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LINEAR BUCKLING ANALYSIS OF LAMINATED COMPOSITE PLATE

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Abstract

In this paper Buckling load factors have been determined for different aspect ratio, d/b ratio & d/D ratio. The buckling load factor increases as the aspect ratio increases up to 1.11. The buckling load factor then decreases, with the increase of aspect ratio. As the d/b ratio increases up to 0.15, our buckling load factor decreases. After that, buckling load factor increases with increase in d/b ratio. . It was seen that buckling load factor decreases up to d/D ratio equals to 0.25. Since localisation of stress concentration is reduced by providing the multiple holes around the cut out shape. Further buckling load factor increases on increase of d/D ratio. The reduction of the buckling load due to the presence of a cutout is found to be significant. It is noted that the presence of cutout lowers the buckling load.

Keywords: *Buckling load factor laminated composite plate, aspect ratio, d/b ratio/D ratio.*

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1. INTRODUCTION

In many engineering structures such as columns, beams, or plates, their failure develops not only from excessive stresses but also from buckling.

Buckling behaviour significantly changes with change in aspect ratio, d/b ratio, d/D ratio. Plate seems to work as a column of finite width at higher aspect ratio. If we decrease aspect ratio, there is also a limit below which failure does not take place by elastic buckling.

A.K. Shrivastava & R.K. Singh (1998)[1] studied the effect of aspect ratio on buckling behavior.

In this paper an attempt has been made to study the effect of aspect ratio, d/b & d/D on the buckling of laminated composite plates by FEA using ANSYS.

2. NUMERICAL ANALYSIS

ANSYS 11 was used to carry out the finite element analysis in the work. ANSYS is used to analyse the critical buckling load on carbon-fibre-epoxy laminated composite plates. The dimension of the specimen were 300*200* 1.7mm of each layer and total number of layers in composite plate were 6.Eigen value buckling analysis in ANSYS has following four steps:

3. BUILD THE MODEL:

It includes defining element type, real constants, material properties and modelling. In this study, 8 noded linear layer shell 99 was selected as the element type.

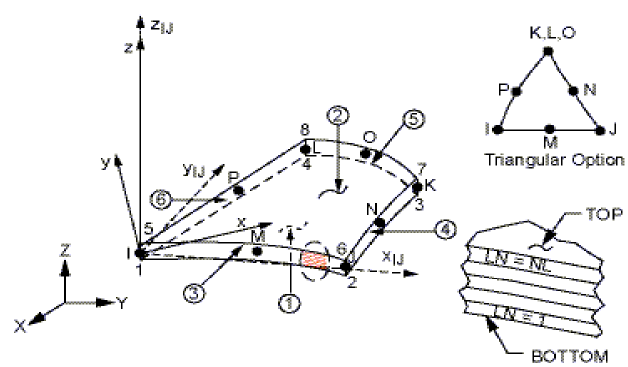

Fig 1: *Element geometry of linear layer shell 99*

Case-1

A composite plate having six laminae with dimensions (l*b*t). Nature of buckling load with respect to aspect ratio. is studied. Here Aspect ratio varies from 1.0 to 5.0. Where l, b, t are the length, width & thickness of the plate respectively

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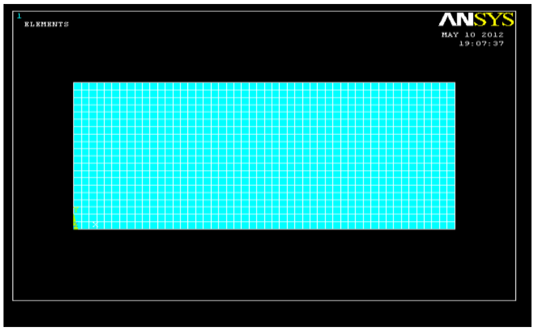


Fig 2: *Meshing of plate*

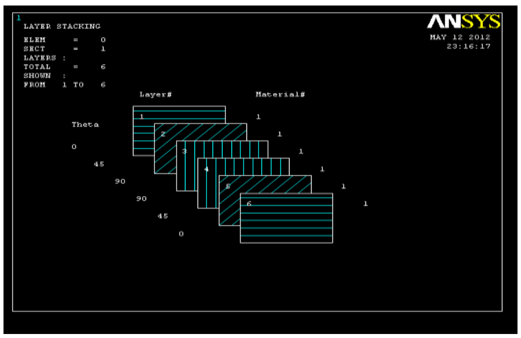


Fig 3: *Lay up of laminae*

Case-2

A composite plate with having six laminae with dimensions (l*b*t), and has a central circular cut out of varying diameter, d. Here d/b ratio varies from 0 to 0.3, in the steps of 0.05. Nature of buckling load with respect to d/b ratio was studied

