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Finite Element Analysis of a Composite Material Sheet that Behaves as a Cantilever

Narendra Kumar Verma[1], Sunil Chanderia[2], Rishabh Kumar Singh[3] and Raghvendra Kumar Misra[4]

[1,2,3,4]Department of Mechanical Engineering School of Engineering
Gautam Buddha University, Greater Noida, U.P. - 201308
E-mail: [1]verma_narendra@outlook.com, [2]sunilchanderia@gmail.com, [3]rishabh.indiana92@gmail.com

Abstract—*In this paper a four layer composite material tested on a load with specified boundary conditions for four different orientations of the individual layer and different stacking sequence. During the study, we have use Uniform Distributed Load. After analysis, we got a comparative result about the deflection on different stacking sequence and orientation. For modelling and analysis, we use 'ANSYS APDL 16' software. This study will be helpful to know which arrangement is better for the development of composite material.*

1. INTRODUCTION

Composite materials are extending the capabilities of the designers to develop improved material that offers the possibility of exciting new solutions to the difficult engineering problems. Composites are combined in such a way that every virtue of it can be utilized in the best manner which includes the minimizing effects of their deficiencies. The process of optimization enables designers to release the constraints associated with the selection and manufacturing of conventional materials. By adopting certain principle designer can use tougher and lighter material, with the property that can be tailored to suit the design requirements.

As we all know wood is a natural composite material consisting of one species of polymer- cellulose fibers with good strength and stiffness-in a resinous matrix of another polymer, the polysaccharide lignin. There are several studies have been done on the composite material in the past that inspired us to present our work that includes the combination of four different layers, arranged in different orientation i.e. 0^o , 45^o, 90^o, -45^o and different layup stacking sequence.

2. Finite element analysis

2.1. Modelling strategy

For finite element analysis, a three-dimensional modal was developed in ANSYS APDL 16. For modelling, we developed a four layer arrangement by using four different material named as Bagasse fiber, Silk fiber, Banana fiber and Jute fiber. The dimension consideration was (150x50x2) mm, the thickness of each layer 0.5mm. A shell 3D-4 node 181 element was selected in Fig.1 followed by boundary conditions to restrict the one end as it behaves as cantilever beam in Fig.2. Under this study, four models had been considered by change the arrangement of the layers and orientation for the individual layer.

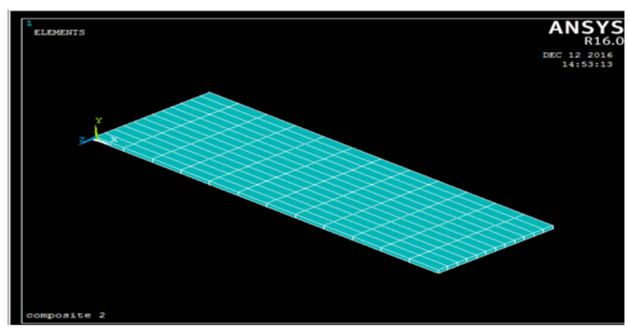


Fig. 1: The element model

2.2. Material

Table 1: Material properties

S. No.	Material	ρ (Kg/m^3)	ν	E (MPa)
1	Jute fiber	1300	0.38	0.4865
2	Bagasse fiber	1250	0.30	17.0
3	Silk fiber	1300	0.24	15.0
4	Banana fiber	1350	0.28	0.6415

2.3. Nomenclature

E Modulus of Elasticity
ν Poisson's Ratio
ρ Density of fiber.

U_x Displacement in x-direction
U_y Displacement in y-direction
U_z Displacement in z-direction
R_x Rotation in x-direction
R_y Rotation in y-direction
R_z Rotation in z-direction
σ_x Stress in x-direction
σ_y Stress in y-direction
σ_z Stress in z-direction

