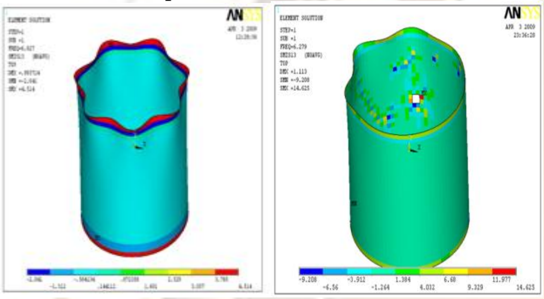


Composite with two holes    Composite shell with four holes



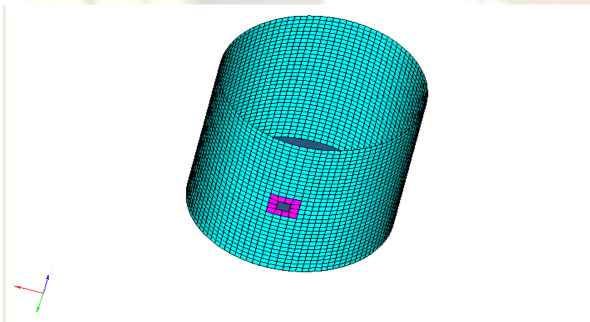
Deformation without hole    Deformation with one hole

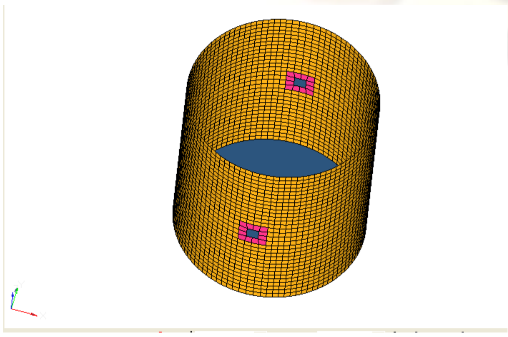
Fig shows the interlaminar shear stress of shell with one hole, the max, min interlaminar shear stress is 14.625,-9.208MPa respectively. maximum interlaminar shear stress is observed at free edge of the hole of composite shell.



Interlaminar shear stress of without hole, with one hole

**4.2 WITH REINFORCEMENT OF COMPOSITE SHELL**





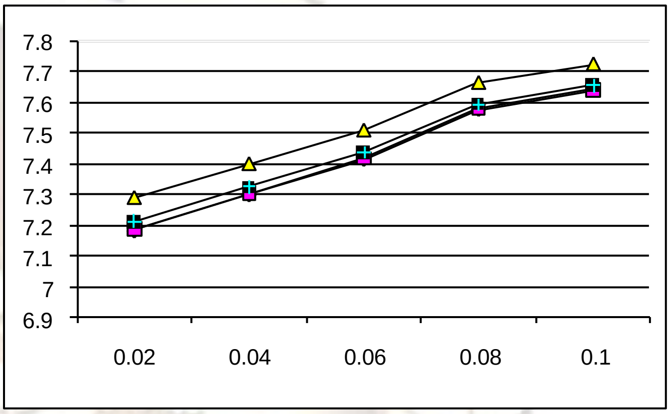
Composite shell with reinforcement of one, two holes respectively

## 4. RESULTS:

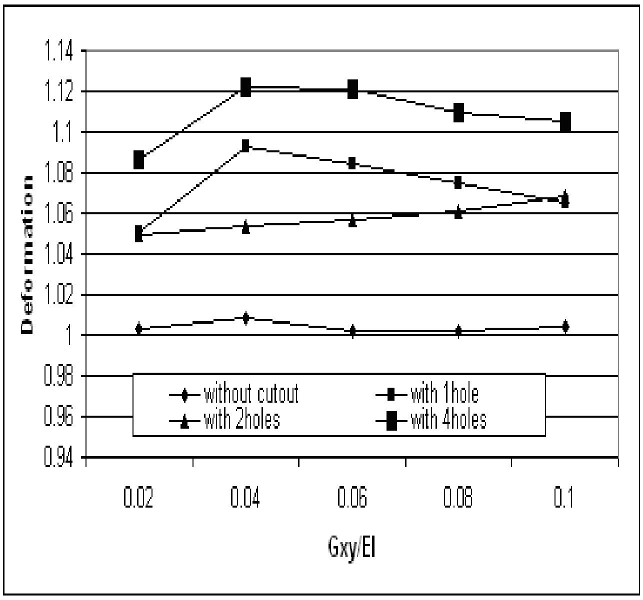
**CHANGE IN RATIO OF $E_T/E_L$ TABLES**

| $E_t/E_l$ | Without hole | With 1hole | With 2holes | with4holes |
|---|---|---|---|---|
| 0.02 | 7.181 | 7.186 | 7.287 | 7.212 |
| 0.04 | 7.298 | 7.302 | 7.398 | 7.325 |
| 0.06 | 7.413 | 7.416 | 7.508 | 7.437 |
| 0.08 | 7.575 | 7.578 | 7.664 | 7.595 |
| 0.10 | 7.639 | 7.641 | 7.725 | 7.657 |

**Table4.1** Variation of buckling factor with change in ratio of $E_t/E_l$




Buckling factor Vs Change in ratio of $E_t/E_l$




Deformation Vs Change in ratio of $G_{xy}/E_l$

## 6. CONCLUSION:

Results from a numerical study of the response of thin-wallcompression-loaded laminated composite cylindrical shells with reinforced and unreinforced square cutouts have been presented. The results identify some of the effects of cutout-reinforcement, size, and thickness on the linear response of the shells. The subspace algorithm is used to determine buckling factor, under buckling load the interlaminar shear stress obtained from ANSYS releace-10 FEA software. In general, the addition of reinforcement around a cutout in a compression-loaded shell can have a significant effect on the shell response. Results have been presented indicate that the reinforcement can affect the local deformations and stresses near the cutout and retard or suppress the onset of local buckling in the shell near the cutout.

1. The maximum interlaminar shear stress is observed at bottom of shell without cutout.
2. The maximum interlaminar shear stress is observed at free edge of cutout in case of without reinforcement.
3. The maximum interlaminar shear stress is observed at away from cutout of shell with reinforcement.
4. Interlaminar failures are reduced by increasing the $G_{xy}/E_l$ as compared with increasing the $G_{yz}/E_l$ and $Et/E_l$.
5. Deformations are greatly reduced by adding reinforcement.

Critical loading also increased considerably by adding reinforcement

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**AUTHORS BIOGRAPHY**:

RAMANTHA DASH was born in India,Orissa in 1975. He received his AMIE(Mechanical) The Institution of Engineers,India from June 2001 to till date working as a Production Engineer in GODREJ AGROVET LTD, Present he is doing M.Tech (CAD/CAM)from SIETK College, Affliated from JNTUA Ananthapur, PUTTUR , Chittoor DIST, Andhra Pradesh. His research areas are Modelling &Analysing on composite materials.

F.ANAND RAJU was born in India,A.P in 1976. He received his Diploma in GMR Polytechnic college,srisailam on September 1995,He completed his B.Tech(Mechanical) in 2000 from SVU college of Engineering,Tirupati in May2002.He did M.Tech (Production Engineering) from S.V University,tirupati in 2002.He having 10 years Teaching Experience,At Present he is working as a HOD of Mechanical Engineering in SIETK College,Puttur,Chittoor Dist,A.P,India