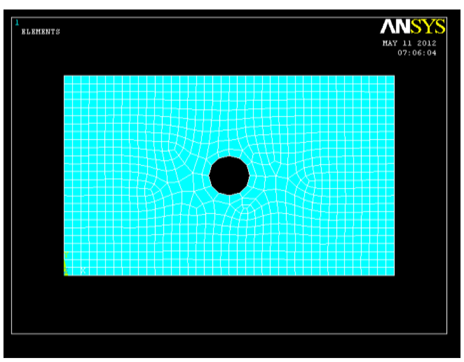


Fig 4 : *Meshing of composite plate with cutout*

Case-3

A composite plate with having six laminae with dimensions (l*b*t), and has a centre hole, D along with multiple holes of varying diameter, d. Nature of buckling load with respect to d/D ratio was studied.

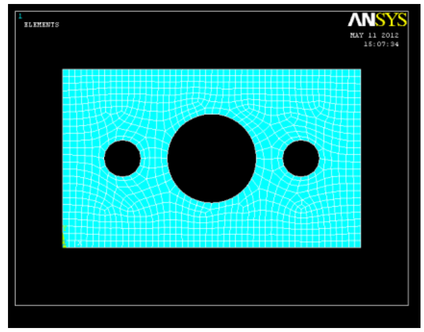


Fig 5: *Meshing of composite plate with central cutout,with multiple holes*

4. SOLUTION (STATIC ANALYSIS):

It includes applying boundary conditions, applying loads and solving the static analysis. The applied boundary condition and load is shown below.

5. EIGEN BUCKLING ANALYSIS

Eigenvalue buckling analysis predicts the theoretical buckling strength of an ideal linear elastic structure.

6. POSTPROCESSOR

This step includes listing buckling loads and viewing buckled shapes. We can plot the deformed and undeformed shape of the plate.

7. RESULTS & DISCUSSION

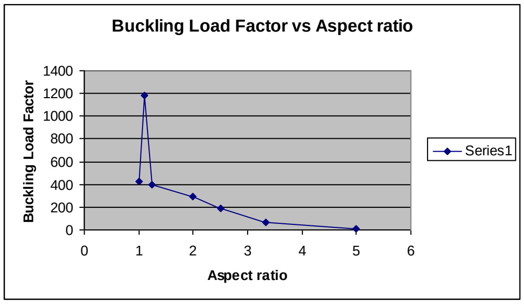
We have taken composite plate initially 300mm x 200 mm, consisted of six laminae ,each having thickness 1.7 mm.The mechanical properties of the analysed composite plate (case 1, 2 and 3) are

E_{11}=1.397*10^{11}	υ_{12}=0.3236	G_{12}=4.753*10^{9}
E_{22}=1.139*10^{10}	υ_{13}=0.3236	G_{13}=4.753*10^{9}
E_{33}=1.139*10^{10}	υ23=0.4610	G_{23}=3.898*10^{9}

The buckling load for clamped- free carbon fibre epoxy plate determined. The results were based on finite element analysis. The critical buckling loads obtained by ANSYS.

Case:1

Here we have taken a carbon fibre epoxy laminated composite plate made of 6 layer(0/45/90)s. Plate size is 300mm in length & thickness of each layer is 1.7mm. Aspect ratio (length/width) is changed from 1 to 5, keeping length constant & varying width according to aspect ratio.



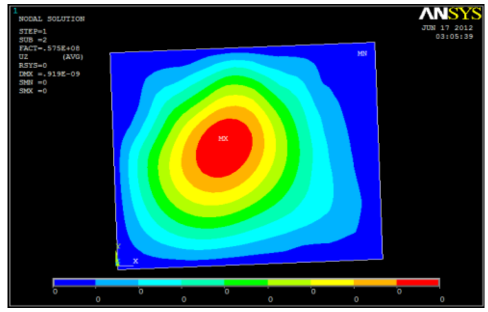


Fig 6: *Contour plot with aspect ratio 1.00*

Case: 2

Here we have taken a carbon fibre epoxy laminated composite plate, with a central circular cutout (diameter d) made of 6 layer(0/45/90)s. Plate size is 300mm in length,200mm in width & thickness of each layer is 1.7mm. d/b ratio (diameter of cutout/width) is changed from 0 to 0.3, keeping length & width of plate constant.

