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# BUCKLING ANANLYSIS OF HYBRID COMPOSITE PLATESUSING CLPT

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**Abstract**

***An important consideration in the analysis of composite structures is the effect of neglecting anisotropy on analytical predictions of structural response. Often, in a preliminary analysis, anisotropy is neglected in the problem formulation, and the analysis of a composite structure is performed in a manner similar to the analysis for a structure made of an isotropic material.***

***This simplifying assumption is valuable in that it permits the structural analyst to make use of existing solutions for especially orthotropic structures and to exploit symmetry in the structural modeling to reduce computational effort and cost. With the increasing use of composite materials the term hybrid effect has been used to describe the phenomenon of an apparent synergistic improvement in the properties of a composite containing two or more types of fiber or Materials are used Then the MATLAB code is again extended for finding out the critical buckling loads for hybrid composites materials of different lamination schemes. Graphite/epoxy sub-laminate designated as (G) consisting of four layers of graphite epoxy and Kevlar/epoxy laminate as (K) , to compare buckling load hybrid composite plate Analytical method using by MAT LAB, hybrid lamination scheme places vital role on critical buckling loads.***

## I. INTRODUCTION

This work deals with the buckling analysis of laminated plates.A variable-buckling analysis Approach with gradable capabilities is taken into account to determine the accuracy of an outsized sort of classical a complicated plate/shell theories so as to judge buckling hundreds. So-calledequivalent-single-layer as well analyses wise-variable descriptions are implemented. Inter laminarcontinuity of transverse shear and normal stresses. Solutions related to simply supported boundaryconditions and axially loaded multilayered plates made of orthotropic layers. The cases of axialconstant strains and constant stresses are considered and compared to available three-dimensionaland two-dimensional results. Results related to Loveand Donnell approximations are implementedfor comparison purposes. The accuracy of various approximations is established for significantmultilayered plate and shell problems

Laminated composite plates are becoming increasingly used in structural applications because oftheir high specific strengths (failure stress/unit weight) and specific stiffness's (stiffness/unitweight). Examples vary from the inexpensive, commonly encountered ones (eg, plywood,cardboard boxes) to the expensive, high performance ones (eg, aircraft and space stationcomponents). As in the case of any plate, the presence of in plane loadings may cause buckling. The correct data of important buckling hundreds and mode shapes, furthermore because the resulting post buckling behavior, is crucial for reliable and light-weight structural style Laminated composite plates are made of plies (lamina or layers), each ply consisting of parallelfibers (eg, glass, boron, graphite, Kevlar epoxy) embedded in a matrix material (eg, epoxy resin,metal). The plies are bonded together by a suitable adhesive, the thickness of which may or maynot be negligible in comparison with the ply thickness. Most theoretical analyses of bucklingloads consider a plate to be comprised entirely of plies bonded together perfectly along their bounding planes, and neglect the effects of the lower stiffness adhesive layers. A ply may beindividually considered as being composed of an orthotropic material having principal axesparallel and perpendicular to the fibers.

## II. LITARATURE REVIEW

Laminated composites square measure used usually as skinny plates, and underneath compressive load the load carrying capability is investigated by most of the researchers. Thus far, there has been analysis on the laminated structures that realize applications in part, biomedical, civil, and marine and engineering science attributable to the improved properties they need and its cost-effectiveness and because of the ease with which they can be handled.

[1 ]Hu and statue maker in 1995 studied the buckling resistance of symmetrically laminated plates with a given material system and subjected to uniaxial compression. The analysis was through with plates having completely different plate thicknesses, side ratios, central circular cutouts and completely different finish conditions. thanks to these variations, the best fiber orientations and therefore the associated best buckling numerous symmetrically laminated plates were investigated. Due to the importance of buckling analysis of composite structures in various industrial applications, Mathematical modelling developed in this work for generally laminated plates was based on classical laminated plate theory (CLPT) and MAT LAB method. The buckling load was analyzed using both the methods and then compared. Studied the buckling of laminated composite plates with internal supports. Both the higher-order shear deformation theory and pb-2 Ritz displacement functions, akin to Associate in Nursing impulsive edge support were utilized in this paper. The buckling load was investigated underneath biaxal compressive loading. Numerical results stressed the result of angle of lamination, boundary conditions, ratio, and internal supports on vital buckling load. Buckling analysis for sq. plate laminated composite plates with biaxal compressive load performing on them. The higher-order shear deformation theory was used and a special displacement perform, that may categorical Associate in Nursing impulsive edge support.

