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

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Abstract- *An enormous application of composites in the engineering field for technology development. More number of research work is going on composite material, thus exchange the predictable materials, which impart higher strength and stiffness. In this study, the buckling analysis on uni-directional glass epoxy laminated composite plate is carried by experimental and finite element method. for a various aspect ratio, fiber orientation and boundary condition. Laminates are prepared by hand layup technique, and then an axial compression testing is carried out. The maximum load composite can sustain before failure (critical buckling load) is taken into account. This tested results are validated in a FEM software ANSYS and obtaining the percentage error. In this study plates with orientation of [0]12, [90]12and[0 90]6 and plate of [a/h] ratio of 10 has been considered. We find that the maximum of fiber orientation of 00 and minimum for orientation 900 and the plates with different aspect ratio 0.20, 0.25, and 0.3 were considered.*

Keywords- Buckling Analysis, Epoxy LY556, Hardner HY951, Aspect ratio, ANSYS Workbench

I. INTRODUCTION

Composite is a type of materials in which is combination of two types of constituents namely fibre and resins, where the fibre and resin bonded together to form a laminate. Composite material if properly designed they will have better property of their constituents along with additional property like strength, weight, corrosion resistance, thermal insulation, toughness, etc. can be improved by using a laminated composite. These are used for commercial and industrial. The production are made for aircrafts, ships, septic tank, submarines, trucks, rails, vehicles and in civil engineering fields.

In this paper we study the buckling behaviour of glass epoxy, cross ply uni-directional, laminated composite plate specimen and its influence by fibre orientation and aspect ratio which are examined and determined experimentally. And To carry out numerical analysis of laminated composite plate in ANSYS workbench 19 and comparing the numerical results with experimental results and to obtaining a percentage error.

II. PROPOSED METHODOLOGY

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

III. EXPERIMENTAL STUDY

3.1. Material required

- E-glass fibers (200GSM)
- Epoxy (LY556) Hardener (HY951)

E-glass fibers

Matrix

3.2. Preparation of specimen

Fabrication:- the specimen is prepared from hand layup technique as per standard procedure

.

There are three main stages for specimen preparation.

A] Preparation of solution:- The mixture of resin LY556 and hardener HY951 both are in a proportion of 100:10 to weight. These two mixtures are taken in a beaker mixed thoroughly for 5-10minutes with stirrer for a clockwise and anticlockwise direction such that it does not remain any air bubbles till it get adhesive property as Immediately after mixing start applying to fibers.

B] Casting:- We are adopting hand lay-up technique,first the mould is prepared with transparent A3 OMR sheet of size 230xmmx230mmx3mm is placed on the plain surface. Before this the fiber and solution should be kept ready. Then matrix is applied on the mould with a painting brush as shown in figure 1.1 was Glass fiber of size 230mmx230mm is placed on the mould such that it is rolled with rotating roller as shown in figure 1.2. this roller helps to fill the matrix inside the fiber uniformly. matrix is painted further fiber is placed on the mould and rolled. Due to hand assembled one should be there for placing a glass fiber as per its orientation. total twelve plies are placed over which another sheet are placed,then finally laminate plate will be ready by placing a weight are kept for a curing of 24hrs. due to reaction takes place a composite plates will be strong and light weight product for placing a glass fiber as per its orientation. total twelve plies are placed over which another sheet are placed, then finally laminate plate will be ready by placing a weight are kept for a curing of 24hrs. Due to reaction takes place a composite plates will be strong and light weight product.

Fig. 1.1: Applying matrix

Fig. 1.2: levelling with roller

C] Cutting of plate :- As per above calculation glass epoxy laminated plates are made in an electrical cutting machine. Cut to a size of 30mmx100mm, 30mmx120mm, 30mmx150mm as a cross ply orientation of $[0]_{12}$, $[90]_{12,}$ $[0\ 90]_6$ as shown in figure 2.6. . For a present study specimen are prepared for testing as shown in table no 1.

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

Table no. 1: No of Specimens prepared

3.3. Testing of specimen: A specimen is prepared by glass epoxy laminated composite plate. These plates are total twelve plies each ply is 0.25mm thick of different orientation $[0]_{12}$, $[90]_{12,}$ $[0\ 90]_6$with a size 30mmx100mm, 30mmx120mm, 30mmx150mm for each specimen three tests are made. total eighteen specimens are tested under boundary condition. The buckling test is conducted in a digital universal testing machine as shown in figure 1.3, having a 100Kn capacity setup as shown in figure. The ultimate load that the plate holds before failure for different aspect ratios is taken into account. An axial compression load goes on increasing slowly from 5N/s till it fails, after buckling of plate is shown in figure 1.4.

