# Comparative Study of Buckling Analysis of Angle Ply And Cross Ply Laminated Composite Plate (Experimental And Numerical Approach)

**Basavaraj M Gudadappanavar[1], Rangappa H Jogannavar[2]**
.[1]Assistant Professor, Dept of Civil Engineering
[2]Dept of Civil Engineering
[1, 2] SDM College of Engineering and Technology, Dharwad

***Abstract:*** *At present the entire world is running under composite materials, there is avast application of composite in all the field of engineering and technology. Most of the research works are being carried out on composite material, so a store place the conventional materials which can impart greater strength and stiffness. For angle ply: The laminated composite plate was studied for buckling both by experimental and numerical approach using ANSYS work bench software and the results are compared to obtain the percentage error. In this study plates with different orientation and plate of a/h ratio has been considered.*

*We find that the buckling load is maximum for fiber orientation of 0/30 and minimum for orientation of 0/60. In this study the plates with different aspect ratios of 0.20,0.25 and 0.30 were considered.*

*We obtained increased buckling strength with increasing a/b ratios of 0.20, 0.25 and 0.30. It was seen that both the experimental and numerical study exhibited a good relation, the buckling loader ror for laminated composite plate was within 6%.*

*For cross ply:It was observed that with increased (a/b) ratio the buckling strength of the composite lamina was also seen increased. The reduction in buckling strength for (a/b) ratio 0.2 to 0.25 is 36%, and (a/b) ratio 0.25 to 0.3 is30%.*

*When a fiber orientation increases, the buckling stress decreases. The specimen with [0] orientation with 12layers having a peak buckling load and a specimen with [90] orientation with 12layers having a lowest buckling load.*

*The reduction in buckling load occurs from[0]to[090]orientation is 41% and from[090]to[90] orientation is 67% decreases.*

*An excellent results are obtained from experimental and FEM analysis with a peak divergence of5.57%.*

## I. INTRODUCTION

When two or more materials are combined on a macroscopic scale to make a third material, the resulting material is called as "composite material". If the materials are combined on a macroscopic scale, the naked eye can identify the components of composite materials. If we design it properly the properties of composite material are far better compared with the properties of its components or constituents. Composite materials uncovers material that is unique in relation to all as relatable to point of heterogeneous materials.

The strong fibres continuous or discontinuous fibres which are covered by a material known as matrixes (acts as a binding material) is being embedded in composites. The matrix solidly holds those fibres and further more will transmit load to the fibres. If we design it properly the properties of composite materials that can be improved are strength, stiffness, corrosion resistance, weight, fatigue life, thermal insulation, etc. Practically at the same time, all properties cannot be improved and there will be no such requirement. The purpose of creating composite material is that, it should satisfy its design requirements. If we design a composite material in a well defined manner, than the property of composite material is far better than the property of its components or constituents.

**Fibers and Matrix :-**

While manufacturing any composite material the bond is developed between fiber and matrix.The mechanical properties depends on manufacturing.

**Fibers:-**

The fibers consist of millions of strands, each of these strands having diameter ranging from 4 to 18 micrometers.

**Types of Fibers:-**

- Glass fiber
- Polyester
- Carbon fiber
- Aramid
- Boron fiber

**Matrix:-**

Matrix is just a binding material to hold the fibers stiff enough and to transfer the load coming over matrix to fibers.

For our study the polymeric matrix i.e., the epoxy which is used is LY556 (Aradalite) and HY951 (Aradur).

## II. METHODOLOGY

1. Calculation of material required for preparation of specimen.
2. Testing of specimen of various ply orientation and aspect ratio.
3. Numerical study is carried out in FEM software ANSYS for various parameters.
4. The behaviour of cross ply orientation and aspect ratio will be studied.
5. To investigate the accuracy of experimental and numerical study.
6. Comparing both results and finding out the percentage error.

