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BUCKLING AND POST BUCKLING ANALYSIS OF NATURAL FIBER REINFORCED POLYMERS

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ABSTRACT

The detailed investigation of buckling analysis of laminated composite plates using the finite element software ABAQUS. The obtained results are validated using the analytical solution from standard journal papers. The goal of this research is to determine the critical buckling load of natural fiber reinforced polymer plates subjected to uniaxial and biaxial compressive loading while varying plate parameters such as a/b (aspect ratio) = 0.5 to 1.5 with 0.5 increment, a/h (length to thickness ratio) = 10 and 100, and E1/E2 (orthotropic ratio) = 10 to 40 with 10 increments. The effect of changing the combination of support conditions on the plate's edges is investigated for the variables listed above. The effect of fiber angle orientation on mesh size for cross-ply and angle-ply with symmetric and antisymmetric stacking sequences will be determined by conducting a convergence test on a plate and changing the mesh size from coarser to finer until the converged mesh size is obtained. To determine the variation in critical buckling loads, the effect of increasing the number of lamina for constant length to thickness ratio, aspect ratio, orthotropic ratio, and boundary condition; for biaxial compressive loading is carried out.

INTRODUCTION

The main materials used in the modern world are composites, plastics, and ceramics. Composites have a significant advantage because they are created through engineering processes and are primarily useful for reducing weight and thus increasing efficiency. A composite material is made up of two or more materials that are in different phases. Impurities in metal can be represented in different phases and by definition considered as a composite in traditional engineering, but are not considered a composite because the modulus of strength is nearly the same as that of pure metal. Natural composites are the oldest known composites; wood consists of cellulose fiber in lignin composites, and human bone can be thought of as osteons embedded in interstitial bone matrix.

Composites are macro-scale materials made up of two or more chemically distinct constituents separated by a distinct interface. To form a composite, one or more discontinuous phases are embedded in a continuous phase [1]. Composites are primarily made up of two distinct materials, one of which is in particle, fiber, or sheet form, that are combined with another material known as a matrix. Because of its high strength modules, fiber in composites acts as the primary load carrying member, while matrix in composites acts as a load transfer medium between the fibers. Because of the composite's greater ductility, the matrix has a high toughness. A different author's definition can be summarized as follows.

Fiber reinforced composites are advanced composites made up of a polymer matrix reinforced with thin diameter fiber. If the reinforcement is in the form of fiber, the composite material is known as fiber reinforced composite. Fiber reinforced composites are advanced composites made up of a polymer matrix reinforced with thin diameter fiber. A fiber is distinguished by a length that is significantly greater than its cross-sectional dimensions. It is further classified into two types.

Short fiber reinforced composites:

It is made up of a matrix that has been reinforced by a dispersed phase in the form of discontinuous fibers (length 100 diameter). Composites with long fiber reinforcement It is made up of a matrix that is reinforced by a dispersed phase in the form of continuous fibers.

ABAQUS, Inc. was founded in 1978 and is the orld's leading provider of advanced Finite Element Analysis software and services used to solve real-world engineering problems. The ABAQUS software suite has an unrivalled reputation for technology, quality, and dependability, and it offers a powerful and comprehensive solution for both routine and complex linear and nonlinear engineering problems. ABAQUS provides a unified FEA environment that is a compelling alternative to multi-product and vendor implementations. In October of 2005 Dassault Systems, the world leader in 3-D and Product Lifecycle Management (PLM) solutions, acquired ABAQUS in its entirety. ABAQUS, Inc. employs over 525 people worldwide, with headquarters in Providence, RI, USA, and research and development centers in Providence and Sureness, France. ABAQUS has 29 technical support, sales, and service offices, as well as a network of distributors in emerging markets.

EXPERIMENT PROCEDURE

Implementation into Abaqus

The PFO model is implemented in Abaqus explicit via a user subroutine. The explicit solver allows the strain increment, and deformation gradient tensor to be fed into the subroutine for each progressive time step. Then the change of SCS and the fiber orientations during the current time step are determined by the user subroutine, using the deformation gradient tensor, as shown in figure (8). Next, the stiffness of the PFO can be obtained once those changes are determined. And the stiffness needs to be rotated to their material coordinate. These steps are repeated for every PFO. When all the PFO stiffness are rotated to their material frames, they are then summed up to get overall stiffness.

Multiply the strain increment with stiffness, the stress increment can be obtained for thetime step. A flow chart of this process can be seen Figure 9.

