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**Research Paper**

# An Effect of Different Plate Aspect Ratio on Stability Analysis of Laminated Composites Under Clamped Clamped Condition

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***Abstract:*** *Equipped with square and rectangular cutouts, this sixteen-ply quasi-isotropic graphite/epoxy symmetrically laminated composite plate [0°/+45°/-45°/90°]$_{2s}$ has been numerically studied to determine the impact of plate aspect ratio on the buckling behavior. The plate was subjected to a range of linearly varying in-plane compressive loads using the finite element method (FEM). In addition, the buckling behavior of symmetrically laminated rectangular composite plates exposed to linearly increasing in-plane compressive loads is discussed in this study along with the impact of boundary conditions, plate length/thickness ratio (a/t), and the size of square or rectangular cutouts. The findings demonstrate that, regardless of the size, shape, or boundary conditions of the cutout, the buckling loads of rectangular composite plates with rectangular or square cutouts subjected to different in-plane loads that vary linearly can be reduced by increasing the ratio of the plate's aspect to its thickness and length. The buckling strength of a rectangular composite plate with a square or rectangular cutout is significantly affected by boundary conditions, aspect ratio (a/b), length/thickness (a/t), and a variety of linearly variable inplane loads.*
***Keywords:*** *Aspect Ratio, Stability Analysis, FEM, Laminated Composites.*

## I. Introduction

When composite laminated plates are exposed to compressive loads, they exhibit buckling. Composites are made up of two or more materials that, when combined, generate properties that are difficult to achieve with a single component employed alone. The fibers carry much of the weight of these materials. Matrices with a low modulus and a high elongation provide flexible structural performance while also protecting fibers from environmental stressors and keeping them aligned and in the appropriate place. Composite materials, which are made up of two or more components, may significantly reduce construction weight while maintaining a high strength-to-weight ratio owing to the composition of the parts. Fiber-reinforced composites are often utilized in the construction sector as laminas, which are thin sheets. Laminae are the most prevalent kind of material macrounit in the material. To attain the desired amount of strength and stiffness for a specific application, changes may be made to the layer stacking sequence as well as the orientation of fibers inside each lamina. A composite material's distinguishing qualities are the result of a unique mix of traits caused by the composition, distribution, and orientation of the composite's components. Cutouts are required for a number of reasons, including weight reduction, improved air circulation, and the formation of connections between components that are near together. Carbon-fiber reinforced plastic is a composite material made by mixing several types of carbon fibers with thermosetting resins. Carbon fiber reinforced plastic, or CFRP, is a lightweight, nonconductive polymer strengthened with fibers. It's a very long-lasting chemical. It is possible to significantly increase the material's strength and stiffness by stacking a large number of fiber sheets in a variety of configurations. Parth Bhavsar and his colleagues used the finite element technique to analyze the buckling behavior of glass fiber reinforced polymer (GFRP) under linearly increasing loads.