Fig. 1.3: Universal testing machine

Fig. 1.4: Buckling Plate

IV. NUMERICAL STUDY

4.1. Material properties:- The behaviour of a lamina was studied in a FEM software ANSYS workbench 19.0. And the properties of material are referred from journal .

SL NO	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	-
8	μ23	0.3	-
9	μ13	0.3	-

Table no. 2: Material Properties

4.2. FEM analysis using ANSYS Software :-The study on laminated plates is carried out using a ANSYS WORKBENCH 19.0 software as shown in below figures and the Steps for analysis using ANSYS software

- The modelling of laminated plate will be done.
- Describing appropriate dimensions, layers, and defining material properties.
- Considering a 4 noded shell element type.
- Surface meshing should be done total nodes 816 and elements 750 are taken for each plate.
- Applying boundary condition bottom edge is fixed applying axial compression load on top edge.
- Start the static analysis by applying load.
- Once the analysis has been completed, go to ANSYS postprocessors to review the results.
- This results containing the list of critical buckling loads and we can view deformed shape of the specimen.
- After this the parametric study will be carried for various fiber orientation and aspect ratio results are taken the figures are shown below.
- From this values discussion will be done by creating a graphs.

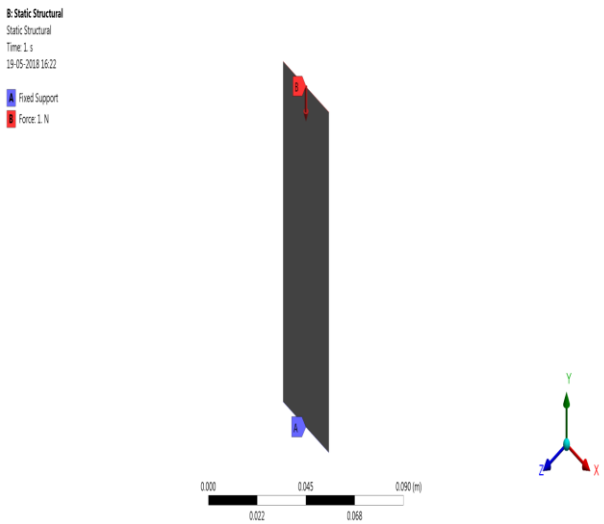

Fig. 1.5: Boundary Condition

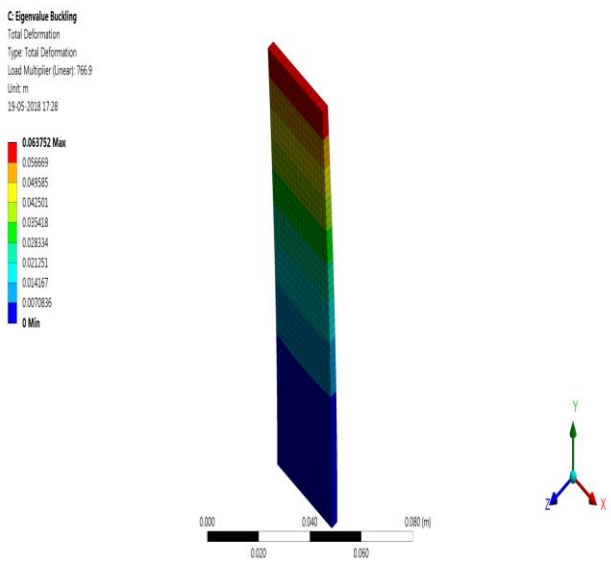

Fig. 1.6: Deformed Shape

V. RESULTS

5.1. Experimental and numerical results:-The buckling strength for various ply orientations having dimensions of 30mmx100mmx3mm,30mmx120mmx3mm,30mmx150mmx3 mm are determined for each specimen three test will be conducted, the average of three are considered. Each plate having total 12 layers corresponding to numerical values are obtained in table no 3.

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

Table no 3 experimental and numerical results

5.2. Influence of a/b ratio:-We have assessed three different aspect ratios 0.2, 0.25 and 0.3 are the results are consistent to its buckling load.