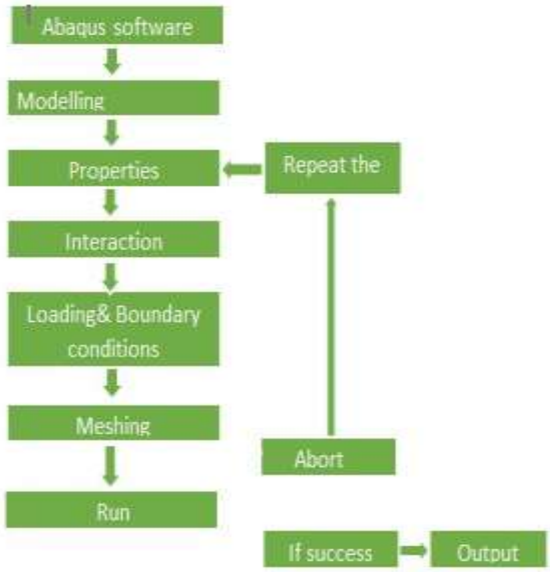

Fig. 1. Methodology for the experimental process.

The natural fiber reinforced polymer tested for the buckling analysis is first created with giving dimensions, orientation and thickness and number of layers for the specimen. And create the specimen. And create the module.

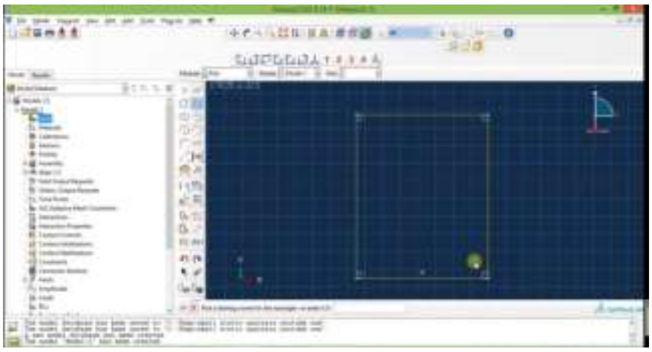

Fig. 2. Create a rectangular module

- Create part and create a rectangle and dimensions 300mm * 300mm and click on done.
- Now click on module and select property and select material, elasticity and type of engineering cost.
- Give composite lay-up and thickness of plate of 8 layers with each 0.2mm thick. And give thickness rotation.
- Then go to assemble and give the load conditions and boundary conditions (top plate, bottom plate, sides… etc)
- Finally run the buckling analysis and determine the maximum buckling values. And note it down.

Where E_{f11} and E_{f22} are the young's modulus of fiber in its fiber direction, and transverse direction. ν_{12} and G_{12} are the Poisson's ratio and shear modulus of fiber. E_m ν_m and G_{12} are the young's modulus, Poisson's ratio, and shear modulus of the matrix, respectively.

And then give the properties to the plate in the ABAQUS software. By clicking on the elastic properties.

Table.1 Properties of Caryota urens fiber

Property	Value
E1	120000 N/mm2
E2	9000 N/mm2
E3	9000 N/mm2
Nu12	0.28
Nu13	0.28
Nu23	0.40
G12	5000 N/mm2
G13	5000 N/mm2
G23	11000 N/mm2

Table.2 Properties of Sisal fiber

Property	Value
E1	120000 N/mm2
E2	9000 N/mm2

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E3	9000 N/mm2
Nu12	0.28
Nu13	0.28
Nu23	0.40
G12	5000 N/mm2
G13	5000 N/mm2
G23	11000 N/mm2

Table.3 Properties of Flax fiber

Property	Value
E1	120000 N/mm2
E2	9000 N/mm2
E3	9000 N/mm2
Nu12	0.28
Nu13	0.28
Nu23	0.40
G12	5000 N/mm2
G13	5000 N/mm2
G23	11000 N/mm2

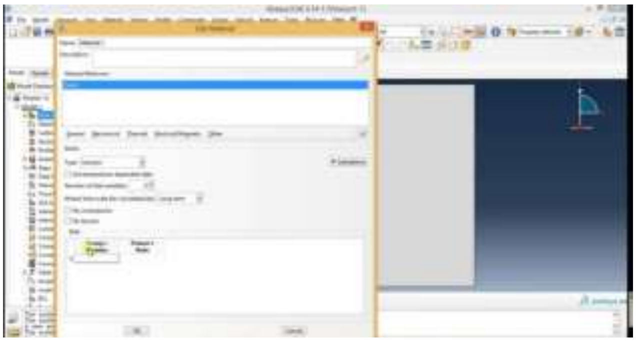

Fig 3. Properties window for adding.