## III. MECHANICAL PROPERTIES OF LAMINATED COMPOSITE PLATE

Reference: [Dr.Premakumar W.P., Dr.Prathapkumar M.T., "Experimental and finite element study on buckling behaviour of laminated e-glass woven fabric epoxy composite plates"]

Table: Properties of E-glass & matrix

| PROPERTY | E-GLASS (glassfiber - 200GSM) | EPOXY RESIN (Aradalite –LY556) |
|---|---|---|
| Volume fraction | 60% | 40% |
| Modulus of elasticity Gpa | 73 | 3.4 |
| Poisson's ratio | 0.2 | 0.35 |
| Modulus of rigidity Gpa | 30 | 1.49 |
| Density g/cc | 2.5 | 1.2 |

Table: Mechanical properties of laminated composite

| S.N | PROPERTY | VALUE | UNIT |
|---|---|---|---|
| 1 | E1 | 46 | Gpa |
| 2 | E2 | 8 | Gpa |
| 3 | E3 | 8 | Gpa |
| 4 | G12 | 3.5 | Gpa |
| 5 | G23 | 2.8 | Gpa |
| 6 | G13 | 2.8 | Gpa |
| 7 | µ12 | 0.3 | Gpa |
| 8 | µ23 | 0.3 | Gpa |
| 9 | µ13 | 0.3 | Gpa |

## IV. EXPERIMENTAL STUDY

Experimental investigation is very important to study how a laminated plate specimen behaves under buckling. The experimental investigation and finite element studies which were done showed an excellent result.

Figure: Universal testing machine (10ton) capacity

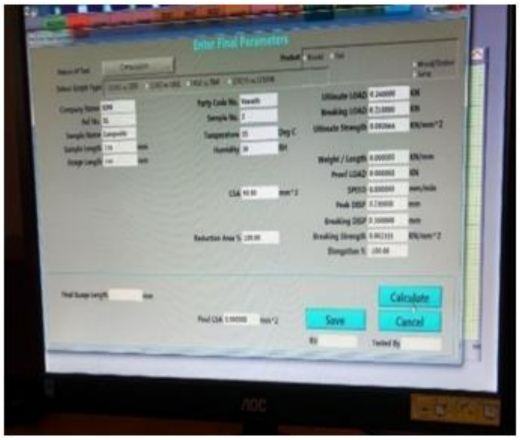

Figure: Buckling load readings

Table: Plates tested in present study (angle ply)

| Plate no. | Stocking Sequence | Length(mm) | Width(mm) | Thickness(mm) |
|---|---|---|---|---|
| Plate 1 | (0 30)° | 100 | 30 | 3 |
| Plate 2 | (0 30)° | 120 | 30 | 3 |
| Plate 3 | (0 30)° | 150 | 30 | 3 |
| Plate 4 | (0 45)° | 100 | 30 | 3 |
| Plate 5 | (0 45)° | 120 | 30 | 3 |
| Plate 6 | (0 45)° | 150 | 30 | 3 |
| Plate 7 | (0 60)° | 100 | 30 | 3 |
| Plate 8 | (0 60)° | 120 | 30 | 3 |
| Plate 9 | (0 60)° | 150 | 30 | 3 |

Table :Plates tested in present study (crosply)

| Fiber orientation | No of samples cast | Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|---|---|
| $0^0$ | 3 | 100 | 30 | 3 |
| $90^0$ | 3 | 100 | 30 | 3 |
| [0 90] | 3 | 100 | 30 | 3 |
| $0^0$ | 3 | 120 | 30 | 3 |
| $90^0$ | 3 | 120 | 30 | 3 |
| [0 90] | 3 | 120 | 30 | 3 |
| $0^0$ | 3 | 150 | 30 | 3 |
| $90^0$ | 3 | 150 | 30 | 3 |
| [0 90] | 3 | 150 | 30 | 3 |

## V. NUMERICAL STUDY

The software which was used to examine the numerical analysis of buckling of laminated composite plates for different aspect ratios and angle orientation was ANSYS workbench. The buckling analysis in ANSYS workbench involves following steps:

**Finite Element analysis using ANSYS workbench software:-**

1) Developing a model: It involves applying the element type, constants, material property and meshing of model. The material property and meshing is as shown in figure respectively.

