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VIBRATION ANALYSIS OF BIO-DEGRADABLE COMPOSITE WITH A NUMBER OF LAYERS

Ashwitha Itha
MTech-2nd Year,
Department of Aeronautical Engineering
Malla Reddy College of Engineering and Technology,
Maisammaguda, Hyderabad, Telangana, India, 500100

D. Smitha
Associate Professor
Department of Aeronautical Engineering
Malla Reddy College of Engineering and Technology,
Maisammaguda, Hyderabad, Telangana, India, 500100

Sachin Srivastava
Assistant Professor
Department of Aeronautical Engineering
Malla Reddy College of Engineering and Technology,
Maisammaguda, Hyderabad, Telangana, India, 500100

Abstract—**Modern scientists are now focusing their research on materials that are naturally biodegradable and kind to the environment. Bio-composite materials formed of natural/regular fiber materials and resins, or a mixture of both, are regarded as one of the key accomplishments in the diverse field of experimental work as we are aware that concerns about natural protections are growing worldwide. The two stages of the composited make up the majority of its constituents: 1) Matrix, and 2) Binder. Natural fiber composites have received a lot of attention from scientists throughout the world due to the availability of the necessary characteristic fiber and the ease of assembly. The Mechanical APDL Analysis tool is used to create the desired model, which has different layers (3, 4, 6, and 8 accordingly). To compare the results, the natural frequencies of each individual layer are taken into consideration and documented in a tabular data format. Both eigen buckling analysis and modal analysis are successfully performed on the desired model. The reference research paper demonstrates the buckling loads for glass fiber with various layers made up of various orientations.**

The main objective of the project is to create a bio-composite with Bamboo fiber and Rice Husk as filler and to perform the vibration analysis with different layers and Eigen buckling analysis. Natural frequencies are obtained from vibration analysis and buckling loads are obtained from Eigen buckling analysis thus for a better understanding of the dynamic behavior of components made from fiber-reinforced composite materials, specifically for the case of plates.

This study contributes to a better& more realistic understanding of the dynamical behavior of plates formed of fiber-reinforced composite materials in order to prevent structural damage imposed on or induced by undesirable vibrations.

Keywords—**Environment agreeable, Composite, Fiber-Reinforced, Vibrations, frequency, Matrix, Biodegradable, Natural frequencies, Orientation.**

I. INTRODUCTION

A composite material is a high-strength material that is created by fusing together two or more materials with different chemical and physical characteristics in order to create a material with a combination of both. The composites generally differ from mixes and solid solutions in that the various components stay distinct and separated within the final structure. For a variety of reasons, new materials might also be taken into consideration. Materials that are lighter, stronger structurally, and less expensive economically than primary materials are a few examples that are frequently utilized. Composite materials are widely employed in spacecraft, the aircraft industry, bridges, the construction sector, and other structures.

Fiber-reinforced composites, high-performance composites, high-strain composites, matrix composites, thermoplastic and

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thermosetting composites, etc. are among the main categories of composites. It basically consists of reinforcement and a matrix. By retaining its spatial orientation, the matrix surrounds and supports the reinforcement.

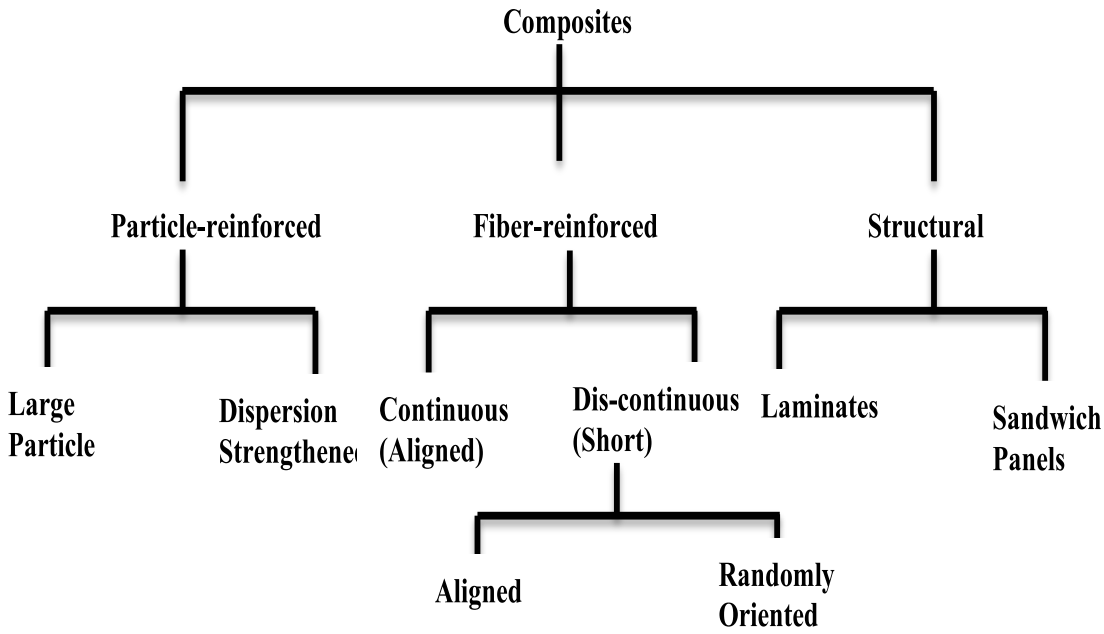

Fig. 1. Types of composites

On the basis of such considerations, the algorithm uses a different color image multiplied by the weighting coefficients of different ways to solve the visual distortion, and by embedding the watermark, wavelet coefficients of many ways, enhance the robustness of the watermark.

A. **Advantages of Composites:**

- High specific strengths compared to metals, non-metals, and even alloys.
- Lower specific gravity in general criterion.
- Despite being exposed to extreme temperatures, composites maintain their weight.
- Stiffness &Toughness is exponentially improved.
- Fabrication or production is relatively economical.
- Strength against creep and fatigue is increased.
- Controlled Electrical conductivity is facilitated.
- Corrosion and oxidation resistance are achieved.

B. **Dis-advantages of Composites:**

- Many composites exhibit anisotropic properties, which implies that they vary depending on the measurement direction that is selected.
- Chemicals and electrolytic solvents attack a large number of polymer-based composites.
- The cost of composite materials is high.
- The manufacturing methods used to create composite materials tend to be costly and time-consuming.