Now give the load and boundary condition fpr the plate and select surface for top and bottom line. And complete the mesh part for the plat and finally complete the buckling analysis.

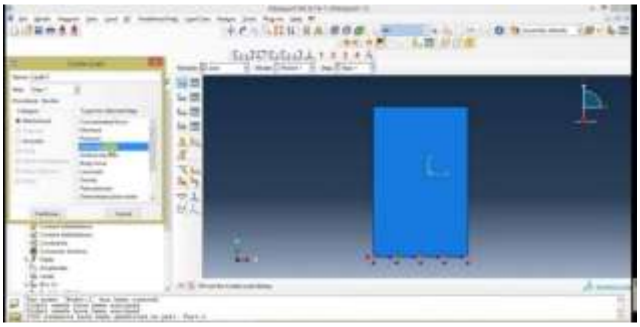

Fig 4. applying load or boundary conditions at bottom

Fig 5. applying load or boundary conditions at top plane

RESULTS

In the present study, buckling analysis of laminated composite plate is done using ABAQUS Software. The following investigations were made by calculating maximum buckling loads carried by the natural fiber reinforced polymers. Out of the selected polymers like Caryota urens, sisal and flax we conclude that Sisal fiber reinforced polymer is carrying more buckling loads with less lateral displacement.

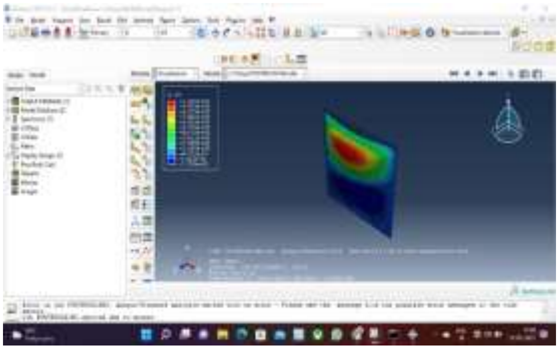

Fig 6. buckling behavior of Caryota urens fiber plate

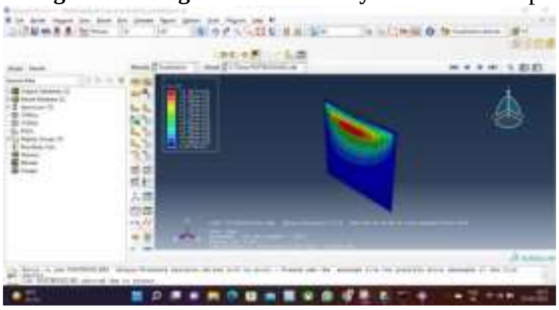

Fig 7. buckling behavior of Sisal fiber plate

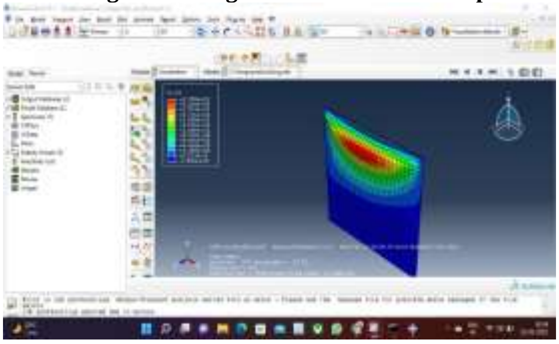

Fig 8. buckling behavior of Flax fiber plate