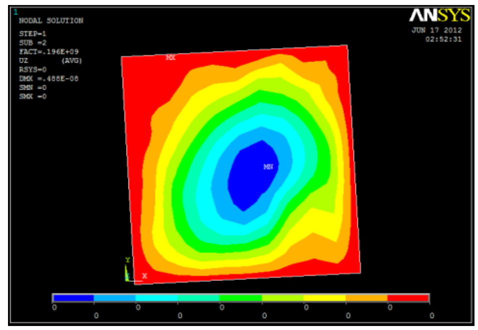
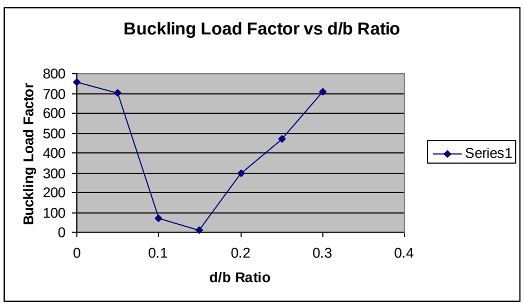


Fig 7: *Contour plot with aspect ratio1.11*



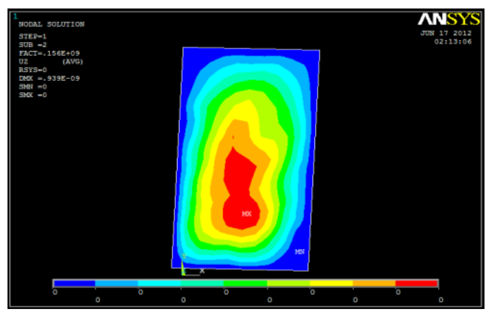


Fig 8 : *Contour plot with aspect ratio 2.0*

Case: 3

Here we have taken a carbon fibre epoxy laminated composite plate, with a central circular cutout (diameter D) made of 6 layer (0/45/90)s. To study the effect of stress concentration due to cutout, we have provided multiple small holes, near the cutout. Plate size is 300mm in length,200mm in width & thickness of each layer is 1.7mm. d/D ratio (diameter of small multiple cutouts/diameter of central cutout)is changed from 0 to 0.35, keeping length & width of plate constant .

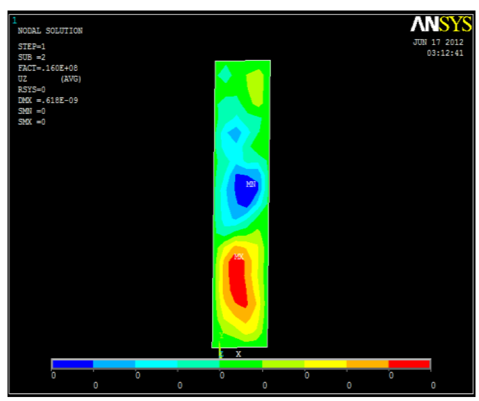
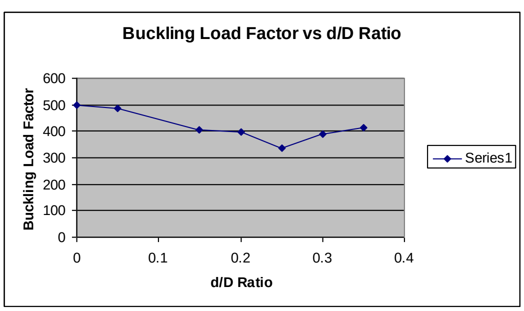