Shell type – 4-Noded shell element
Total number of nodes – 816 nodes
Total number of elements – 750 elements

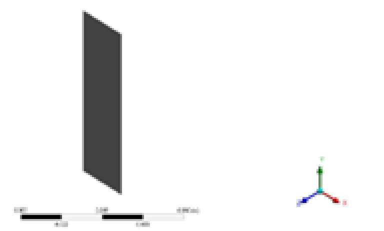

Figure. Defining geometry of plate

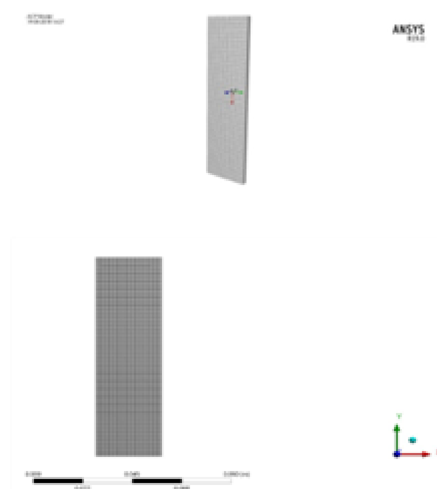

Figure. Surface Meshing

2) Solution (Analysis): This procedure involves adding the boundary condition to the model, application of load and running the analysis to get the solution. The applied boundary condition and load is as shown in figure.

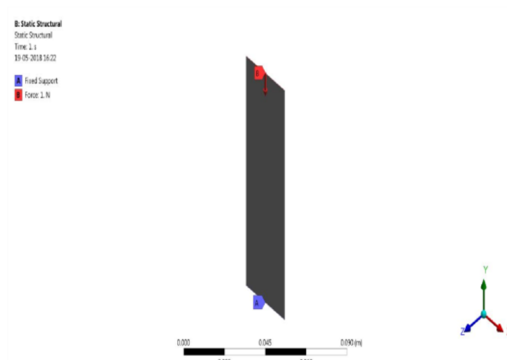

Figure. Applying Load

3) Post processing: This step involves the buckled loads and buckled shape of the composite plate. The deflected shape of composite specimen is as shown in figure.

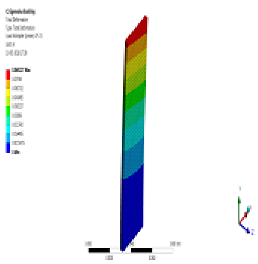

Figure. Buckled shape of composite plate

| Plate no. | Stocking Sequence | Length {mm} | Breadth {mm} | Thickness {mm} | Experimental Buckling {N} | Numerical Buckling (ANSYS) {N} | Percentage error (Exp.val-num. val)*100/exp.val |
|---|---|---|---|---|---|---|---|
| Plate 1 | (0 30)° | 100 | 30 | 3 | 525 | 541.86 | 3.21% |
| Plate 2 | (0 45)° | 100 | 30 | 3 | 495 | 475.72 | 3.89% |
| Plate 3 | (0 60)° | 100 | 30 | 3 | 470 | 450.81 | 4.08% |
| Plate 4 | (0 30)° | 120 | 30 | 3 | 395 | 374 | 5.32% |
| Plate 5 | (0 45)° | 120 | 30 | 3 | 315 | 329.11 | 4.48% |
| Plate 6 | (0 60)° | 120 | 30 | 3 | 305 | 312.66 | 2.51% |
| Plate 7 | (0 30)° | 150 | 30 | 3 | 230 | 237.79 | 3.39% |
| Plate 8 | (0 45)° | 150 | 30 | 3 | 215 | 209.78 | 2.43% |
| Plate 9 | (0 60)° | 150 | 30 | 3 | 210 | 199.82 | 4.84% |