Where a = width of plate , b = length of plate

1) Aspect ratio, a/b = 0.3

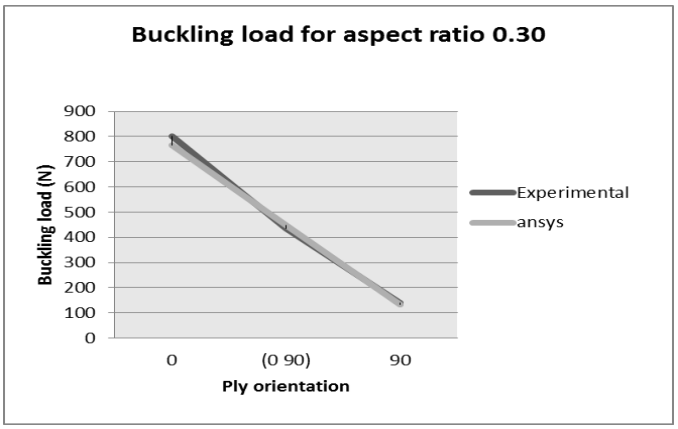

Fig. 1.7: Graph for Buckling Load For Aspect Ratio 0.3

2) Aspect ratio, a/b = 0.25

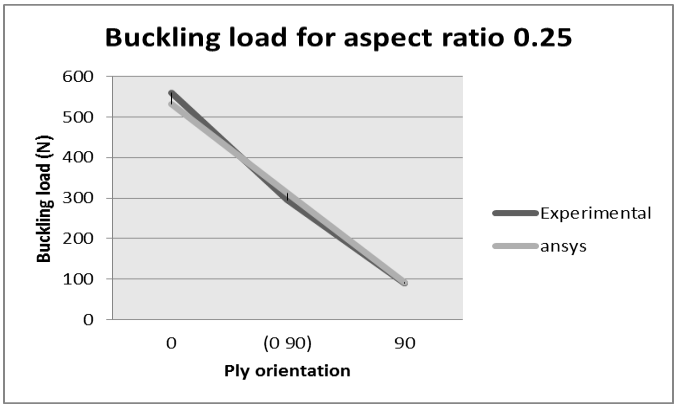

Fig. 1.8: Graph for Buckling Load For Aspect Ratio 0.25

3) Aspect ratio, a/b = 0.2

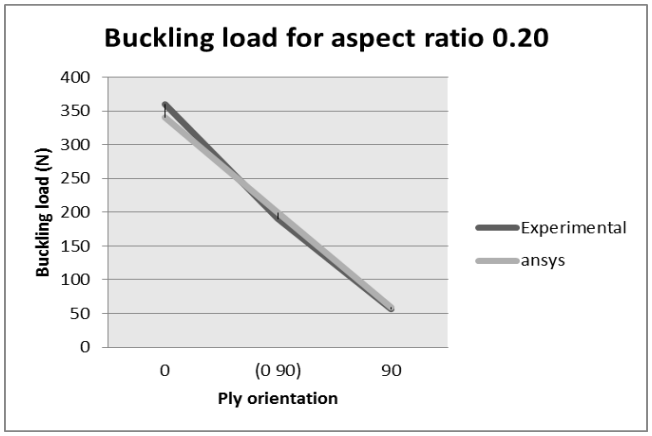

Fig. 1.9: Graph for Buckling Load For Aspect Ratio 0.20

5.3. Effect of Fiber Orientation:-The buckling load for a cross ply such as [0], [90], [0 90] orientation results are shown in table no 8. There are total 12 layers in each plate. Which ply orientation can carry maximum and minimum load are determined.

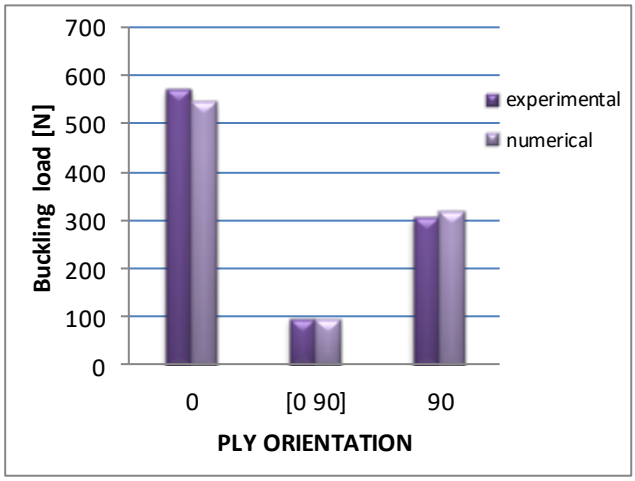

Fig. 2.0: Graph for Buckling Load V/S Ply Orientation

VI. CONCLUSIONS

In this case, buckling behaviour for a laminate specimen and its influence by fibre orientation and aspect ratio are determined by experimentally and numerical analysis by ANSYS. From this study, following conclusions are made:

- The value obtained from numerical results is higher than the experimental results.
- 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 is 30%.
- When a fiber orientation increases, the buckling stress decreases. The specimen with [0] orientation with 12 layers having a peak buckling load and a specimen with [90] orientation with 12 layers having a lowest buckling load. The reduction in buckling load occurs from [0] to [0 90] orientation is 46% and from [0 90] to [90] orientation is 68% decreases.
- An excellent results are obtained from experimental and FEM analysis with a peak divergence of 5.57%.

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