Buckling Analysis Of Angle Ply Laminated Composite Plates (Experimental And Numerical Approach)

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Abstract- *The main purpose of this study was to investigate the buckling behaviour of laminated composite plate both by experimental and numerical approach using ANSYS workbench software, and the results are compared to obtain the percentage error. In this study plates with orientation of 0/30, 0/45, 0/60 are being considered. We find that the buckling load was maximum for fibre orientation of 0/30 and minimum for orientation of 0/60. In this study, the plates having different aspect ratios of 0.20, 0.25 and 0.30 were also 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 load error for laminated composite plate was within 6%.*

Keywords- Lateral buckling, Laminated composite, woven fabric ,fibre orientation, ANSYS workbench.

I. INTRODUCTION

Composite material uncovers material that is unique in relation to all as relatable point 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.

The thought of mixing one material with another material to form a finished product, which has high material property that cannot be achievable by a single material, is being used for several years. Accordingly, most of natural occurring materials that are evolved because of the long-term experimentation research carried out are treated as a composite material. 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.

The composite materials have wide range of application in the field of civil engineering like retrofitting works, claddings, construction of shells and domes. In field of automobiles for body works of cars, trucks and aeroplanes, they are also used in manufacture of lightweight and high strength armoured military vehicles like tankers, missiles and jets.

II. MATERIALS AND METHODOLOGY

The methodology used in the present thesis work is

(1) Experimental buckling using universal testing machine 10ton capacity
(2) Finite element analysis using ANSYS work bench software and computing percentage error.

A. Properties of composite material used

The properties of E-glass fibre and Epoxy resin are as shown in table -1.

Table 1: Properties of composite materials

Properties	**E-glass (glass fiber - 200GSM)**	**Epoxy resin (Aradalite – LY556**
Volume fraction	60%	40%
Modulus of elasticity Gpa	73	3.4
Poisson's ratio	0.20	0.35
Modulus of rigidity Gpa	30	1.49
Density g/cc	2.5	1.2

Number of layers = 12; Longitudinal Young's modulus = 46GPa; Transverse Young's modulus = 8GPa; Major Poisson's ratio = 0.30; Rigidity modulus = 3.5Gpa.

B. Preparation of composite specimens

The surface was cleaned properly with thinner and made sure was flat surface. A plastic sheet (A3) was placed on the cleaned flat floor and the edges were fixed by using paper tape. The glass fibres were cut to a size of 230 mm x 230 mm, in case ply orientations with 30the glass fibres were cut to the required orientation using a protector and setsquares. The aradalite and the hardener were mixed thoroughly in a mug, by using a brush the mixed solvent was applied on the open mould.

Figure 1: E-glass fibre

Figure 2: Epoxy resin

The first layer of glass fibre was laid on the open mould applied with solvent and was rolled by using a roller to remove any entrapped air bubbles. The solvent was applied again over the first layer and the next layer of glass fibre was placed over the other and again rolled using a roller, it was seen that the fibre orientation was taken care while placing the glass fibres one over another. The process was continued till the last glass fibre layer was laid and the top of the last layer was applied with the solvent and an transparent paper was placed over the top of upper most layer and was rolled using a roller and some dead weight was placed over it and allowed to curing for a period of minimum 48 hours.

Figure 3: Laminated composite plate

C. Details of the composite lamina plates

Table 2: Plates tested in present study

Plate no.	Stocking Sequence	Length (mm)	Width (mm)	Thickness (mm)
Plate 1	**$[0/30]_6$**	100	30	3
Plate 2	**$[0/30]_6$**	120	30	3
Plate 3	**$[0/30]_6$**	150	30	3
Plate 4	**$[0/45]_6$**	100	30	3
Plate 5	**$[0/45]_6$**	120	30	3
Plate 6	**$[0/45]_6$**	150	30	3
Plate 7	**$[0/60]_6$**	100	30	3
Plate 8	**$[0/60]_6$**	120	30	3
Plate 9	**$[0/60]_6$**	150	30	3

C

D. Experimental study on buckling of composite

The composite plates were tested under axial compression in compression testing machine under a rate of 5N/sec having 10-ton capacity. The ultimate buckling load after failure of composite laminated plate was taken into consideration. The buckling test was carried out both by experimental and by using finite element software ANSYS workbench. The buckling test carried out is as shown in figure 3.

Figure 4: Universal testing machine (10-ton capacity)

E. Numerical study

The numerical study on composite laminated plates was carried out using ANSYS workbench software.