C. **Applications of Composites:**

- Spacecraft: Antenna structures, solar reflectors, Satellite structures, Radar, Rocket engines, etc.
- Aircraft: Jet engines, Turbine blades, Turbine shafts, Compressor blades, Airfoil surfaces, Wing box structures, Fan blades, Flywheels, Engine bay doors, Rotor shafts in helicopters, Helicopter transmission structures, etc.
- Automobile: Engines, bodies, pistons, cylinder, connecting rod, crankshafts, bearing materials, etc
- Miscellaneous: Pressure vessels, Electrical machinery, Truss members, Cutting tools, bearing materials, Electrical brushes, Abrasive materials, etc.

D. **Failure of Composite Materials:**

- Failure under longitudinal compressive loading.
- Failure under longitudinal tensile loading.
- Failure under transverse compressive loading.
- Failure under transverse tensile loading.

II. BIO-COMPOSITES

A bio-composite is a substance composed of a matrix (resin) and reinforcement from natural fibers (which is frequently derived from plants or cellulose), with applications in tissue engineering, aesthetically pleasing orthodontics, and the biomedical field. They often mimic the living material structures involved in the process of improving the matrix's characteristics while maintaining biocompatibility, such as when constructing an arena in bone tissue engineering. The progressive rise in oil prices, the need for recycling, and other environmental concerns are all leading to the significant development of such sectors. The substitution of natural fiber (like wood fibers, hemp, sisal, jute, or flax) for the bolsters (such as fiberglass, carbon fiber, or talc) and/or the substitution of a vegetable or animal resin for the petrochemical resin are both characteristics of bio-composites.

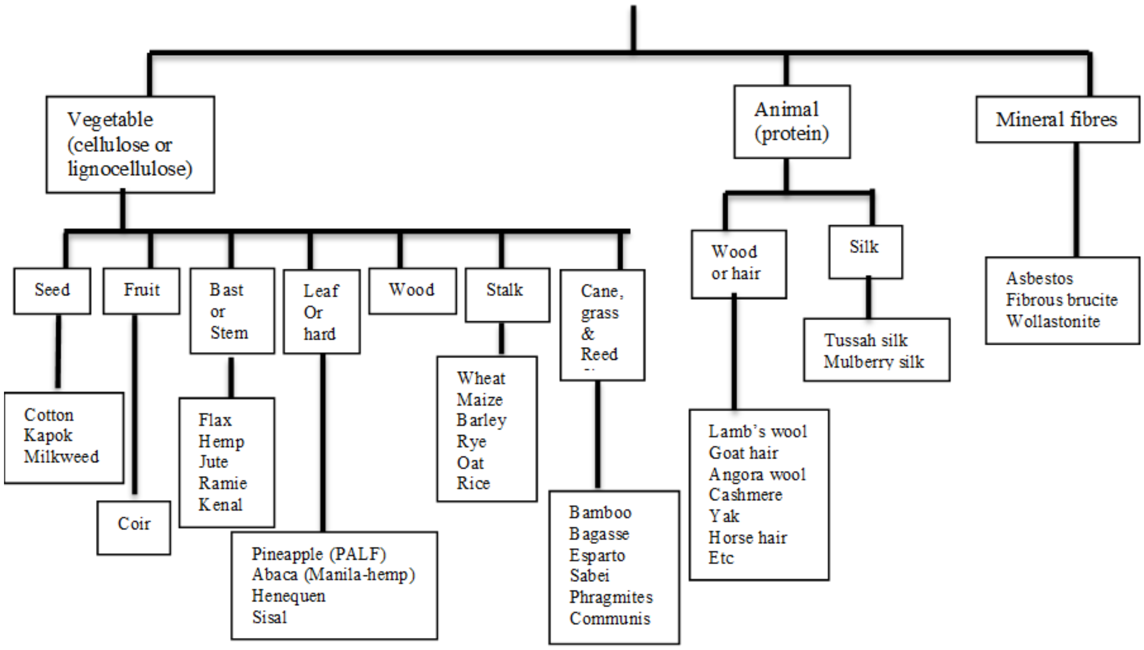

Fig. 2. Types of natural fibers

A. **Applications of Bio-Composites:**

- They have fire resistance.
- Natural fibers do not release hazardous fumes when they are burned.
- Natural fibers are easily and reasonably priced.
- Because these fibers absorb moisture and perspiration, summertime clothing made of them is comfortable.
- Natural fibers are biodegradable and safe for human skin.

III. LITERATURE SURVEY

[1] Ain U. Md Shah, Mohamed T.H. Sultan, Mohammad Jawaid, Francisco Cardona, and Abd R. Abu Talibet al. (2017) concluded that Bamboo fibers have excellent tensile characteristics and can take the place of traditional glass in reinforcing polymer matrices. Eco-friendly products are created when bamboo fibers are used instead of synthetic fibers, notably in terms of energy usage and solid waste disposal.

[2] Motohiro Sato, Akio Inoue, and Hiroyuki Shimaet al. (2017) determined the best design strategy for bamboo-like wild plants in order to create fiber-reinforced cylindrical composites. According to the hypothesis they have established, switching from a parabolic to a linear gradation with increasing the mean volume fraction of the fibers will result in the most efficient distribution of reinforcing fibers in the radial direction..

[3] Del Masto et al. (2017) discovered a connection between the tensile characteristics and the natural fiber's cross-section. They used several elliptical cross-sections of hemp fiber to model and assess its tensile behavior. The outcome demonstrated that the degree of ellipticity is significantly influenced by the tensile characteristics. The geometry of the natural fiber was significantly influenced by the micro fibril angle and the viscoelastic characteristics.

[4] Zhong et al. (2017) evaluated the damage prediction of unidirectional flax/polypropylene composites with a multiscale RVE model. The micro scale RVE model was initially developed in order to account for the decrease in stiffness and damage to the fiber/matrix. The bending and tensile behavior was then assessed using macroscale modeling.

[5] Reza Arjmandi, Azman Hassan, Khaliq Majeed, and Zainoha Zakariaet al. (2015) worked on a better understanding of the use of polymer blends as the matrix and secondary fillers in controlling the properties of polymer composites would provide interesting areas to be investigated.

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[6] Fu et al. (2014) developed a finite element model to investigate the shear capability of bamboo using brittle fracture mechanics with the assumption that bamboo has a gradient elastic modulus. Chand et al. (2018) used modelling and experimental to confirm the tensile and bending behaviour of bamboo.

[7] According to Phong et al. (2013), the characteristics of carbon fabric composites composed of neat epoxy and modified epoxy with MBF were compared. Plain woven carbon fiber was used to prepare the composites by a manual lay-up process. As the MBF percentage rose, the tensile strength of CF/EP composites remained essentially unchanged, with just a minor rise. When compared to the original composite, the modified composite's Young's modulus had a higher value.

[8] According to Abdul Khalil et al. (2012), the usage of bamboo fibers in a variety of applications has created new opportunities for academics and businesses to create a sustainable bamboo fiber module..

