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BUCKLING & POST BUCKLING RESPONSE AND FAILURE ANALYSIS OF HYBRIDIZEDCOMPOSITE PANELS

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ABSTRACT

This study investigates the buckling and post-buckling behavior of hybridized composite panels, as well as failure analysis. The effects of stacking sequences and fiber orientation on the buckling and post-buckling reactions of unidirectional fiber reinforced polymer (FRP) plates were studied. Initially, plates with (0/90) fiber alignment are fabricated and evaluated under uniaxial compressive pressures with simply supported boundary conditions. Following that, the plates are modelled and analyzed using the FEM-based program ABAQUS, followed by a parametric analysis with various fiber orientations. To predict the composite panel's post-buckling behavior, a progressive failure model is developed. At first, the technique was validated using a simple stress and deflection investigation. The composite was then fed into a computer and subjected to progressive processing.

KEY WORDS:ABAQUS, Buckling, Composite laminates, Post buckling, Sandwich hybrid

INTRODUCTION

A composite material is made up of two components that have distinct physical and chemical properties. When they are mixed, they form a material that is specialized to perform a specific task, such as becoming stronger, lighter, or more resistant to electricity.Natural fiber composite materials have prompted the interest of many researchers and scientists due to their numerous advantages over traditional epoxy and carbon micromaterials. Natural fiber-reinforced polymer composite materials are generating a lot of attention, both in terms of industrial applications and fundamental research. India is one of the largest countries having agriculture as the main

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profession for many people. A huge amount of natural fibers are present in the plants of agricultural land and forest. Now a days, the natural plant fiber form is an interesting option for the most widely applied fiber in the composite technology. The development of environmentally friendly green composites is because of natural fibers biodegradability, light weight, relative cheapness, high specific strength, natural abundance and plentiful supply. Since 1995, natural plant fiber has emerged as the most acceptable alternative reinforcement for fiber composite products. From an economic development and sustainability perspective, natural fiber reinforced composites provide an opportunity to develop forestry and agriculture –based economy.

Liu et al. [1] studied the flexural buckling behavior of the laminated glass columns made up of multi-layered annealed glass consisted of two, three and four plies of annealed glass, bonded together by two types of adhesives under axial compression. Analysis of composite laminated plates is more difficult due to anisotropic and heterogeneous nature of composite materials [5].Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. Natural fibers composites like Jute, Sisal, and Kenaf were found to be having an ease in absorption handling and good acoustic insulation properties. [9,10]. Buckling of rectangular composite plates with rectangular cutouts has rarely been examined. To produce lighter and more efficient structures, cutouts are often required in structural components.[6] and stiffness-to-weight ratios can bring a further substantial reduction in structural weight.

NUMERICAL APPROACH

For analysis, many types of layup sequences are modelled. The plate's dimensions are 279x279x2.4mm, with each layer having 0.3mm thick. Finite element analysis based software ABAQUS is used for simulating the panels. All the panels are created with same dimensions in 8 layers. For analysis, different types of layup sequences are developed with different orientations. The various types of panels are represented in the below Table 1.

Table1: Specifications of laminates

Sl.no	Representation	Sequence	Orientation
1	JFRP	All eight layers are jute fiber	0/90/0/90/0/90/0/90

2	HFRP	All eight layers are hemp fiber	0/90/0/90/0/90/0/90
3	BFRP	All eight layers are bamboo fiber	0/90/0/90/0/90/0/90
4	SFRP	All eight layers are sisal fiber	0/90/0/90/0/90/0/90
5	RFRP	All eight layers are ramie fiber	0/90/0/90/0/90/0/90
6	CFRP	All eight layers are coir fiber	0/90/0/90/0/90/0/90
7	BFRP	All eight layers are bamboo fiber	0/90/0/90/0/90/0/90
8	WFRP	All eight layers are wood fiber	0/90/0/90/0/90/0/90