Shell type – 3 Noded shell element
Total Number of nodes – 816 nodes
Total Number of elements – 750 elements

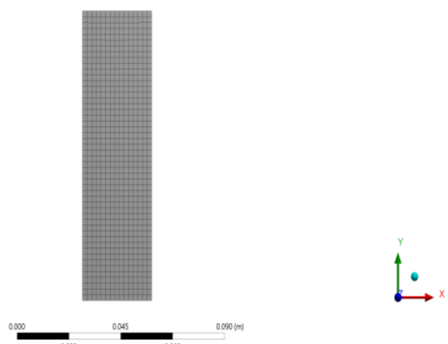

Figure 5: Meshing of plate

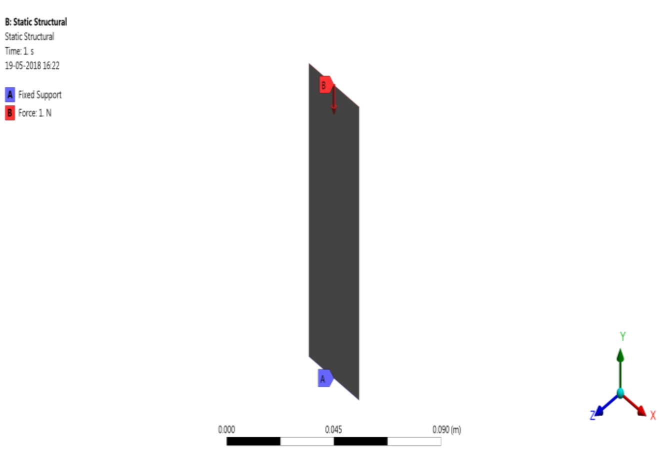

Figure 6: Boundary condition and load application

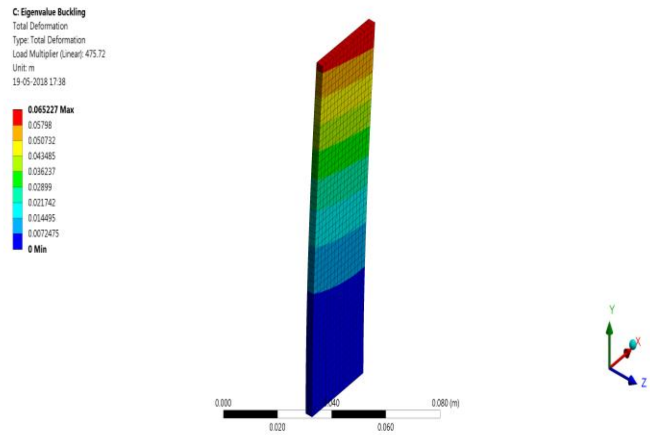

Figure 7: Buckled shape of composite

III. RESULTS AND DISCUSSIONS

The composite lamina was studied for its buckling behaviour 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 3.

Table 3: Buckling load results for laminated plates

Stocking Sequence	Length (mm)	Breadth (mm)	Thick (mm)	Experimental Buckling (N)	Numerical Buckling (ANSYS) (N)	% error
$[0/30]_s$	100	30	3	525	541.86	3.21%
$[0/45]_s$	100	30	3	495	475.72	3.89%
$[0/60]_s$	100	30	3	470	450.81	4.08%
$[0/30]_s$	120	30	3	395	374	5.32%
$[0/45]_s$	120	30	3	315	329.11	4.48%
$[0/60]_s$	120	30	3	305	312.66	2.51%
$[0/30]_s$	150	30	3	230	237.79	3.39%
$[0/45]_s$	150	30	3	215	209.78	2.43%
$[0/60]_s$	150	30	3	210	199.82	4.84%

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 fibre orientation with (0 30) gives higher buckling strength compared to other ply orientation and with composite plate having fibre orientation of (0 60) gives lower buckling strength for all aspect ratios.

A. Effect of aspect ratio (a/b)

In the present thesis work, the composite laminate plates are being determined for three types of aspect ratio i.e., 0.20, 0.25 and 0.30. It was observed that with increase in a/b ratio the buckling strength of laminated was also found high, it can be seen that the buckling load is maximum for aspect ratio of 0.3 and minimum for aspect ratio of 0.20. The difference in buckling was 41% for change in a/b ratio from 0.20 to 0.25 and for a/b ratio changing from 0.25 to 0.30 the bucking load variation was 25%. The buckling load for various aspect ratios of 0.20,0.25 and 0.30 are as shown in figures.