[9] Sen and Reddy et al. (2011), Mahdavi et al. (2012), and Suhaily et al. (2016) came to the conclusion that natural fiber composites' low cost, environmental friendliness, accessibility, and ease of production make them appealing for design development and applications.

IV. METHODOLOGY

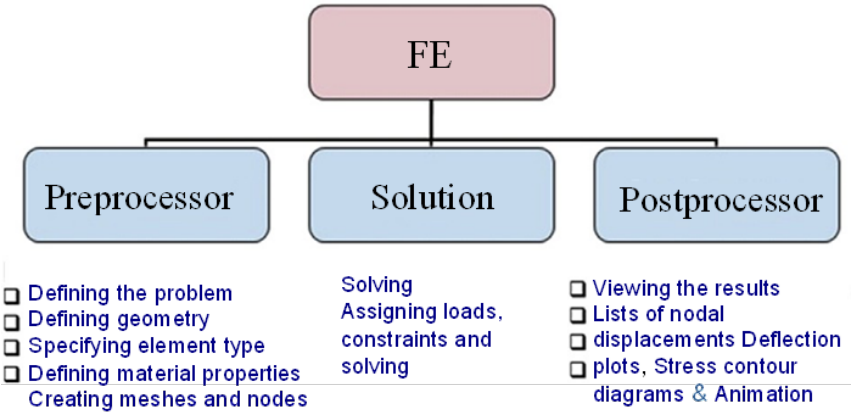

Fig. 3. Overview of finite element analysis (FEA)

ANSYS is used to analyze the critical buckling load of composite laminate plates of four orientations. The dimension of the specimen was constant for all laminates and the dimensions are 200*100* 2mm in length, breadth, and thickness. And they have the laminate fiber orientation is as follows:

I. [0/45/90/-45]º
II. [45/90/-45/0]º
III. [90/-45/0/45]º
IV. [-45/0/45/90]º

An eigenvalue buckling analysis was done to determine the critical buckling load. Eigen-value buckling analysis predicts the breaking point (the critical buckling load) of an ideal linear elastic structure. Eigen-value buckling analysis in ANSYS has the following steps:

A. Designing the Model:

This step includes assigning the element type, material properties, and modeling.

- Element type:Shell281
- Material properties:

Fiber	Glass fiber
Ex (Gpa)	29
Ey (Gpa)	5.3
Ez (Gpa)	5.3
PRxy	0.44
PRyz	0.44
Gxy (Gpa)	5.11
Gyz (Gpa)	5.11

s

- Section: In sections, different layers are laid up for our required model. Four layers are added and different orientations are given. The thickness of each layer is given as 0.00025m (whole model of 2mm).
- Modeling: Here a rectangle with 0.2x0.1m is created.
- Meshing: The above model is meshed with a free mesh option.

B. **Solution (Static Analysis):**

It includes applying boundary conditions, applying loads, and static analysis. The applied BC is that the left end is fixed in all directions and the right end is fixed in Z direction. A force of 1N acted along the negative X-axis.

C. **Eigen Buckling Analysis:**

It provides a theoretical buckling strength to the linear elastic structure.

D. **Post-Processor:**

This step includes listing buckling loads and viewing the buckling shapes.

- Deformation of model:

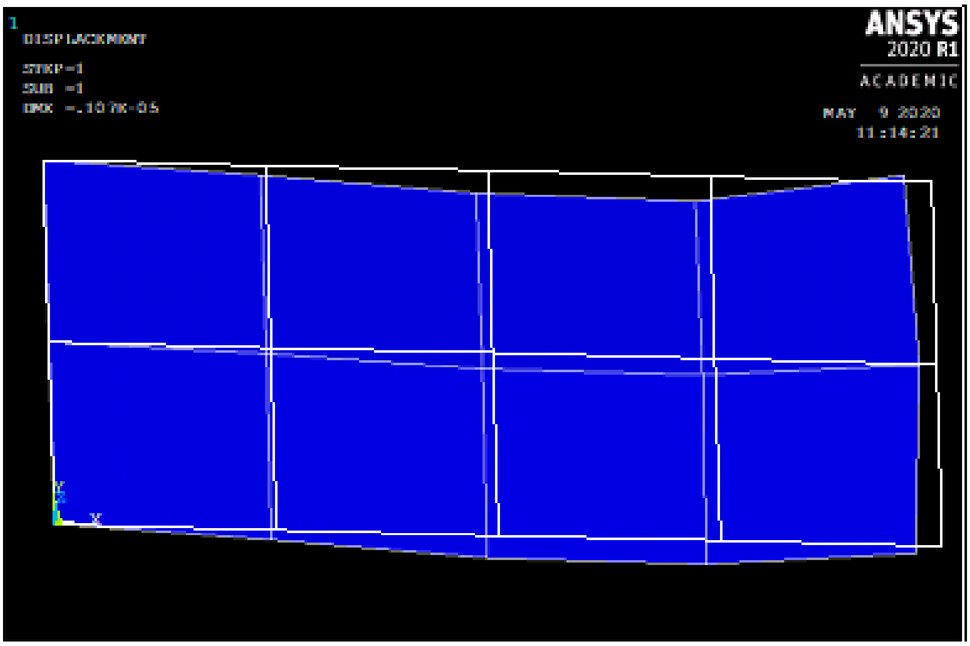

Fig. 4. Deformation of model

- Nodal solution:

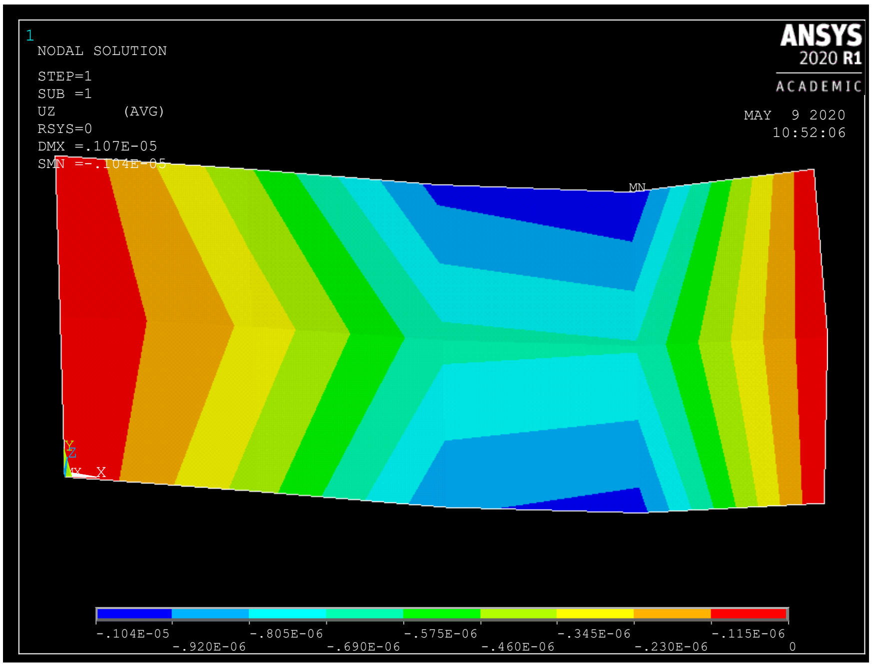

Fig. 5. Nodal solution for laminate for 1st model

V. MODAL ANALYSIS

A. Designing the Model:

This step includes assigning the element type, material properties, and modeling.