Angle ply

The composite lamina was studied for its buckling behavior by experimental and numerical technique. The study enhanced a good relation with the experimental results and finite element results .The percentage error and their buckling values obtained from experimental test set up and by using software - ANSYS workbench is as shown in table.

| Plate no | Fibre direction | Length in [mm] | Width in [mm] | Thickness in [mm] | Critical buckling strength values [N] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Experimental results | Numerical results | Percentage error |
| 1 | 0o | 100 | 30 | 3 | 800 | 766.90 | 4.13% |
| 2 | 90⁰ | 100 | 30 | 3 | 140 | 133.47 | 4.66% |
| 3 | [0 90] | 100 | 30 | 3 | 435 | 448.34 | 3.06% |
| 4 | 0o | 120 | 30 | 3 | 560 | 532.72 | 4.87% |
| 5 | 90⁰ | 120 | 30 | 3 | 90 | 92.657 | 2.95% |
| 6 | [0 90] | 120 | 30 | 3 | 295 | 311.43 | 5.57% |
| 7 | 0o | 150 | 30 | 3 | 360 | 340.97 | 5.29% |
| 8 | 90⁰ | 150 | 30 | 3 | 57 | 59.283 | 4.0% |
| 9 | [0 90] | 150 | 30 | 3 | 190 | 199.36 | 4.93% |

Cross ply

From the above table it can be seen that the buckling resistance is more for a/b ratio of 0.30 and plates with aspect ratio of 0.20 have lowest buckling loads. The composite lamina having fiber orientation with (0 30)°gives higher buckling strength compared to other ply orientation and with composite plate having fiber orientation of (0 60)° gives lower buckling strength for all aspect ratios.

## VI. CONCLUSIONS AND SCOPE

**Conclusions:-**

This thesis work is dealt with Comparisons between buckling behavior of laminated (cross ply and anle ply) plates having varying aspect ratio i.e., 0.20, 0.25 and 0.30 and with fiber orientation of (angle ply) 30°, 45° and 60°And 0°,90°(cross ply).The experimental test is carried out for the composite laminated plates and the test results obtained are clarified numerically using ANSYS workbench software.

For angle ply;

Based on the results obtained by carrying out the experimental and numerical analysis the following conclusions are made.

1. It can be seen that both the experimental and numerical study exhibited a good relation, the buckling load error for thick plate (a/h =10) is within 6%.
2. It was observed that with increased (a/b) aspect ratio, the buckling strength of the composite lamina was also found increased.
3. As the aspect ratio(a/b) was changed from 0.20 to 0.25, the difference in buckling was 41% and for change of aspect ratio from 0.20 to 0.30 the buckling load changed up to 25%.

4. As from the above parametric study it was seen that buckling strength was more for 30º ply orientation and was low for ply orientation of 60º.
5. The change in ply orientation from 30ºto 45º,the buckling load varied up to 9% and for ply orientation of 45º to 60º, the change in buckling load was up to 2% .

For cross ply;

1. The values obtained from numerical results is higher than the experimental results
2. It was observed that with increased (a/b) ratio. The buckling strength of the composite lamina was also seen increased. The reduction in buckling strength for (a/b) ratio 0.2 to 0.25 is 36%, and (a/b) ratio 0.25 to 0.3 is30%.
3. When a fiber orientation increases, the buckling stress decreases. The specimen with [0] orientation with 12layers having a peak buckling load and a specimen with [90] orientation with 12layers having a lowest buckling load. The reduction inbucklingloadoccursfrom[0]to[090]orientationis41% andfrom[090]to[90] orientation is 67% decreases.
4. An excellent results are obtained from experimental and FEM analysis with a peak divergence of5.57%.

## REFERENCES


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