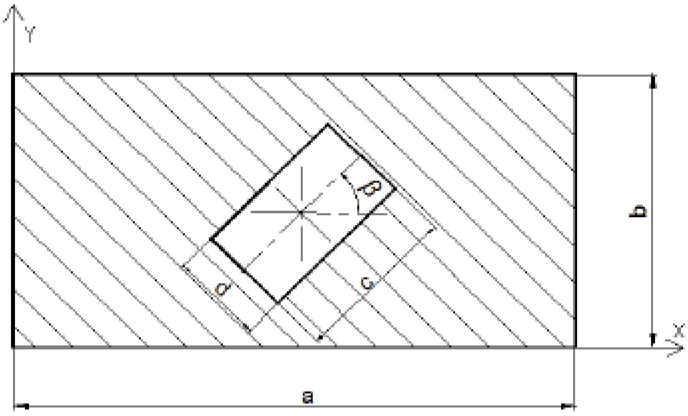


**Figure 1: Geometry of the model.**

Researchers have looked at a variety of parameters to see how they affect the buckling stress of rectangular plates with an aspect ratio of one. Joshi and colleagues utilized two-dimensional finite element analysis to calculate the buckling stress per unit length of a rectangular plate with circular cutouts under biaxial compression. To assess the buckling variables, two ways may be used: changing the length-to-thickness ratio and situating the holes. Nagendra Singh Gaira and colleagues explored the buckling behavior of laminated rectangular plates under clamp-free boundary circumstances. The existence of cutouts reduces the buckling load, which is a good thing. Increasing the aspect ratio will result in a lower buckling load factor, which is the intended outcome. Hamidreza Allahbakhsh and Ali Dadrasi conducted a buckling study on a laminated composite cylindrical panel to explore the effect of an axial load on its buckling load. The research featured an elliptical cut-out in a variety of sizes and locations. Container Okutan Baba's study focuses on how varying cut-out geometries, length-to-thickness ratios, and ply orientations effect the buckling stress produced on rectangular plates. To determine the effects of these variables on the buckling behavior of E-glass/epoxy composite plates subjected to in-plane compression stress, the researchers employed both theoretical and experimental techniques. In their finite element buckling study of composite laminate skew plates exposed to uniaxial compressive loads, Hsuan-Teh Hu and colleagues revealed that the failure criteria and nonlinear in-plane shear had a substantial influence on the skew plates' ultimate loads. This contrasts with the linearized buckling loads, which have a lesser influence.

## II. Finite Element Model

A simple technique to meet the format requirements for the conference paper. The goal of this study is to establish the buckling load factors of carbon fiber composite plates with square or cylindrical shapes using finite element analysis. ANSYS Version 14.5 is the APDL version. When examining the plate's dimensions, three distinct boundary conditions are taken into account: fixed, clamped, and unclamped situations. The first scenario consists of two levels, while the second scenario is divided into three levels. This might be due to the stacking sequences utilized, which were [0°/+45°/-45°/90°]2s, respectively. To conduct the research, the plate must be perforated with a large number of center holes of equal volume. The center holes may be placed in a number of ways, including square, triangular, circular, and star arrangements. An examination of the buckling load factor's characteristics is now underway.

This study uses FEM to analyze the impact of plate aspect ratio (a/b), length/thickness ratio (a/t), and boundary conditions on the buckling response of quasi-isotropic graphite/epoxy composite plates with square/rectangular cutouts under linearly varying in-plane compressive loading. The lamina is made of graphite fibers as reinforcement and epoxy as matrix material. Table 1 lists the material parameters of graphite/epoxy, as cited in Hsuan*Teh Hu and Bor*Horng Lin (1995). Material axis 1 aligns with the global x axis, whereas material axis 2 aligns with the global y axis. The compressive loads applied to the plate align with the global x*axis. The 0° fiber direction aligns with the direction of the compressive load.