- Element type: Shell281
- Material properties:

Fiber	Untreated fiber	Fiber with 6 wt% of rice husks	Fiber with 10 wt% of rice husks
Ex (Gpa)	9.8	11.2	6.1
Ey (Gpa)	8.2	8.8	5.2
Ez (Gpa)	8.2	8.8	5.2
PRxy	0.278	0.278	0.278
PRyz	0.013	0.013	0.013
Gxy (Gpa)	1.726	1.726	1.726
Gyz (Gpa)	1.726	1.726	1.726

- Section: In sections, different layers are laid up for our required model. Fiber with different layers is taken such as 3,4,6,8 layers respectively.
- Modeling: Here a rectangle with 1.5x0.8m is created.
- Meshing: The above model is meshed with the mesh tools option.

B. Solution (Modal Analysis):

- Solution type: Modal analysis
- Loads: Left end is fixed

C. **Post-Processor:**

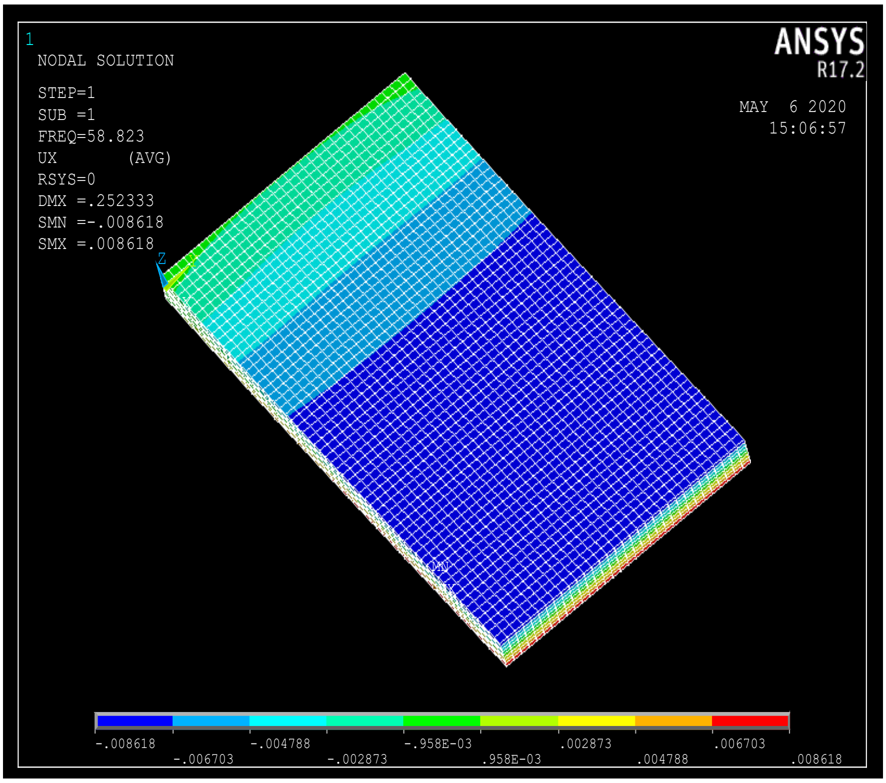

Fig. 6. Mode-1 Contour

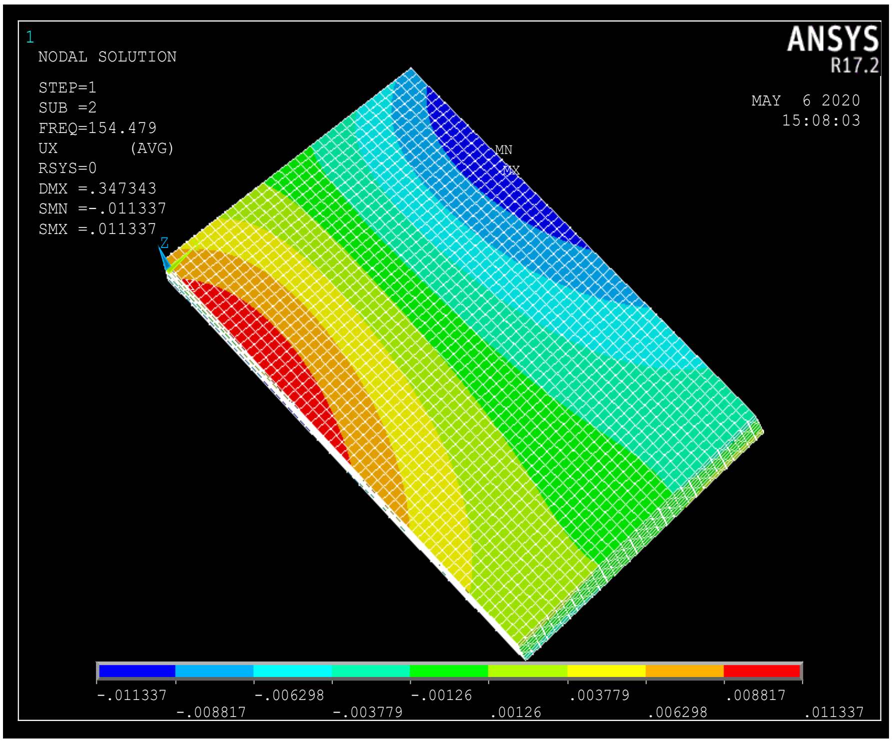

Fig. 7. Mode-2 Contour

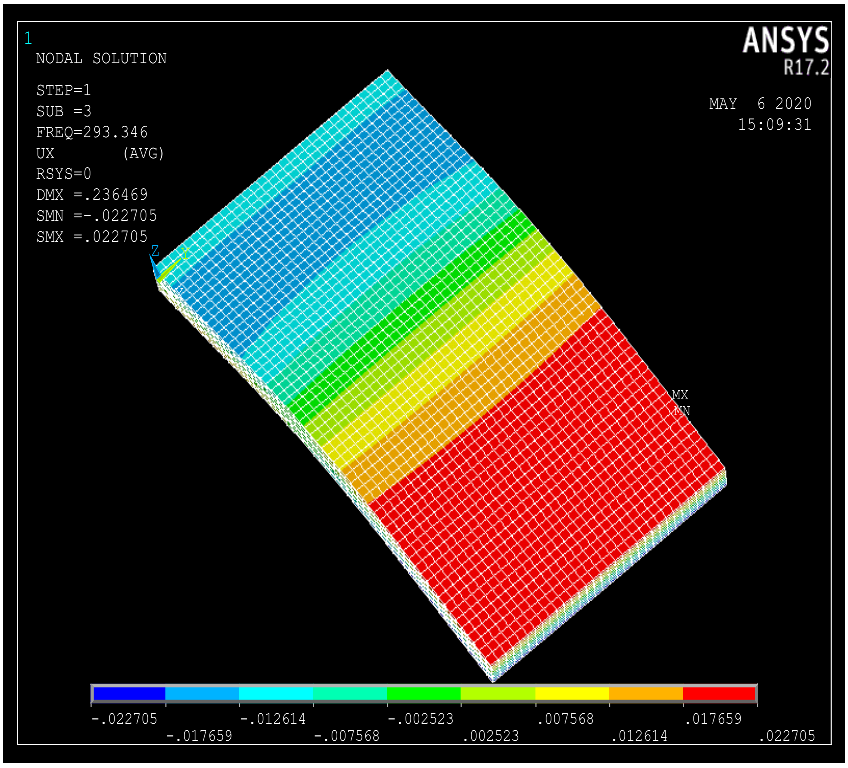

Fig. 8. Mode-3 Contour

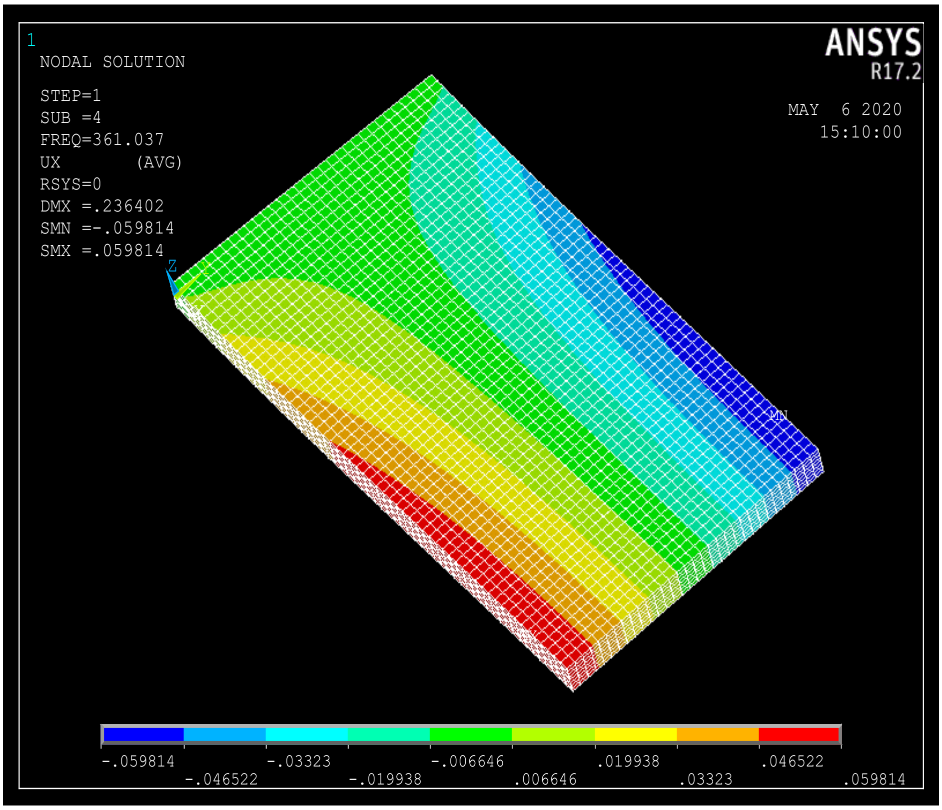

Fig. 9. Mode-4 Contour

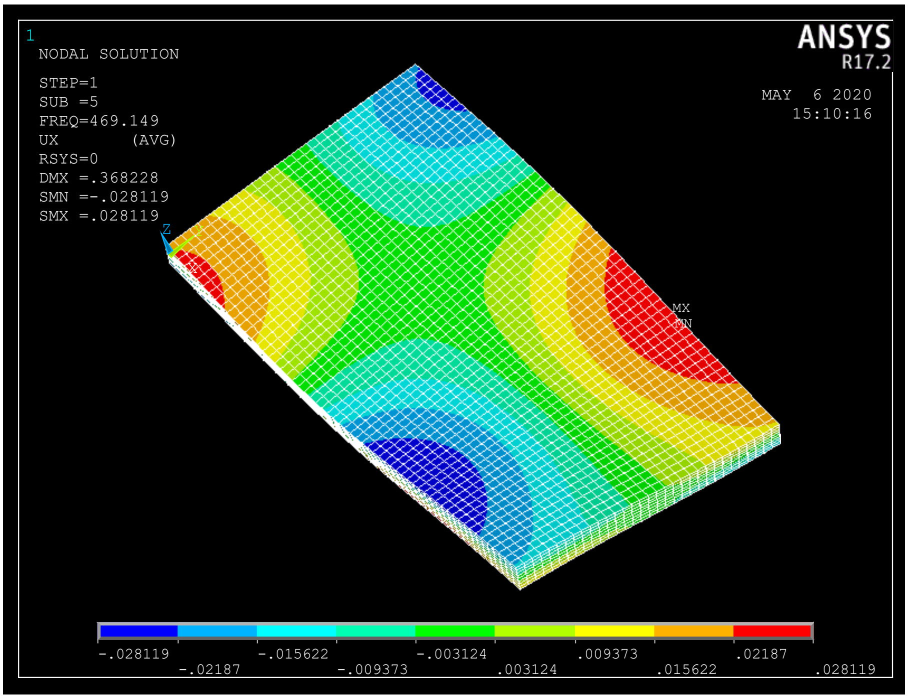