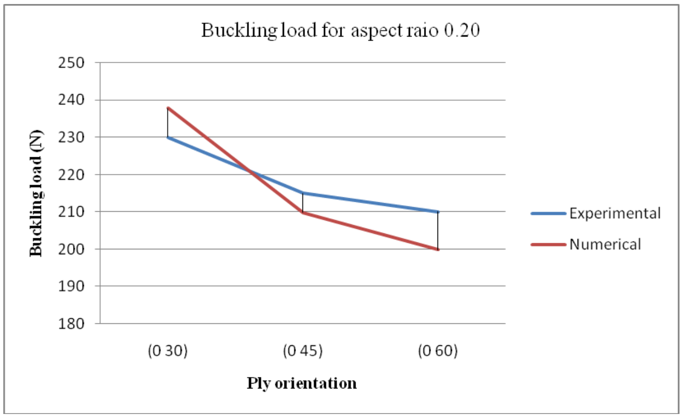

Figure 8: Effect of buckling load for aspect ratio 0.20

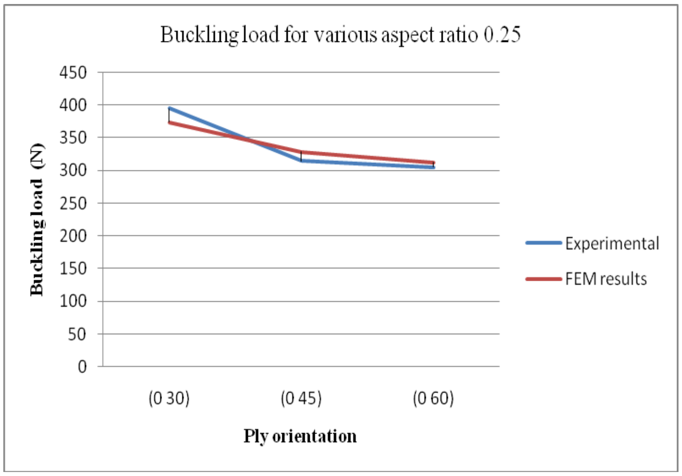

Figure 9: Effect of buckling load for aspect ratio 0.25

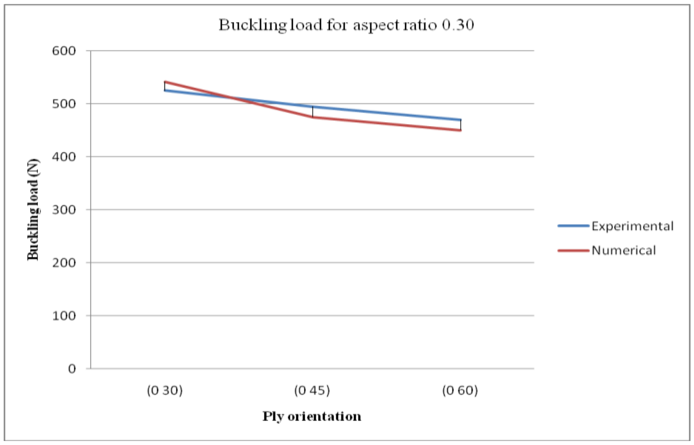

Figure 10: Effect of buckling load for aspect ratio 0.30

B. Effect of Ply orientation

In this study, the buckling load was determined for different ply orientations. For our study the ply orientations considered were 30°, 30° and e buckling load was maximum for ply orientation of 30°, 45° and 60°. The buckling load gradually decreased with increases in fibre orientation. When fibre orientation changed from 30° to 45° the buckling decreased up to 9% and for orientation from 30° to 60° the load decreased up to 2%. The buckling load for various ply orientation is as shown in figure 11

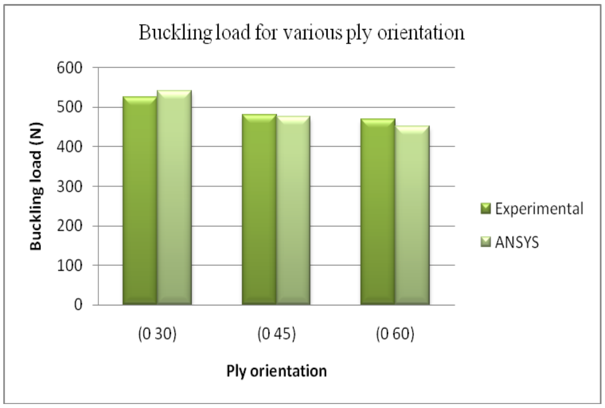

Figure 11: Effect of buckling load for various ply orientation

IV. CONCLUSIONS

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

- 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%.

- It was observed that with increased (a/b) aspect ratio, the buckling strength of the composite lamina was also found increased.
- 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%.
- As from the above parametric study it was seen that buckling strength was more for 30° ply orientation and was low for ply orientation of 60°.
- The change in ply orientation from 30° to 45°,the buckling load varied up to 9% and for ply orientation of 45° to 60°, the change in buckling load was up to 2%

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