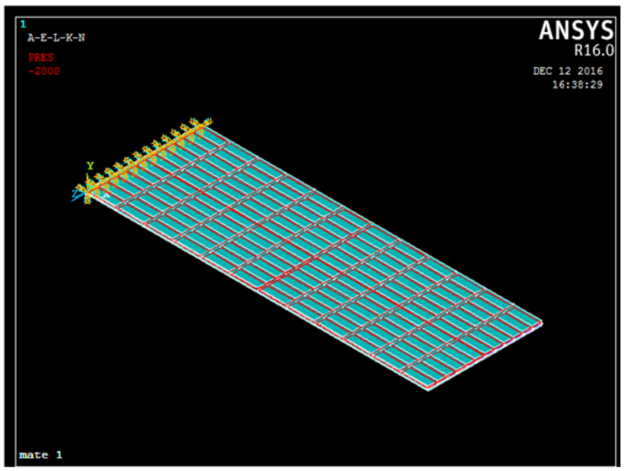


Fig. 2: Boundary condition and force

2. RESULTS AND DISCUSSION

After applying boundary conditions, a load of 2KN applied to the composite material, we got displacement, rotation and stress in x, y and z direction.

For analysis, we took four layers composite material on the respective orientation of 0°, 45°, 90° and -45° and arranging them in random sequence as shown in table 1.

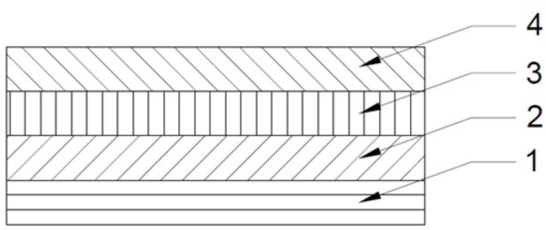


Fig. 3: lamina arrangement

Table 2: Layup order

Composite	Layup order
Composite 1	1-2-3-4
Composite 2	1-3-2-4
Composite 3	1-4-2-3
Composite 4	2-1-4-3

For better understanding, notified material by numeric as explained in table 1. But, the orientation sequence was same irrespective of the composite layup.

3.1. Contour plots and values

So many results were obtained during the analysis, the contour plots are given below for every composite.

Here we are only presenting plots for 1-2-3-4 layup composite among all for getting an overview.