Fig. 10. Mode-5 Contour

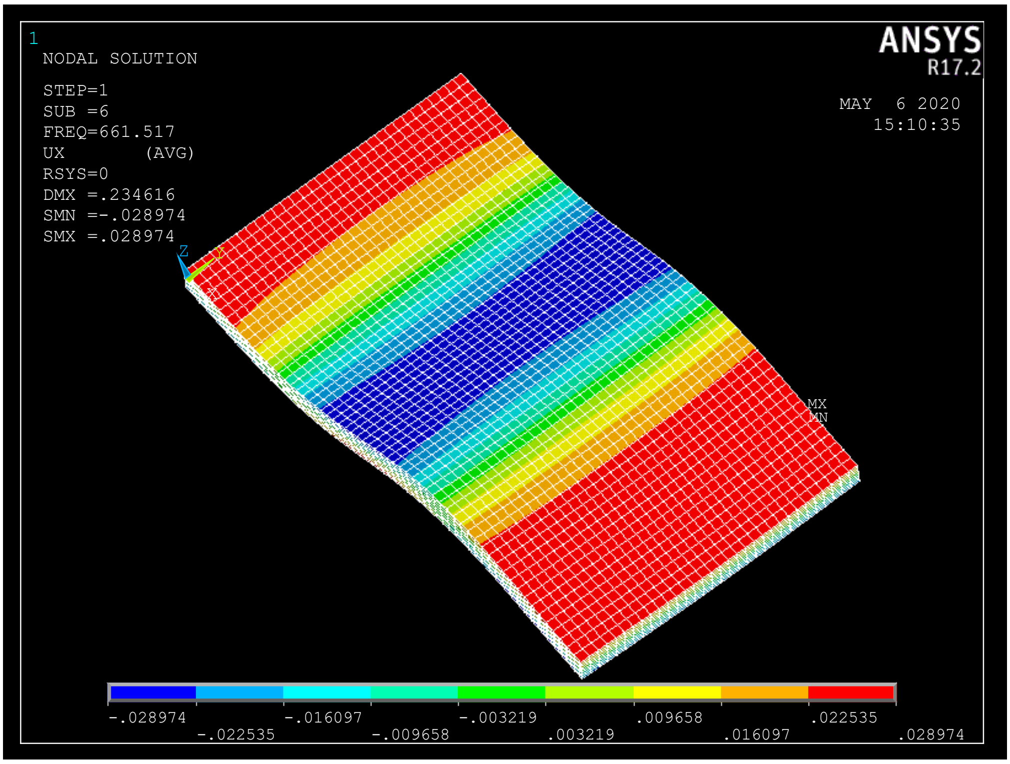

Fig. 11. Mode-6 Contour

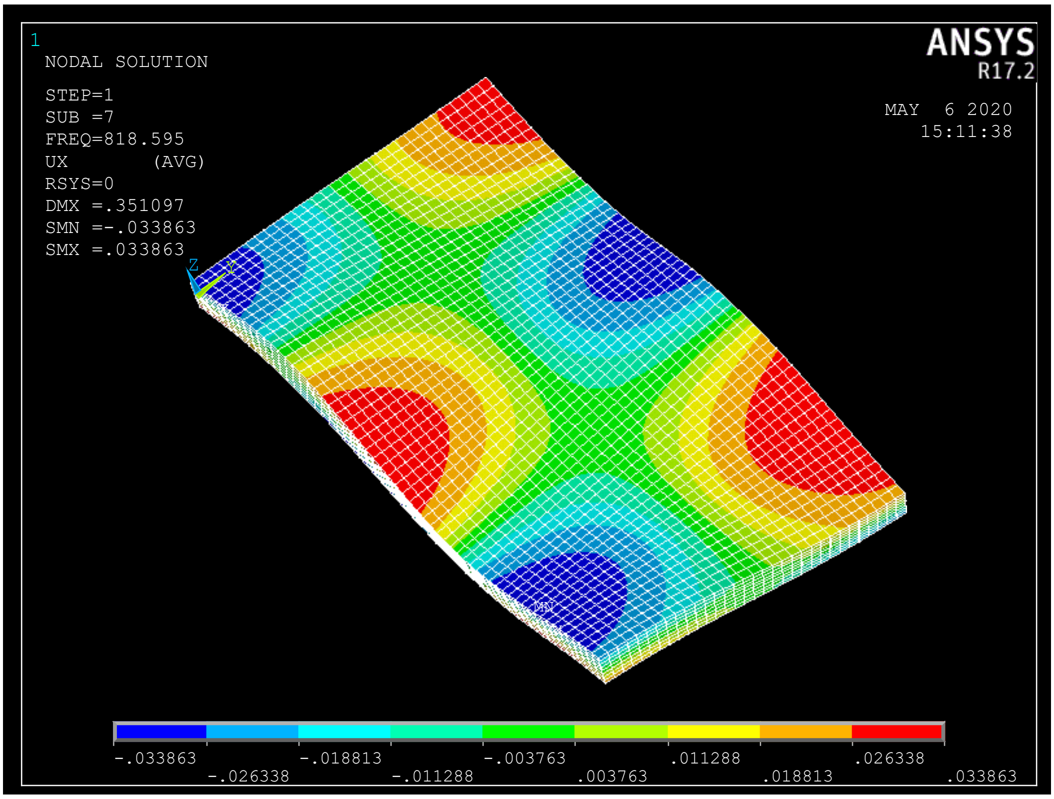

Fig. 12. Mode-7 Contour

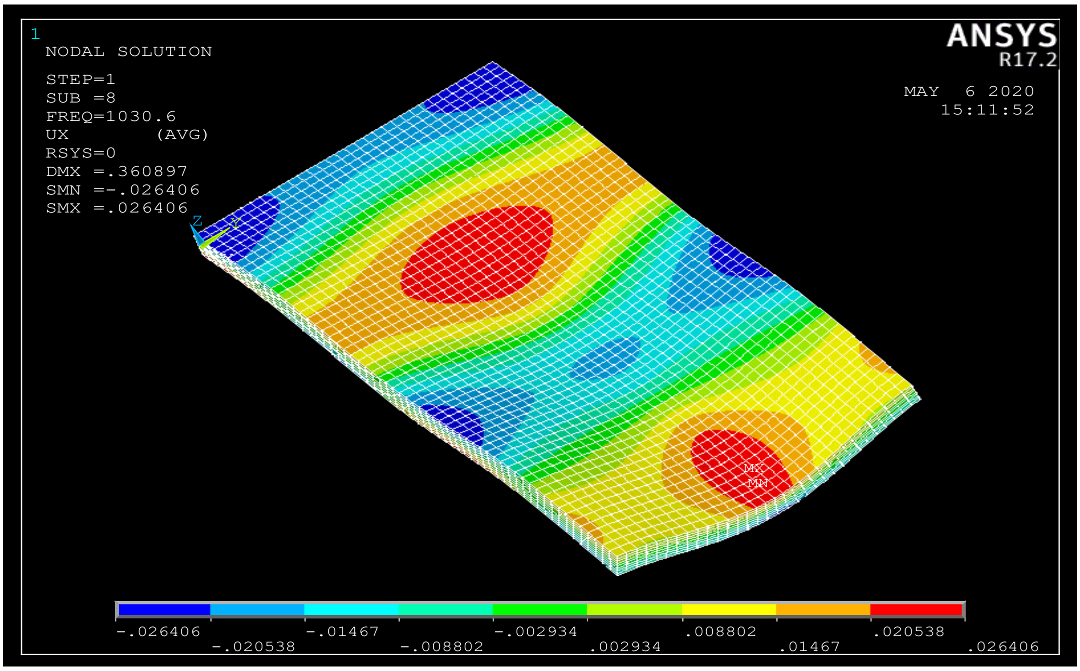

Fig. 13. Mode-8 Contour

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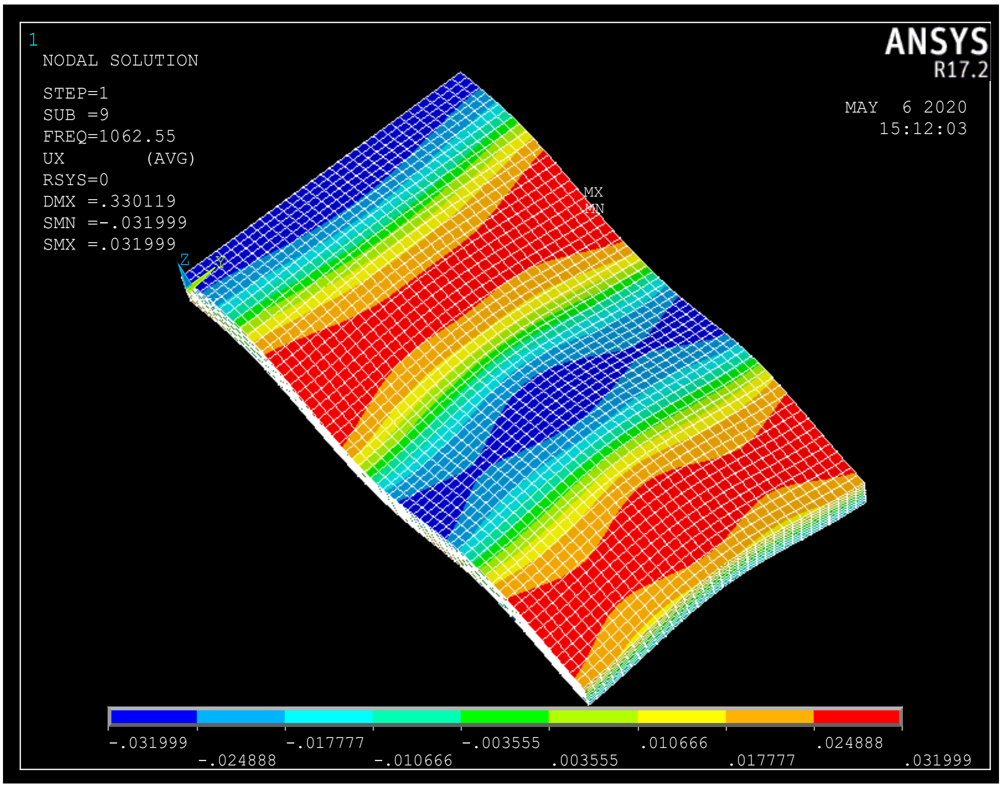

Fig. 14. Mode-9 Contour

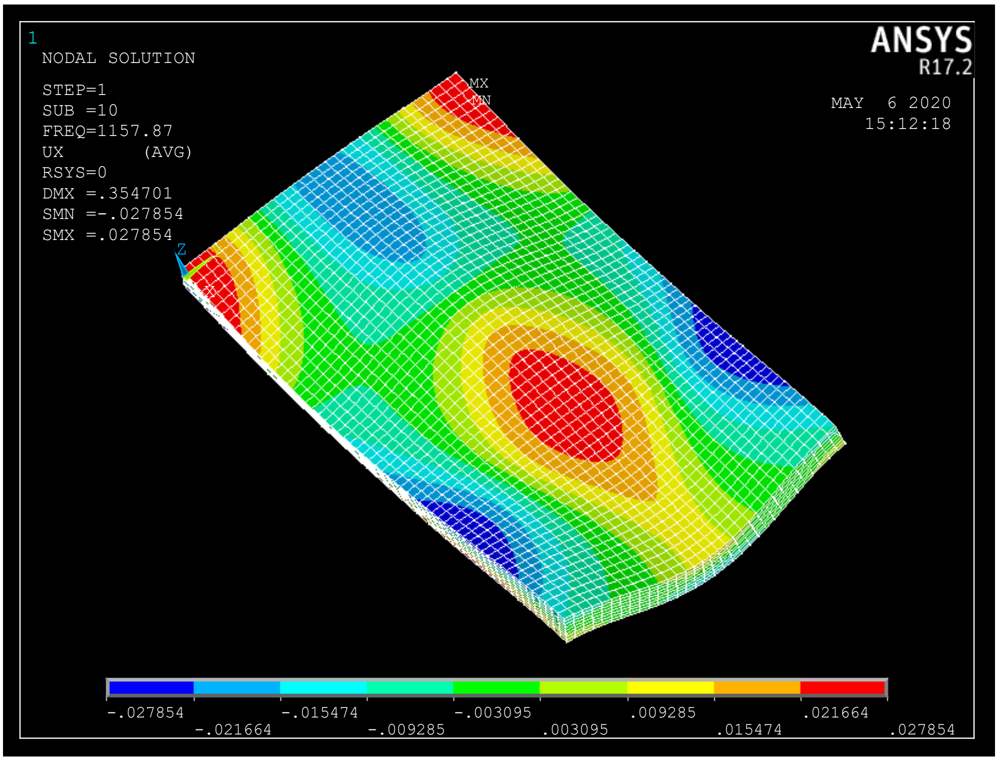

Fig. 15. Mode-10 Contour

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VI. RESULTS AND DISCUSSION

Table -1 Comparison of obtained results with that of the research paper

Modes	Analysis results				Research paper results			
Orientation	[0/45/ 90/-45]	[45/90/ -45/0]	[90/-45/ 0/45]	[-45/ 0/45/90]	[0/45/9 0/-45]	[45/90/ -45/0]	[90/- 45/0/45]	[-45/0 /45/90]
1	142.75	142.75	127.09	127.09	143.2	143.2	76.243	76.243
2	556.94	556.94	291.04	291.04	523.58	523.58	298.54	298.54
3	954.66	954.66	672.45	672.45	1023.8	1023.8	671.13	671.13
4	1141.1	1141.1	843.70	843.70	1127.1	1127.1	903.14	903.14