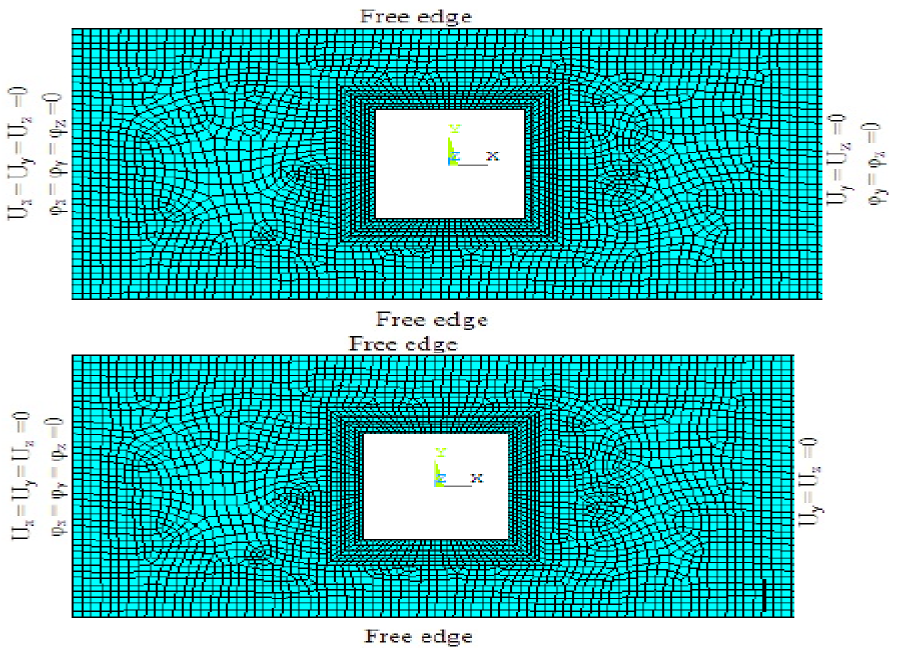


**Figure 2: FE model with mesh**

## III. Description Of Element

For this project, the SHELL281 element type is employed. The existence of this shell element facilitates the analysis of extremely thin or somewhat thick shells. Furthermore, since it can be utilized in so many different ways, it is an ideal material for modeling layered composite coatings and sandwich structures. Applications that exhibit significant strain nonlinearity, linearity, or rotation are ideal candidates for the successful utilization of this material. The element consists of eight nodes, each of which has six degrees of freedom. These degrees of freedom enable rotation around the three axes as well as translations along the x, y, and z axes that are contained inside the element. When doing research with cylindrical plates, the nonlinear element S8R5 is used. This element is identified by the presence of eight nodes, each with five degrees of freedom.

## IV. Geometric Modelling And Material Property

The geometry is as indicated in Figure 1. Plate 'a' is 200mm long and plate 'b' 100mm wide. This sixteen-layer laminate has a thickness of 0.125mm per layer, where "t" represents plate thickness and "β" represents cutout orientation angle. This research assumes a cutout orientation angle of zero degrees. This work assumes a rectangle cutout centered on a rectangular plate. The cutout has length c and width d. When the ratios c and d are equal, the rectangular hole transforms into a square hole. The impact of square holes is also investigated under the same settings.
The buckling analysis covers both square and rectangular holes.

Table 1 : Property of composite material

| $E_{11}$ (GPa) | $E_{22}$ (GPa) | $v_{12}$ | $G_{12} = G_{13}$ (GPa) | $G_{23}$ (GPa) |
|---|---|---|---|---|
| 128 | 11 | 0.25 | 4.48 | 1.53 |

## V. Results And Discussion

The purpose of this section is to investigate the effect that varied ply orientations of the plate have on the plate when subjected to the same boundary condition. This will all happen at the same time. This is an example of a fixed condition at the border, and it is being considered. This section uses a variety of ply orientations. The orientations are as follows: [0°/+45°/-45°/90°]2s. For further information, please see the list given below. Both of them are examined, and study is undertaken to determine the repercussions of the situation. Both are analyzed, and the resulting ramifications are investigated.

Figures illustrates how plate aspect ratio (a/b), length/thickness ratio (a/t), boundary conditions, and linearly increasing in-plane compressive loading affect the buckling loads of a rectangular composite plate with rectangular/square cutout.