Note:
JFRP: Jute fiber reinforced polymer; HFRP: Hemp fiber reinforced polymer; BFRP: Bamboo fiber reinforced polymer; SFRP: Sisal fiber reinforced polymer; RFRP: Ramie fiber reinforced polymer; CFRP: Coir fiber reinforced polymer; BFRP: Banana fiber reinforced polymer; WFRP: Wood fiber reinforced polymer

Table 1 shows the material parameters of the fibers. Modeling the panel, assigning properties, applying load, and implying boundary conditions are the first steps in the analysis. Step is created for simulation purposes. A mechanism was provided in the initial step buckle option under the linear perturbation to calculate the critical buckling load before post-buckling analysis. After the analysis is completed, the eigenvalues are multiplied by the edge length to produce the critical buckling load. The Static-Riks approach was used for non-linear post-buckling analysis, and the magnitude buckling load obtained in buckling analysis was assigned. In the y-direction, shell edge compression is performed to the top edge of the panel. All four corners of the boundary conditions are simply supported. After that, meshing is performed with an element size of about 0.3. To run the analysis, a job is established. To calculate the first ply failure load, which reflects the first failure in the panel after the load is applied; Tsai-hill failure criteria have been introduced into the step module of non-linear post-buckling analysis. When the panel can no longer handle any more loads, it is said to have reached its limit.

TABLE 2:PROPERTIES OF FIBRES

TYPE OF FIBERS	Mechanical properties (GPa)				
	E1	E2=E3	G12=G13	G23	µ12
Hemp	70	35	50	25	0.4
Flax	70	35	50	25	0.45
Jute	20	10	14	7	0.36
Kenaf	53	27	36	18	0.47
Bamboo	11	5.5	8	4	0.108
Sisal	16	8	29	14.5	0.32
Ramie	44	22	29	14.5	0.5
Coir	6	3	5	2.5	0.3
Polylactide	3.5	1.75	1.287	0.643	0.36
Banana	30	15	20	10	0.28

NUMERICAL STUDY

The composite panels are simulated, and the buckling modes are depicted in figure 2. Buckling mode shapes of the functionally graded hybrid plate analyzed using numerical simulation under uniaxial compression buckling load: (a) Mode-I buckled shape (b) Mode-II buckled shape (c) Mode-III buckled shape.

Experimental post buckling analysis is conducted only on plates with fiber aligned in (0/90).The mode-I buckling shape is used for the post-buckling analysis since it is similar to the buckling shapes in the referred journals. The critical buckling load is determined by the eigenvalue achieved in mode-I buckling. The GRAPH shows the critical buckling load for each panel based on the eigenvalue analysis. The load versus displacement charts and post-buckling

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analyses of these composite panels are achieved using non-linear static riks analysis. FIG. 1 shows a graph of load vs. displacement for panels aligned in the direction (0/90).

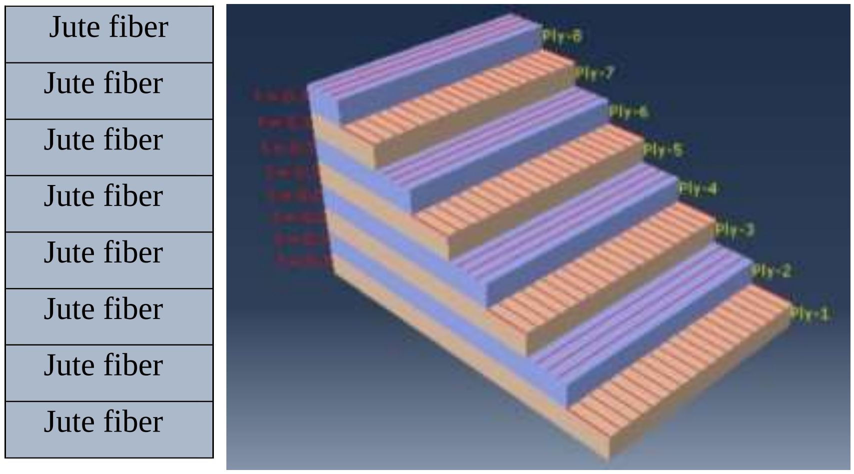

Fig.1 Composite panel with 0/90 orientation

RESULTS:

Table-3: Results

FIBER NAME	BUCKLING LOAD (KN)	FIRST PLY FAILURE LOAD (KN)	ULTIMATE FAILURE LOAD (KN)
JUTE	7.107	17.7675	42.396
HEMP	25.31	63.275	149.86
BAMBOO	3.492	8.73	22.591
SISAL	10.749	26.872	64.065
RAMIE	15.395	38.4875	91.216
COIR	2.3699	5.922	13.792
BANANA	10.26	25.65	61.165
WOOD	0.8477	2.119	5.1157

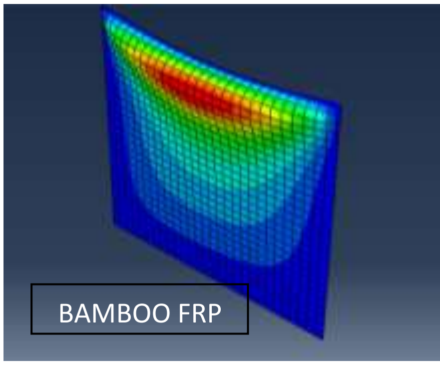

Fig-2

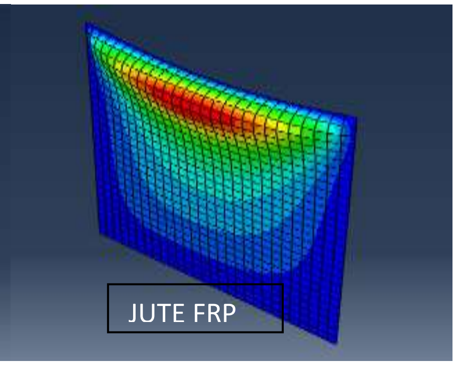

Fig-3

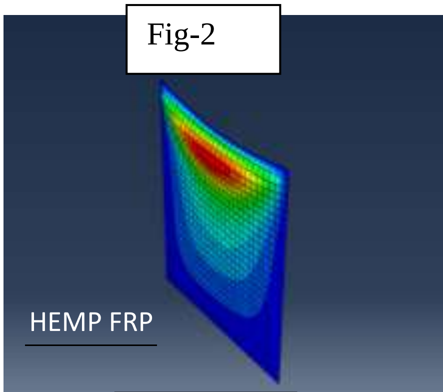

Fig-4

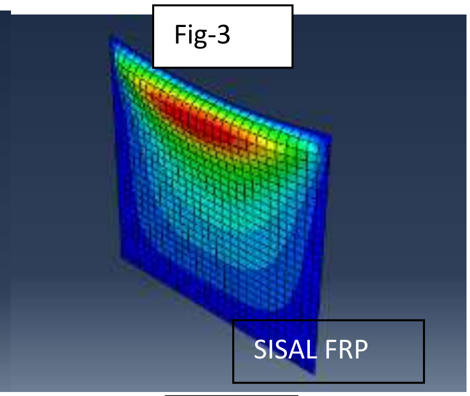

Fig-5

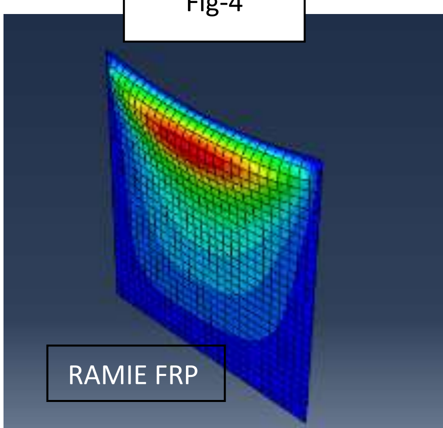

Fig-6

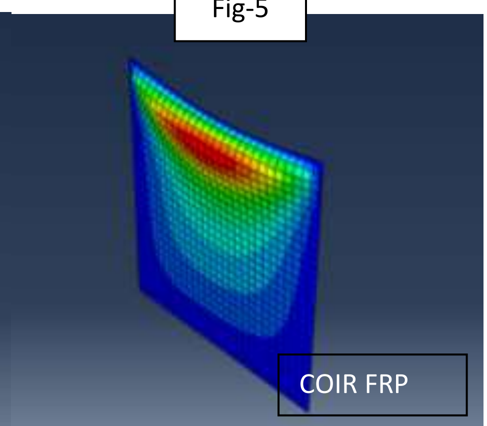

Fig-7

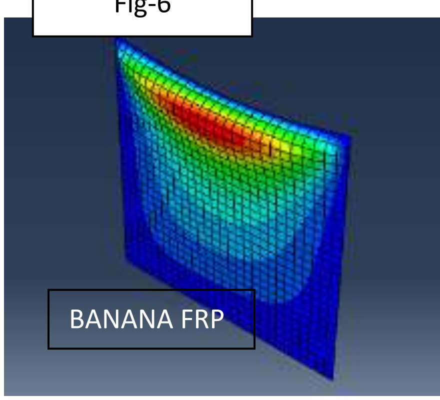

Fig-8

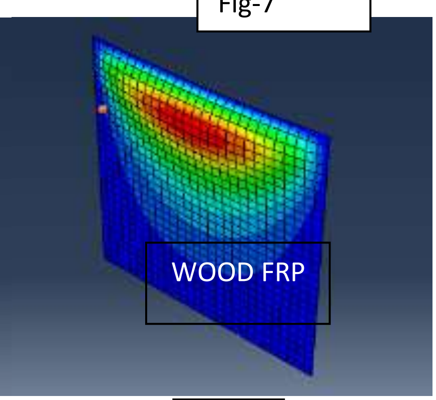

Fig-9

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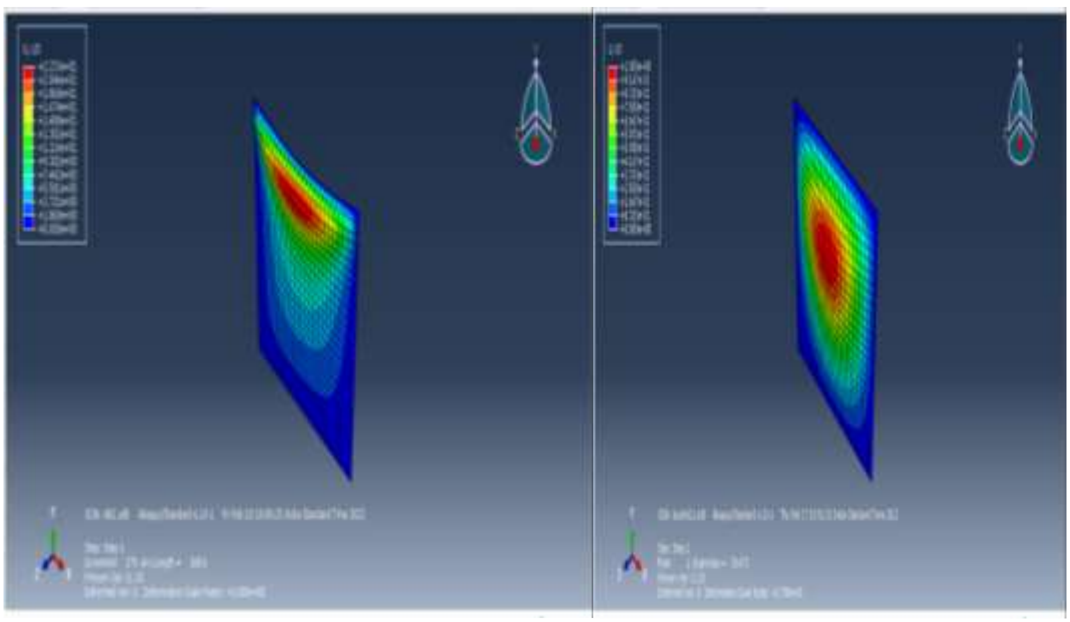