Fig 9: *Contour plot with aspect ratio 5.0*



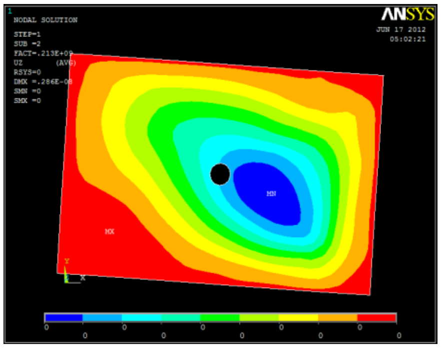


Fig 10: *Contour plot with d/b ratio 0.05*

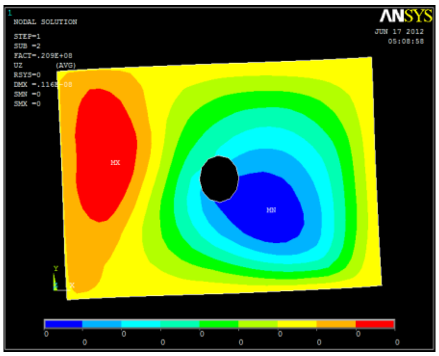


Fig 11: *Contour plot with d /b ratio 0.1*

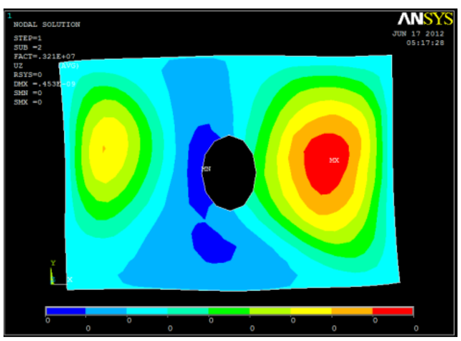


Fig 12: *Contour plot with d /b ratio 0.15*

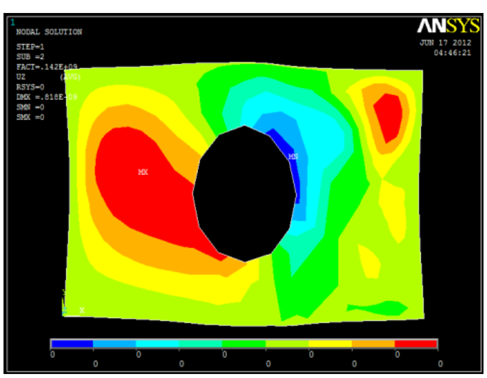


Fig 13: *Contour plot with d /b ratio 0.25*

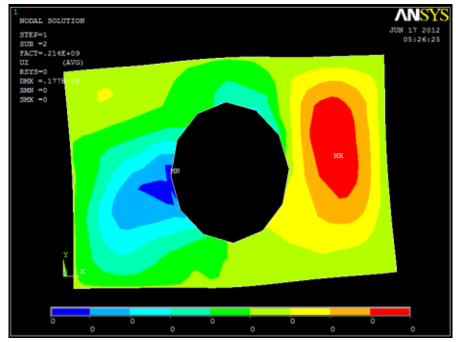


Fig 14: *Contour plot with d /b ratio 0.3*

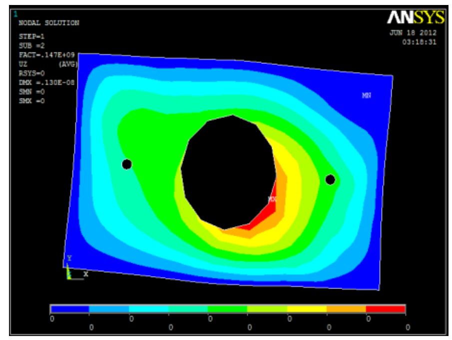


Fig 15: *Contour plot with d/D ratio 0.05*

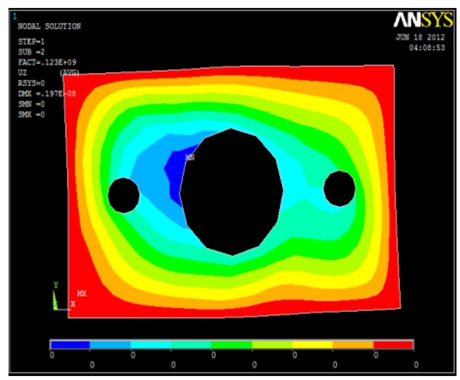


Fig 16: *Contour plot with d/D ratio 0.15*

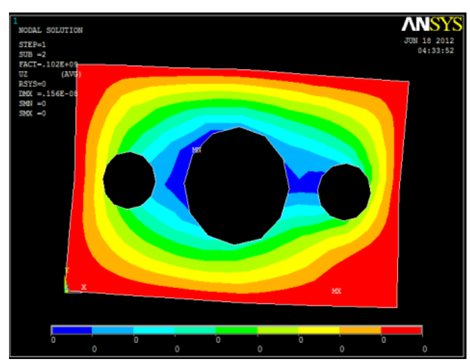


Fig l7: *Contour plot with d/D ratio 0.25*

8. CONCLUSION

This study considers the buckling response of laminated rectangular plates with clamped-free boundary conditions. The laminated composite plates have varying aspect ratio, cut out shape and effect of stress concentration. From the present analytical study, the following conclusions can be made.

1. It was noted that different aspect ratio affected the buckling load factor. The buckling load factor increases as the aspect ratio increases up to 1.11. The buckling load factor decreases, with the increase of aspect ratio.

2. As the d/b ratio increases up to 0.15, our buckling load factor decreases. After that, buckling load factor increases with increase in d/b ratio.

3. It was seen that buckling load factor decreases up to d/D ratio equals to 0.25. Since localisation of stress concentration is reduced by providing the multiple holes around the cut out shape. Further buckling load factor increases on increase of d/D ratio.

4. The reduction of the buckling load due to the presence of a cutout is found to be significant. It is noted that the presence of cutout lowers the buckling load.

9. FUTURE SCOPE OF THE WORK

In the present study the buckling load of the laminated composite plate was determined. The effect of aspect ratio, cutout shape and stress concentration technique on buckling load was studied. The future scope of the present investigation can be expressed as follows:

1. We have studied effect of cut out on reduction of stress concentration, but in future other methods (providing multiple notches & removal of material around the discontinuity) can also be done.

2. We can study Post Buckling behaviour of laminated composite material, which is a nonlinear analysis.

3. Temperature effect on laminated composite plate can also be encountered.

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