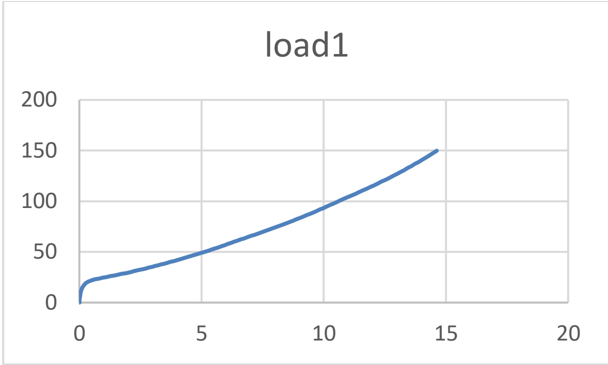

Fig 9. buckling loads of Caryota urens fiber plate

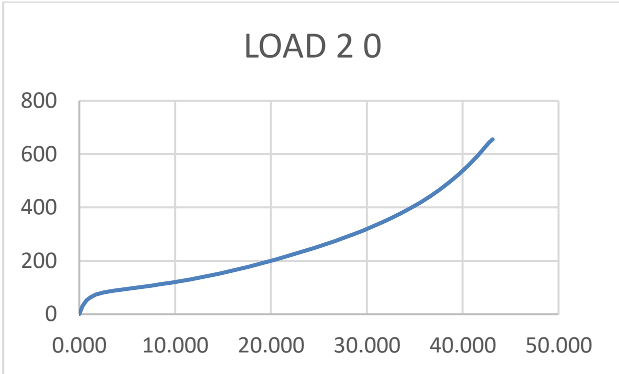

Fig 10. buckling loads of Sisal fiber plate

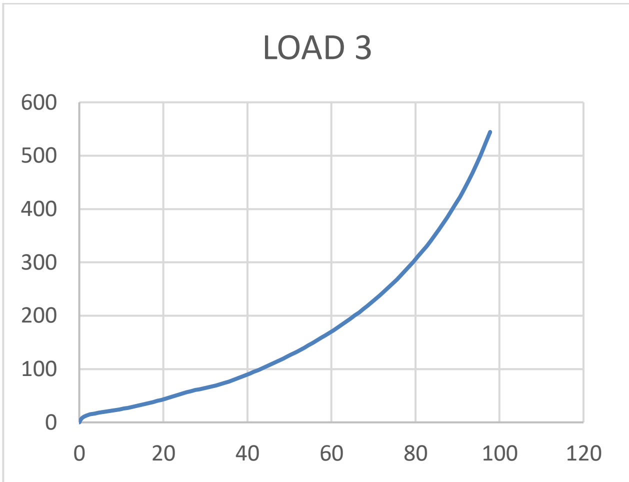

Fig 11. buckling loads of Flax fiber plate

RESULT COMPARISION

The buckling analysis of three natural fiber reinforced polymers are studied and plotted a graph based on the maximum buckling load carried by the Various natural fiber reinforced polymers as shown in the below graph or figure

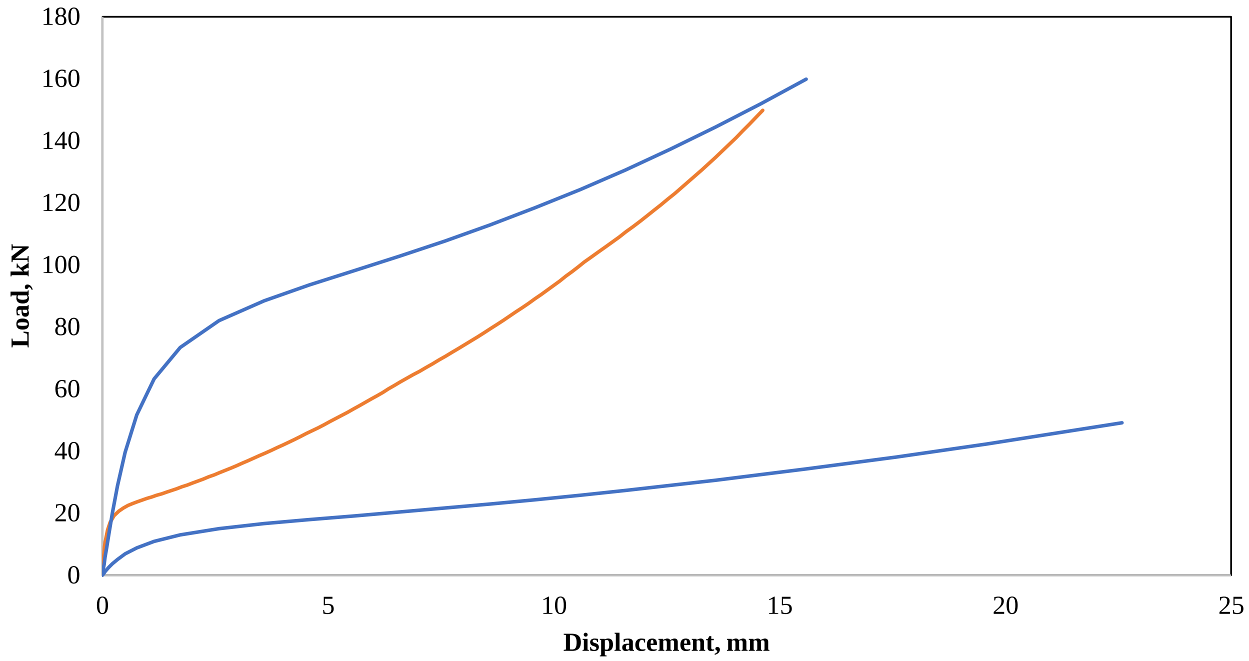

Fig 12. comparison buckling loads between sisal fiber and flax fiber

CONCLUSION

The below conclusions are derived from this study

- Based on the experiment done we had come to a conclusion that, flax fiber out of the other two fibers. Flax Fiber is carrying more buckling loads.
- Caryota urens fibers are subjected to low lateral displacement during loading. But not carrying more loads.
- Flax fiber had undergone high lateral displacement as well as carrying high buckling loads.