[2] Khaliliet moreover during this paper, the buckling modes were determined. additionally in 2005 developed a replacement analytical methodology to research the response of laminated composite plates subjected to static and dynamic loading.

[3]Zhong and Gu The modal forms were presented in terms of double Fourier series. The derivatives of the double Fourier series were legitimized using Stoke's transformation. The influence of boundary conditions on the buckling load for sq. plates of varied form, length/thickness quantitative relation, and ply orientation was examined by cake in 2007. Boundary conditions considered were clamped, pinned and their various combinations. The plates were subjected to in plane compression load. The results of experimentation were validated using analytical method MAT LAB. An exact solution for square plates buckling of symmetrical cross-ply composite square plates under a linearly varying boundary load was presented by Zhong and Gu in 2007. It was developed based on the first-order shear deformation theory for moderately thick laminated plates. Buckling many tire sq. Plate thickness quantitative relation, material modulus quantitative relation, ply lamination pure mathematics, loading sorts, and boundary conditions on buckling load were investigated.

[4] Qablan et al in 2009 evaluated the effect of cutout size, cutout location, fiber orientation angle and type of loading on the buckling load of square cross-ply laminated plates. Presented an experimental study of the behavior of epoxy graphite, epoxy carbon epoxy glass laminated panels with ply orientation (0/90º/90º/0) s under compression. Compression tests were performed on plates with and without holes. The results indicated that the plates exhibited higher fracture load .

## III. BUCKLING ANANLYSIS OF PLATES

### Governing Equations

When a plate is subjected to in-plane compressive forces, $N_{xx}<0$, $N_{yy}<0$, and $N_{xy}=0$, and if the forces are sufficiently small, the equilibrium of the plate is stable (4.2.1). The plate remains flat until a certain load is reached. At that load, called the buckling load, the stable state of the plate is distributed and the plate seeks an alternative equilibrium configuration accompanied by a change in the load deflection behavior. The phenomenon of changing the equilibrium configuration at the same load and without drastic changes in deformation is termed bifurcation.

The load-deflection curve for buckled plates is often bilinear. The magnitude of the buckling load depends, as will be shown shortly, on geometry, material properties, as well as on the, buckling mode shape. Here we determine the critical buckling loads of simply supported especially orthotropic plates using the Navier method.

$$D_{11}\frac{\partial^4 w_0^b}{\partial x^4} + 2\left(D_{12}+2D_{66}\right)\frac{\partial^4 w_0^b}{\partial x^2 \partial y^2} + D_{22}\frac{\partial^4 w_0^b}{\partial y^4} = \hat{N}_{xx}\frac{\partial^2 w_0^b}{\partial x^2} + \hat{N}_{yy}\frac{\partial^2 w_0^b}{\partial y^2}$$

**Biaxial Compression of a Square Laminate (k=1)**

When the edges x=0, a are subjected to compressive load Nxx= -N0 and the edges y=0, b are subjected to tensile load Nyy= kN0.

$$N_0(m,n) = \left(\frac{\pi^2}{a^2}\right)\frac{[D_{11}m^4 + 2(D_{12}+2D_{66})m^2n^2 + D_{22}n^4]}{m^2 - kn^2}$$

For $n^2 < m^2/k$. For example, when k=0.5, the minimum buckling load occurs at m=1 and n=1.

For the isotropic material properties

$$N_{cr} = 26\left(\frac{\pi^2 D}{a^2}\right)$$

Uni-axial Compression of a Rectangular Laminate (k=0)

$$\begin{aligned} N_0(m,n) &= \frac{a^2}{m^2\pi^2}\left[D_{11}\left(\frac{m\pi}{a}\right)^4 + 2(D_{12}+2D_{66})\left(\frac{m\pi}{a}\right)^2\left(\frac{n\pi}{b}\right)^2 + D_{22}\left(\frac{n\pi}{b}\right)^4\right] \\ &= \frac{\pi^2}{m^2b^2}\left[D_{11}m^4\left(\frac{b}{a}\right)^2 + 2(D_{12}+2D_{66})m^2n^2 + D_{22}n^4\left(\frac{a}{b}\right)^2\right] \end{aligned}$$