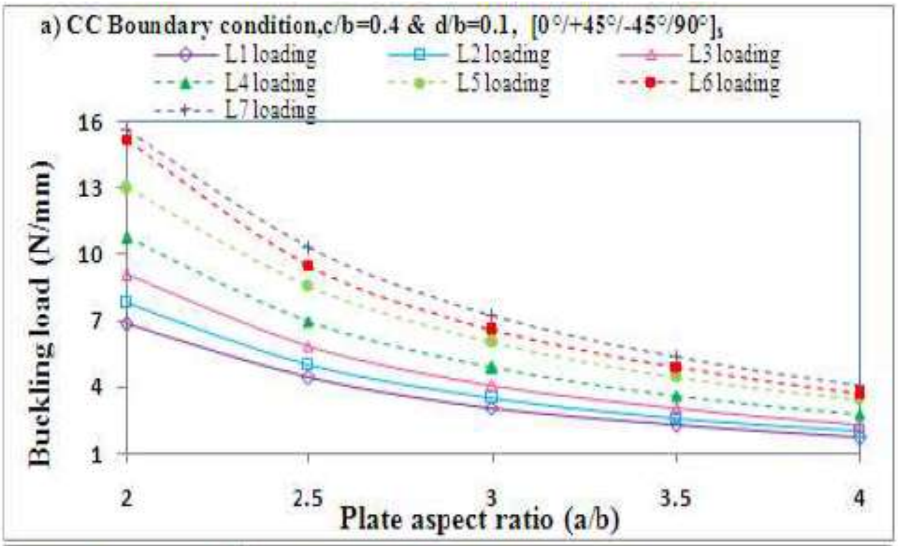


**Figure 3 : Effect of plate aspect ratio with holes with unsymmetrical (S) layup**

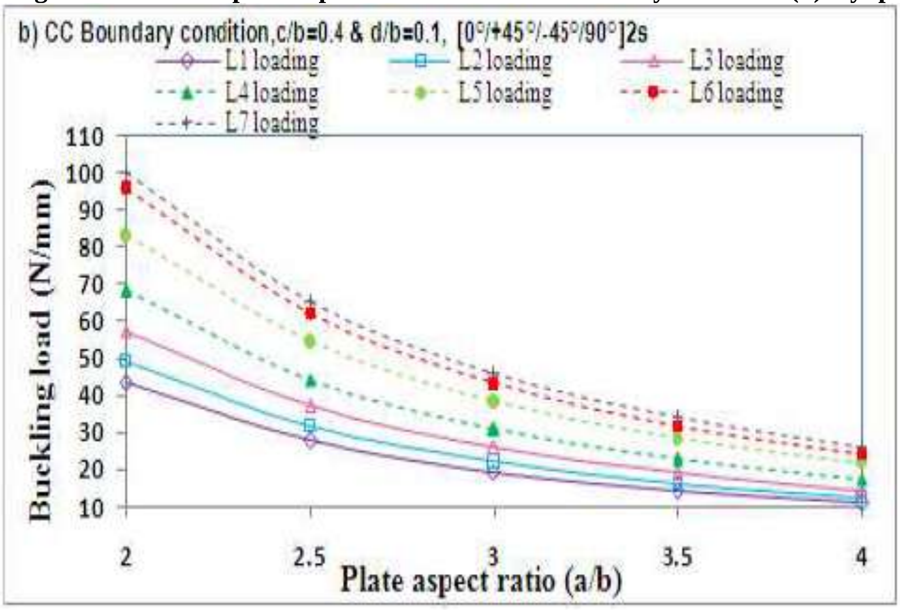


**Figure 4 : Effect of plate aspect ratio with holes with symmetrical (2S) layup**

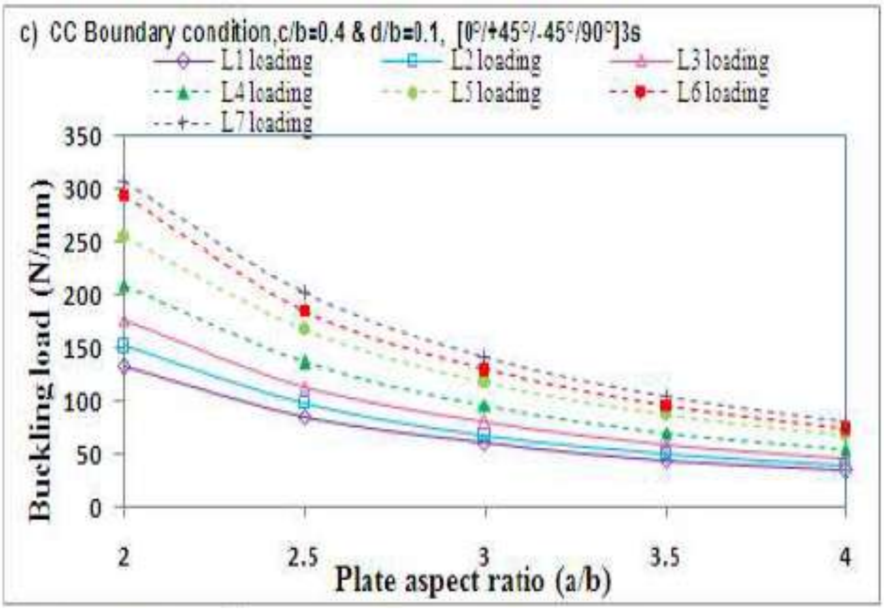


**Figure 5 : Effect of plate aspect ratio with holes with symmetrical (3S) layup**

Figures illustrates how plate aspect ratio (a/b), length/thickness ratio (a/t), boundary conditions, and linearly increasing in-plane compressive loading affect the buckling loads of a rectangular composite plate with rectangular/square cutouts.