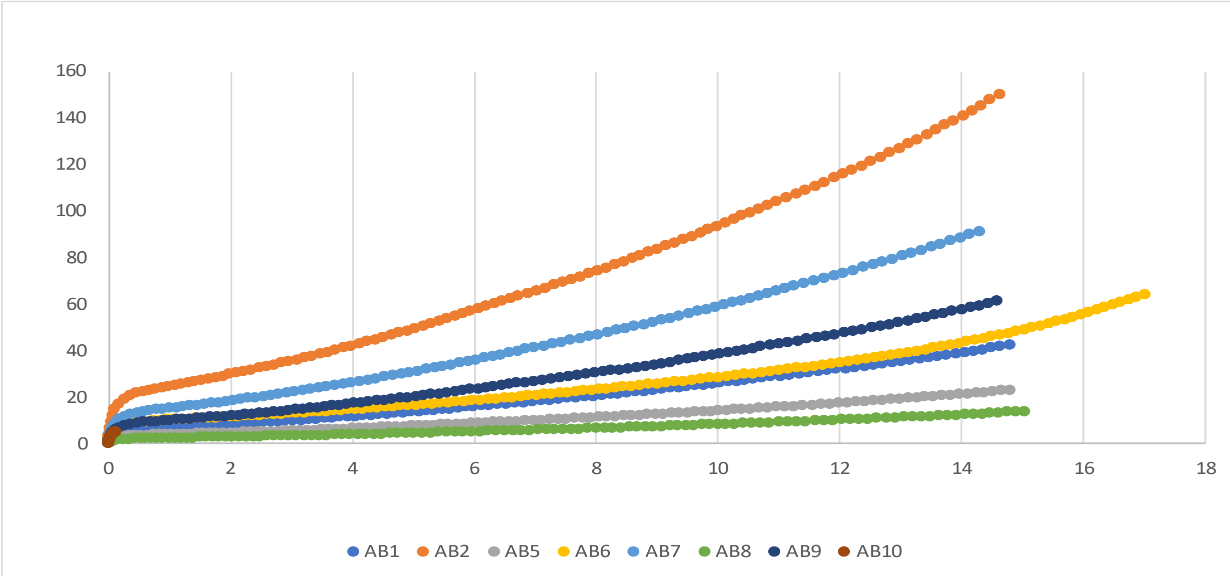
FIG.2 Buckling analysis of Jute fiber reinforced polymer



Buckling and post buckling graph of jute after analysis

- The highest buckling & Post buckling strength is obtained in HEMP fiber.
- The lowest buckling & post bucking strength is obtained in WOOD fiber.
- The highest first failure load is obtained in RAMIE fiber.
- The lowest first failure load is obtained in COIR fiber.
- The highest Ultimate failure load is obtained in HEMP fiber.
- The lowest Ultimate failure load is obtained in WOOD fiber.

According to Graph COIR fiber bears less amount of load that's why it has less Displacement ,Hemp fiber bears more amount of load & it shows high displacement also.



GRAPH BETWEEN LOAD AND DISPLACEMENT FOR DIFFERENT TYPES OF COMPOSITE PANELS

AB1 – jute fiber (0/90)
AB2- hemp fiber (0/90)
AB5 – kenaf fiber(0/90)
AB6 –bamboo fiber(0/90)
AB7 - sisal fiber(0/90)
AB8- coir fiber(0/90)
AB9 - polyactide fiber(0/90)
AB10 -banana fiber(0/90)

Where AB is the respresentation of the different composite panels.

CONCLUSION

- The laminate made with hemp fiber is having highest buckling load ,first ply failure load &ultimate failure load as compare to all laminates .
- The laminate made with wood fiber is having least buckling load first ply failure load &ultimate failure load as compare to all laminates .
- Ramie fiber is having second highest buckling load after hemp FRP with difference of 40%.
- Hence Hemp fiber is recommended for the structural applications.
- Since wood fiber is having less strength, it is not recommended.

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