An examination of the above expression shows that the smallest value of N0 for any m, occurs for n=1:

$$N_0(m,1) = \frac{\pi^2 D_{22}}{b^2}\left[m^2\frac{D_{11}}{D_{22}}\left(\frac{b}{a}\right)^2 + 2\frac{(D_{12}+2D_{66})}{D_{22}} + \frac{1}{m^2}\left(\frac{a}{b}\right)^2\right]$$

The critical buckling load is then determined by finding the minimum of N0=N0 (m) in Equation with respect to m then.

$$\frac{dN_0}{dm} = 0 \text{ gives } m^4 = \frac{D_{22}}{D_{11}}\left(\frac{a}{b}\right)^4$$

Thus, for aspect ratios between 2.66 and 4.44, the plate buckles into two half- waves in the x direction (and one half-wave in the y-direction). Thus larger aspect ratios lead to higher modes of buckling. After substituting m2 from above equations.

$$N_{cr} = 2\left(\frac{\pi^2 D_{22}}{b^2}\right)\left[\sqrt{\frac{D_{11}}{D_{22}}} + \frac{(D_{12}+2D_{66})}{D_{22}}\right]$$

After simplification

$$N_{cr} = 4\left(\frac{\pi^2 D}{a^2}\right)$$

## IV. RESULT AND DISSCUSION

### Buckling of Plates

Finding out the critical buckling loads of rectangular laminated composite plates subjected to uniform compression (k=0) and biaxial compression (k=1). The developed code is capable to handle different anisotropy in the material. As an example, rectangular cross ply composite plates are considered for the analysis. Numerical results are computed for [0o/90o]s the critical buckling mode is (m, n) =(1,1), for a/b=0.5,1,1.5 and k=0, k=1for which case the mode are (1,1), for modulus ratio 5,10, 20, 25 and 40 respectively.

**Non-dimensional zed buckling loads of rectangular laminates under uniaxial and biaxial compression**

| Lamination scheme | k | a/b | Buckling Loads | | | |
|---|---|---|---|---|---|---|
| | | | Reference values | Present values | Reference values | Present values |
| $[0^o/90^o]_{2s}$ | 0 | 0.5 | $E_1/E_2$=5 | $E_1/E_2$=5 | $E_1/E_2$=10 | $E_1/E_2$=10 |
| | | 1 | 4.705 | 4.7047 | 4.157 | 4.15686 |
| | | 1.5 | 2.643 | 2.6428 | 2.189 | 2.1887 |
| | 1 | 0.5 | 2.955 | 2.957 | 2.487 | 2.4867 |
| | | 1 | 3.764 | 3.7597 | 3.325 | 3.323 |
| | | 1.5 | 1.322 | 1.324 | 1.095 | 1.097 |
| $[0^o/90^o]4$ | 0 | 0.5 | 1.009 | 1.0093 | 0.86 | 0.87 |
| | | 1 | 13.9 | 13.879 | 18.126 | 18.129 |
| | | 1.5 | 5.65 | 5.657 | 6.347 | 6.349 |
| | 1 | 0.5 | 5.233 | 5.22856 | 5.277 | 5.278 |
| | | 1 | 11.12 | 11.1897 | 12.694 | 12.696 |
| | | 1.5 | 2.825 | 2.827 | 3.174 | 3.17397 |
| | | | 1.61 | 1.6108 | 1.624 | 1.62389 |