REFERENCES

[1] [Online]. Available: http://web.mit.edu/course/3/3.064/www/slides/composites_overview.pdf.
[2] W. a. B. P. Watt, Handbook of Composites, Vol. 1: Strong fibers, Amsterdam: North-Holland, 1985.
[3] G. H. Staab, Laminar Composites, Boston: Butterworth-Heinemann, 1999.
[4] R. M. Koide, G. v. Z. d. Franca and M. A. Luersen, "An ant colony algorithm applied to lay-up optimization of laminated composite plates," Latin American Journal of Solids and Structures, vol. 10, 2013.
[5] A. Yousefpour, "Fusion Bonding/Welding of Thermoplastic Composites," Journal of Thermoplastic Composite Materials, vol. 17, pp. 303-341, 2004.

ISSN: 2278-4632
Vol-12 Issue-01 No.01: 2022

[6] G. Schinner, "Recycling Carbon-Fiber-Reinforced Thermoplastic Composites," Journal of Thermoplastic Composite Materials, vol. 9, pp. 239-245, 1996.

[7] N. E. Kuuttila, "Composite Thermo-Hydroforming of Millitary Ballistic," East Lansing, 2014.

[8] R. Jones, "Chpater 4: Macromechanical Behavior of a Laminate," in Mechanics of Composite Materials, Washington D.C., Scripta Book Company, 1975, pp. 147-173.

[9] M. Zampaloni, "A multipreferred fiber orientation constitutive model for fiber mat- reinforced thermoplastics with a random orientation applied to the stamp thermohydroforming process," East Lansing, 2003.

[10] P. L. A. P. P.de Luca, "Numerical and experimental investigation of some press forming parameters of two fibre reinforced thermoplastics: APC2-AS4 and PEI-CETEX," Composite Part A: Applied Science and Manufacturing, vol. 29, no. 1-2, pp. 101-110, 1998.

[11] J. C. Xiongqi Peng, "A dual homogenization and finite element approach for material characterization of textile composites," Composites Part B: Engineering, vol. 33, no. 1, pp. 45-56, 2002.

[12] X. P. J. C. Pu Xue, "A non-orthogonal constitutive model for characterizing woven composites," Composites Part A: Applied Science and Manufacturing, vol. 34, no. 2, pp. 183-193, 2003.

[13] P. X. X. P. N. K. Jian Cao, "An approach in modleing the temperature effect in thermo-stamping of woven composites," Composite Structures, vol. 61, no. 4, pp. 413-420, 2003.

[14] Y. W. X. P. J. W. S. W. zhenyi Yuan, "An analytical model on through-thickness stresses and warpage of composite laminates due to tool–part interaction," Composites Part B: Engineering, vol. 91, pp. 408-413, 2016.

[15] A. International, "Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials," ASTM International , 2008.

[16] "Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method," ASTM International, 2012.

[17] A. International, "Standard Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method," ASTM International, 2012.

[18] W. Yan-lei, "Evaluation of in plane shear test methods for composite material laminates," Journal of Chongqing University, vol. 6, pp. 221-226, 2007.

[19] J. C. X. L. J. S. Lu Liu, "Two-dimensional macro-mechanics shear models of woven fabrics," Composites Part A: Applied Science and Manufacturing, vol. 36, no. 1, pp. 105-114, 2005.

[20] M. H. Hassan Alshahrani, "A new test method for the characterization of the bending behavior of textile prepregs," Composites Part A: Applied Science and Manufacturing, vol. 97, pp. 128-140, 2017.

[21] S. W. Tsai, "Mechanics of Composite Materials," Part II, Technical Report AFML- TR-66-149.

ISSN: 2278-4632
Vol-12 Issue-01 No.01: 2022

[22] C. L. a. M. B. U. Mohammed, "Experimental studies and analysis of draping of woven fabrics," Composites: Part A, vol. 31, pp. 1409-1420, 2000.

[23] R. A. M. R. F. P. R.M.J.S Sidhu, "Finite element analysis of textile composite preform stamping," Composite Structures, vol. 52, no. 3-4, pp. 483-497, 2001.