Figures shows that the buckling loads of a rectangular composite plate with square/rectangular cutout differ by 35.8%, 30.4%, 26.44%, and 23.4% for a/b=2-2.5, a/b=2.5-3, a/b=3-3.5, and a/b=3.5-4, respectively, regardless of length/thickness ratios (a/t), boundary conditions, and linearly varying inplane compressive loading. The buckling load of a rectangular composite plate with a plate aspect ratio of a/b=2 is 1.5 times, 2 times, 3 times, and 4 times higher than that of a plate with plate aspect ratios of 2.5, 3, 3.5, and 4, respectively. This holds true regardless of length/thickness ratios (a/t), boundary conditions, or linearly varying inplane compressive loading. Increasing the plate aspect ratio from 2 to 4 reduces the buckling load of a rectangular composite plate with a square/rectangular cutout by 74%, regardless of length/thickness ratios (a/t), boundary conditions, and linearly variable inplane compressive loads.

## VI. Conclusions

This study examines the impact of plate aspect ratio, length/thickness ratio, boundary conditions, and linearly varying in-plane compressive loading conditions on the buckling behavior of a sixteen-ply quasi-isotropic graphite/epoxy symmetrically laminated rectangular composite plate [0°/+45°/-45°/90°]2s with square/rectangular cutout.

The rectangular composite plate with a/b=2 has a higher buckling load than plates with a/b=2.5, 2.5, 3.5, and 4, regardless of length/thickness ratios (a/t), boundary conditions, or linearly varying inplane compressive loading.

As the plate length/thickness ratio increases from 50 to 200, the buckling load of a rectangular composite plate with square/rectangular cutout decreases by 97%, regardless of plate aspect ratios (a/b), boundary conditions, and linearly varying inplane compressive loading.

## References

[1]. Aydin Komur.M et al. (2010) Buckling analysis of laminated composite plates with an elliptical/circular cutout using FEM. Advances in Engineering Software 41: 161-164.

[2]. B.O. Baba, A. Baltaci, Buckling characteristics of symmetrically and antisymmetrically laminated composite plates with central cutout, Applied Composite Materials 14(4) (2007) 265-276.

[3]. Ghannadpour, S.A.M., Najafi,A., Mohammadi,B.: Buckling of Cross-ply laminate composite plates due to circular/elliptical cutouts. Compos.Struct.27 pp. 3-6 (2006).

[4]. Afsharmanesh, B., Ghaheri, A. and Taheri-Behrooz, F. (2014), "Buckling and vibration of laminated composite circular plate on winkler-type foundation", Steel and Composite Structures, 17(1), 1-19.

[5]. F. Millar, D. Mora, A finite element method for the buckling problem of simply supported Kirchhoff plates, Journal of Computational and Applied Mathematics 286 (2015) 68-78.

[6]. Y. Zhang, C. Yang, Recent developments in finite element analysis for laminated composite plates, Composite Structures 88(1) (2009) 147-157.

[7]. M. Dehghan, G.H. Baradaran, Buckling and free vibration analysis of thick rectangular plates resting on elastic foundation using mixed finite element and differential quadrature method, Applied Mathematics and Computation 218(6) (2011) 2772-2784.

[8]. R. Mania, Buckling analysis of trapezoidal composite sandwich plate subjected to in-plane compression, Composite Structures 69(4) (2005) 482-490.
[9]. B.O. Baba, Buckling behavior of laminated composite plates, Journal of Reinforced Plastics and Composites (2007).
[10]. Jain,P., Ashwin,K.. Post buckling response of square laminates with a central/elliptical cutout. Compos Struct. 75, (2004).
[11]. Khdeir AA. Free vibration and buckling of symmetric cross-ply laminated plates by an exact method. J Sound Vib 1988; 126:447–61.
[12]. Ganesh Soni, Ramesh Singh and Mira Mitra, Buckling behavior of composite laminates subjected to nonuniform In-plane loads, International Journal of Structural Stability and Dynamics 2013.
[13]. Topal U, Uzman U (2008) Maximization of buckling load of laminated composite plates with central circular holes using MFD method. Struct Multidisc optim35:131-139.