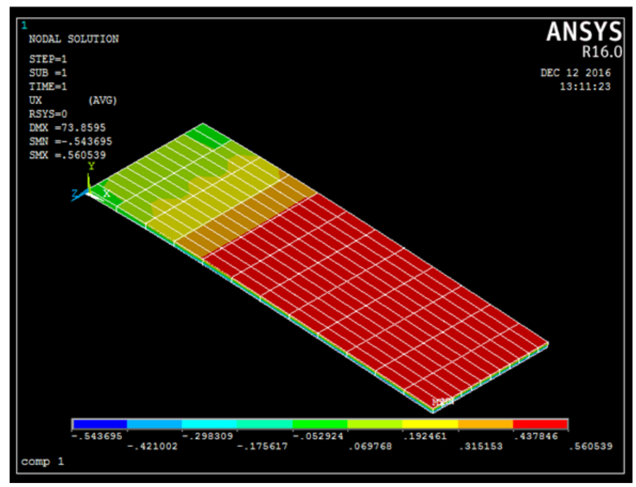


Fig. 4 Displacement of x-direction for 1-2-3-4

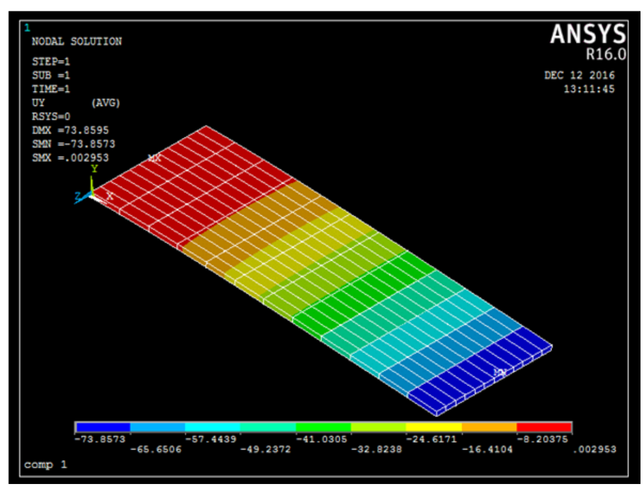


Fig. 5 Displacement of y-direction for 1-2-3-4

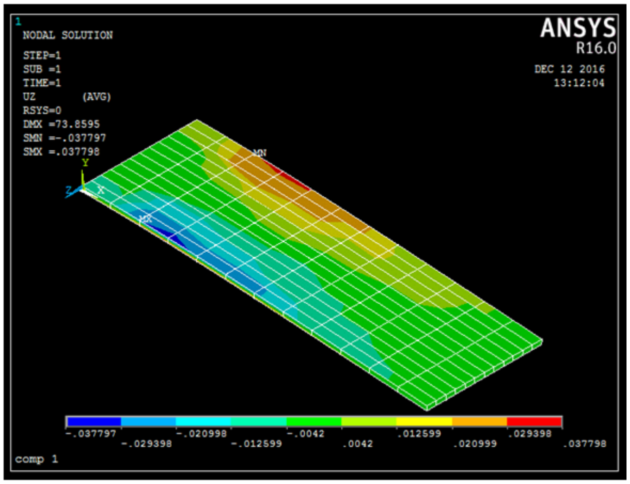


Fig. 6 Displacement of z-direction for 1-2-3-4

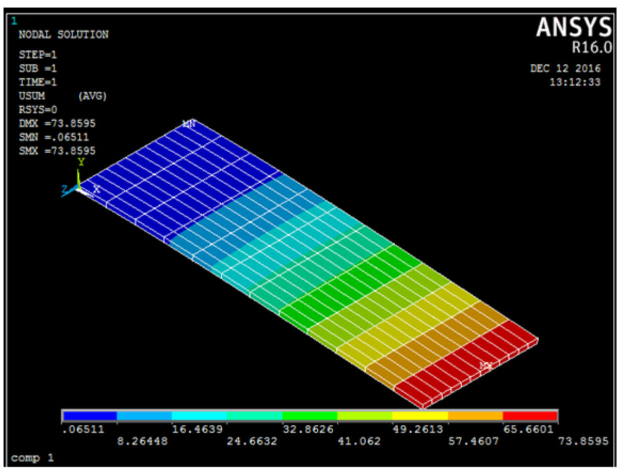


Fig. 7 Vector sum of displacement for 1-2-3-4

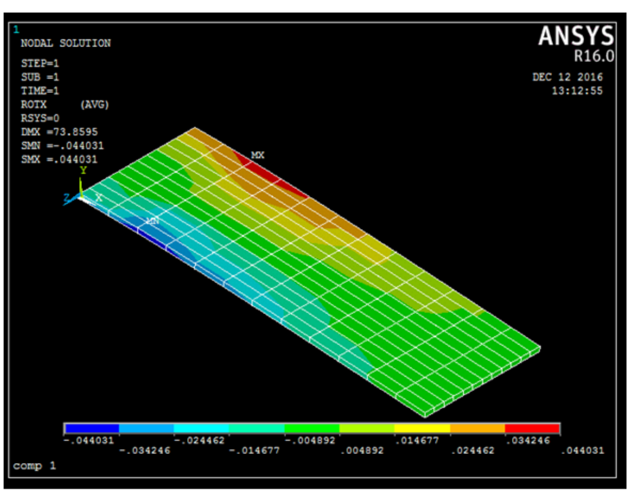


Fig. 8 Rotation of x-direction for 1-2-3-4

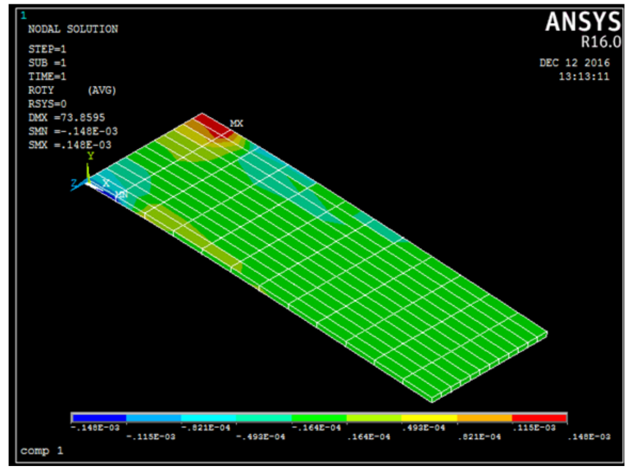


Fig. 9 Rotation of y-direction for 1-2-3-4

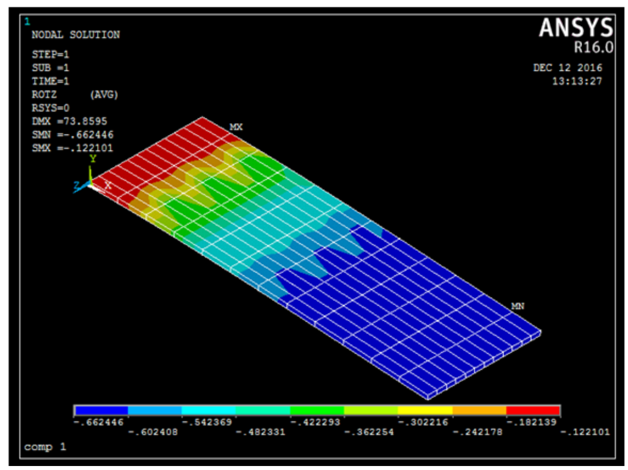


Fig. 10 Rotation of z-direction for 1-2-3-4

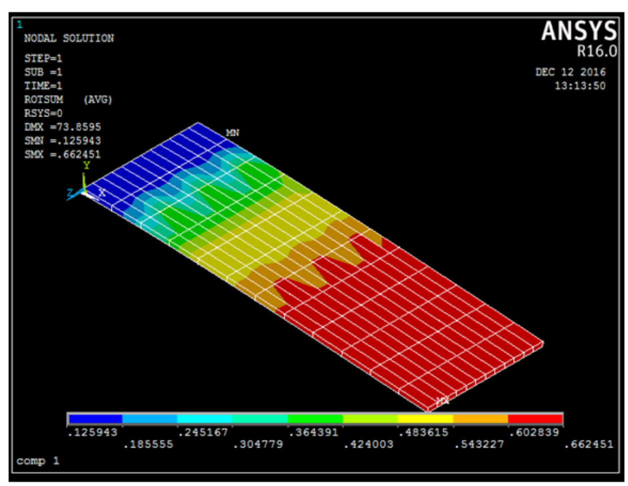


Fig. 11 Vector sum of rotation for 1-2-3-4

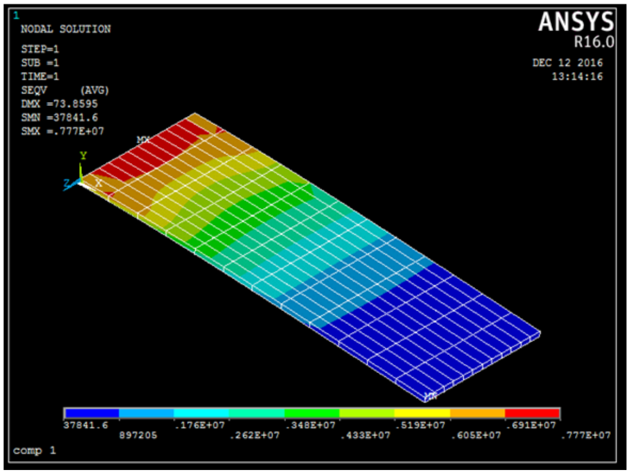
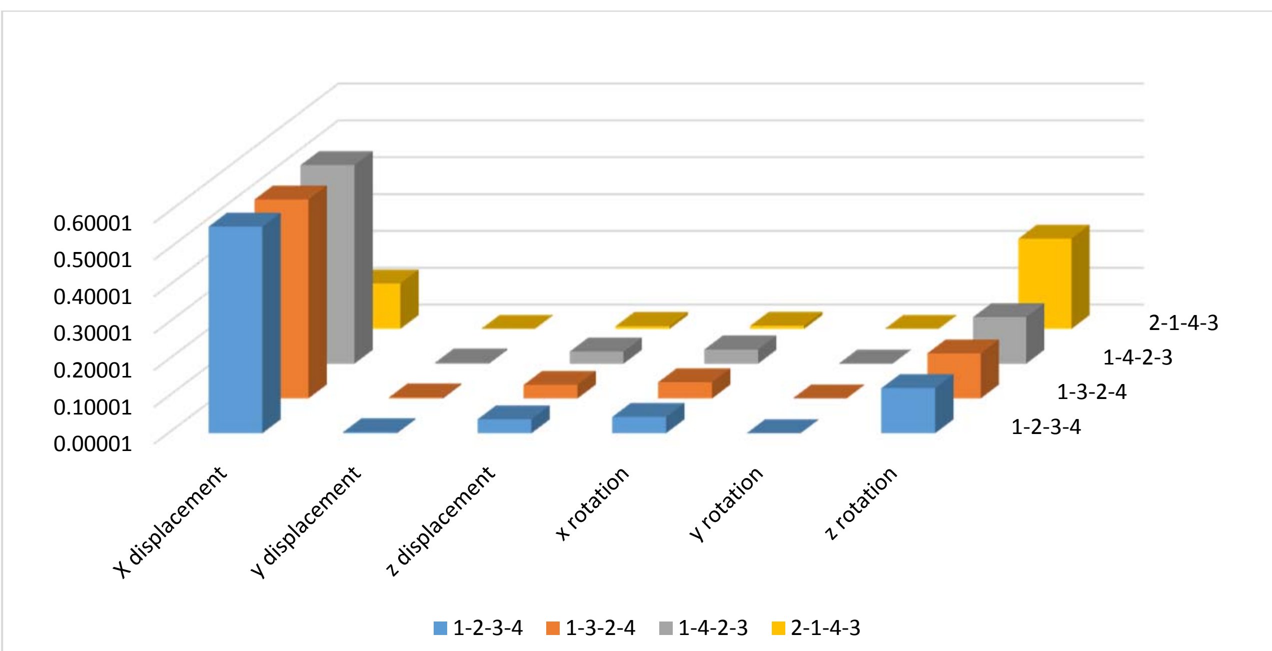


Fig. 12 Von-mises stress for 1-2-3-4

Table 3: Result of static load analysis