Table containing buckling load various modulus ratios 5,10

| | | | Buckling Loads | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lamination scheme | K | a/b | Reference values | Present values | Reference values | Present values | Present values | Present values |
| | | | $E_1/E_2$=20 | $E_1/E_2$=20 | $E_1/E_2$=25 | $E_1/E_2$=25 | $E_1/E_2$=40 | $E_1/E_2$=40 |
| $[0^o/90^o]_{2s}$ | 0 | 0.5 | 3.828 | 3.8278 | 3.757 | 3.7568 | 3.647 | 3.6468 |
| | | 1 | 1.923 | 1.9289 | 1.866 | 1.86572 | 1.778 | 1.77863 |
| | | 1.5 | 2.211 | 2.21089 | 2.152 | 2.1508 | 2.061 | 2.0608 |
| | 1 | 0.5 | 3.062 | 3.0622 | 3.005 | 3.0047 | 2.917 | 2.91656 |
| | | 1 | 0.962 | 0.9608 | 0.933 | 0.93276 | 0.889 | 0.8867 |
| | | 1.5 | 0.773 | 0.77097 | 0.754 | 0.7538 | 0.725 | 0.7248 |
| $[0^o/90^o]_{4s}$ | 0 | 0.5 | 21.878 | 21.87876 | 22.874 | 22.878 | 24.59 | 24.5923 |
| | | 1 | 6.961 | 6.9578 | 7.124 | 7.126 | 7.404 | 7.407 |
| | | 1.5 | 5.31 | 5.3102 | 5.318 | 5.3178 | 15.332 | 15.3289 |
| | 1 | 0.5 | 13.922 | 13.925 | 14.248 | 14.246 | 14.766 | 14.768 |
| | | 1 | 3.481 | 3.4809 | 3.562 | 3.5607 | 3.702 | 3.708 |
| | | 1.5 | 1.634 | 1.6307 | 1.636 | 1.63567 | 1.641 | 1.644 |

Table containing buckling load various modulus ratios 20,25,40

Non-dimensionalzed buckling loads of rectangular laminates under uniaxial and biaxial compression

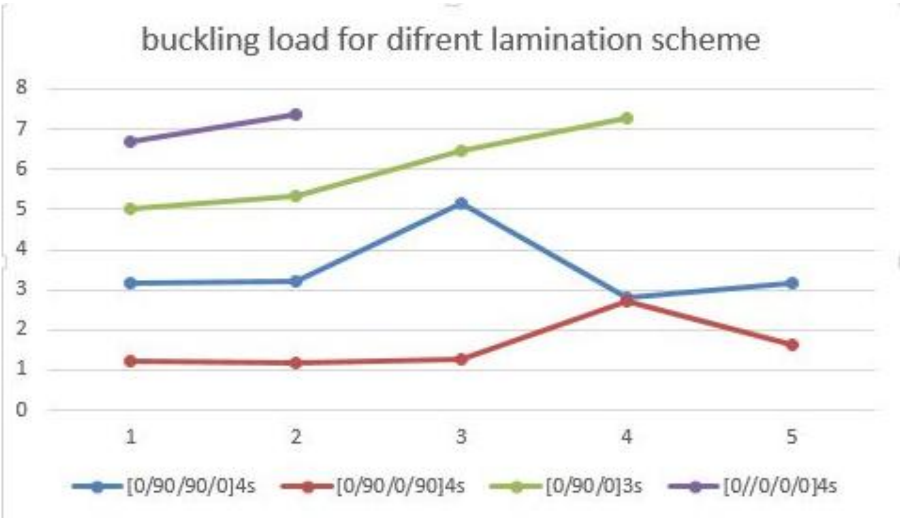
| Lamination scheme | K | a/b | Buckling Loads | | | |
|---|---|---|---|---|---|---|
| | | | Reference values | Present values | Refere values | Presentvalues |
| | | | $E_1/E_2=10$ | $E_1/E_2=10$ | $E_1/E_2=20$ | $E_1/E_2=20$ |
| $[45^o/-45^o]_{2s}$ | 0 | 0.5 | 12.633 | 12.6435 | 18.14 | 18.1437 |
| | | 1 | 9.06 | 9.0664 | 13.373 | 13.375 |
| | | 1.5 | 9.603 | 10.16 | 23.963 | 23.966 |
| | 1 | 0.5 | 11.893 | 11.8896 | 14.518 | 14.516 |
| | | 1 | 4.53 | 4.533 | 6.692 | 6.688 |
| | | 1.5 | 3.129 | 3.1275 | 9.021 | 9.023 |
| $[45^o/-45^o]4_s$ | 0 | 0.5 | 23.746 | 23.748 | 43.841 | 43.8398 |
| | | 1 | 17.637 | 17.6283 | 33.32 | 33.323 |
| | | 1.5 | 18.565 | 18.5648 | 34.909 | 34.907 |
| | 1 | 0.5 | 18.999 | 18.995 | 35.076 | 35.075 |
| | | 1 | 8.813 | 8.8127 | 16.66 | 16.658 |
| | | 1.5 | 6.001 | 6.00156 | 11.251 | 11.2508 |

| Lamination scheme | K | a/b | Buckling Loads Reference values | Present values | Refere values | Presentvalues |
|---|---|---|---|---|---|---|
| | | | $E_1/E_2=25$ | $E_1/E_2=25$ | $E_1/E_2=40$ | $E_1/E_2=40$ |
| $[45^o/-45^o]_{2s}$ | 0 | 0.5 | 20.825 | 20.875 | 28.809 | 28.8101 |
| | | 1 | 15.475 | 15.4758 | 21.713 | 21.7089 |
| | | 1.5 | 16.285 | 16.283 | 22.779 | 22.7784 |
| | 1 | 0.5 | 16.66 | 16.667 | 23.045 | 23.0448 |
| | | 1 | 7.738 | 7.7379 | 10.856 | 10.8559 |
| | | 1.5 | 5.27 | 5.275 | 7.353 | 7.3538 |
| $[45^o/-45^o]4_s$ | 0 | 0.5 | 53.888 | 53.884 | 84.02 | 84.025 |
| | | 1 | 41.166 | 41.163 | 64.685 | 64.684 |
| | | 1.5 | 43.091 | 43.09 | 67.607 | 67.609 |
| | 1 | 0.5 | 43.11 | 43.108 | 67.22 | 67.223 |
| | | 1 | 20.578 | 20.576 | 32.343 | 32.347 |
| | | 1.5 | 13.877 | 13.875 | 21.743 | 21.748 |

Table of buckling load various different lamination scheme ratios 10, 20,25,40

| Lamination scheme | Hybrid Lamination scheme | Critical buckling load |
|---|---|---|
| $[0/90/90/0]_{4s}$ | [G/G/G/G] | 3.1793 |
| | [K/K/K/K] | 3.2188 |
| | [G/K/K/G] | 5.142 |
| | [G/K/G/K] | 2.7908 |
| | [K/G/G/K] | 3.1864 |
| $[0/90/0/90]_{4s}$ | [G/G/G/G] | 1.2357 |
| | [K/K/K/K] | 1.1983 |
| | [G/K/K/G] | 1.2612 |
| | [G/K/G/K] | 2.7112 |
| | [K/G/G/K] | 1.624 |
| $[0/90/0]_{3s}$ | [G/G/G] | 5.0379 |
| | [K/K/K] | 5.3249 |
| | [G/K/G] | 6.4691 |
| | [K/G/K] | 7.2828 |
| $[0//0/0/0]_{4s}$ | [G/G/G/G] | 6.6828 |
| | [K/K/K/K] | 7.3497 |

Critical buckling load for hybrid composites with different lamination schemes




Graph explaining hybrid composite materials different laminates vs buckling load.

## V. CONCLUSIONS

An attempt is made to analyze the critical buckling load variation for hybrid composite plates.

1. A systematic procedure is developed to study the buckling analysis of hybrid composites. The procedure is implemented through MATLAB code.
2. Further the code is extended for the prediction of critical buckling loads of hybrid composites under various lamination conditions.
3. A positive hybrid effect is noticed for a segregated hybrid, where graphite/epoxy sub-laminate is sandwiched between sub-laminates of Kevlar/epoxy. Buckling load is increased may be due to sandwiching of graphite epoxy.
4. Critical buckling loads are calculated for the various lamination scheme with [0/90/90/0], [0/90/0/90] and [0/90/0] fiber orientations.
5. With the same quantity of material by placing the different lamination schemes [G/K/K/G] grater buckling loads among other schemes.
6. With the [0/90/0] fiber orientation [K/G/K] lamination scheme can with stand grater buckling load among all the scheme.

## VI. FUTURE SCOPE OF THE WORK

In this study the buckling load of the laminated composite plate was firm. The impact of ratio, cutout form and stress concentration technique on buckling load was studied. The future scope of the present investigation can be expressed as follows:

1. The laminated composites will be subjected to bi-axial compressive loading and therefore the result on buckling behavior will be studied.

2. The plate will be subjected to shear loading too and therefore the buckling behavior will be studied extensively

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

4. Load effect on laminated composite plate can also be encountered

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