Composites	U_x	U_y	U_z	U	R_x	R_y	R_z	R	σ
1-2-3-4	0.56054	0.00295	0.03779	73.8995	0.04403	0.00014	0.12210	0.66245	$7.77x10^6$
1-3-2-4	0.54009	0.00296	0.03697	73.9912	0.04411	0.00011	0.12234	0.66362	$7.50x10^6$
1-4-2-3	0.53898	0.00290	0.03275	73.6879	0.03834	0.00007	0.12619	0.66135	$9.95x10^6$
2-1-4-3	0.12332	0.00001	0.00771	13.2722	0.00852	0.00005	0.24489	0.11863	$3.88x10^6$



Graph 1: Displacement and rotation in x, y, z direction

The table 3 showing the value of displacement, rotation and stress, here S represents the vector sum of displacement and R represents the vector sum of rotation at nodal position and σ represents the value of stress at the element. These results are obtained at the orientation for all composite would follow the same sequence as later i.e. 0^o, 45^o, 90^o, -45^o.

The graph 1 showing a graphical representation of the displacement and rotation in x, y and z direction. It is clearly giving a comparative view of U and R in all direction. It can easily visualize that the value of Ux is minimum in composite 4, Uy is minimum in composite 4, Uz is minimum in composite 4 and the value of Rx is minimum in composite 4, Ry is minimum in composite 4, Rz is minimum in composite 1.

3. CONCLUSION

From the table 3 and graph 1, we can easily conclude that the composites 4 was giving best result as per the displacement and rotation concern. In this composite, we were getting minimum value of displacement and rotation in all three directions as compared to other composite samples. So, these results are very useful to design a composite by using Silk, Bagasse, Jute and Banana fiber in the layup order as mention in table 2 with UDL and specified boundary conditions.

4. ACKNOWLEDGEMENTS

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