- Natural frequencies of Bamboo fiber with 3 layers:

0	0
1	58.823
2	154.48
3	293.35
4	361.04
5	469.15
6	661.52
7	818.59
8	1030.6
9	1062.5
10	1157.9

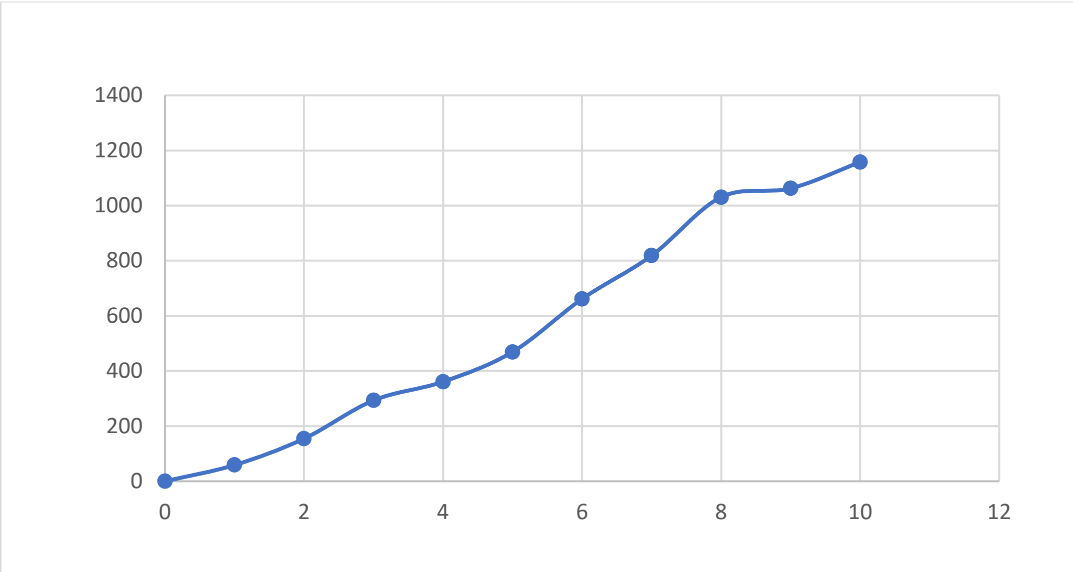

Fig. 16. Plot of frequencies Bamboo fiber with 3 layers

- Natural frequencies of Bamboo fiber with 4 layers:

0	0
1	44.42
2	125.04
3	244.1
4	387.6
5	395.46
6	587.14
7	727.09
8	902.99
9	982.42
10	1035

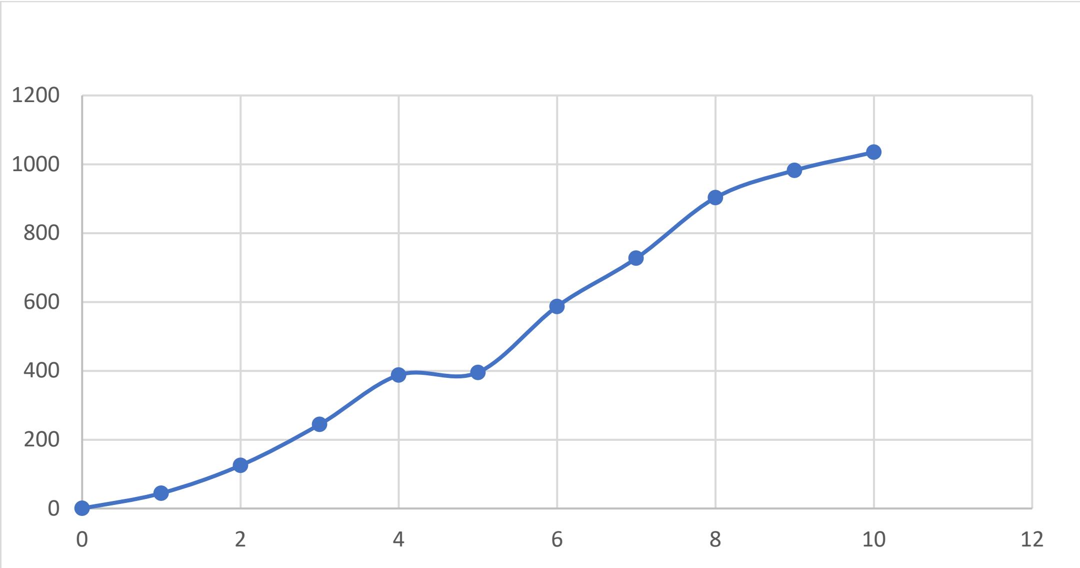

Fig. 17. Plot of frequencies Bamboo fiber with 4 layers

- Natural frequencies of Bamboo fiber with 6 layers:

0	0
1	30.617
2	90.265
3	178.09
4	294.22
5	361.03
6	452.3
7	564.17
8	683.17
9	781.57
10	810.47

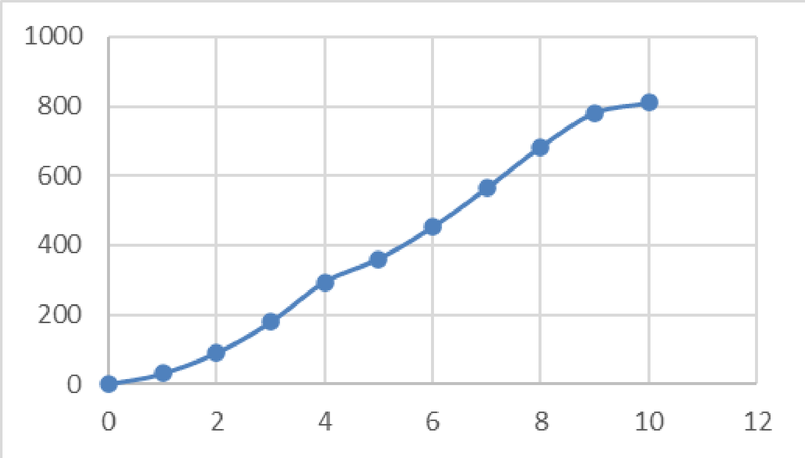

Fig. 18. Plot of frequencies Bamboo fiber with 6 layers

- Natural frequencies of Bamboo fiber with 8 layers:

0	0
1	22.698
2	69.024
3	136.69
4	230.08
5	362.22
6	382.6
7	456.48
8	538.47
9	633.63
10	672.53

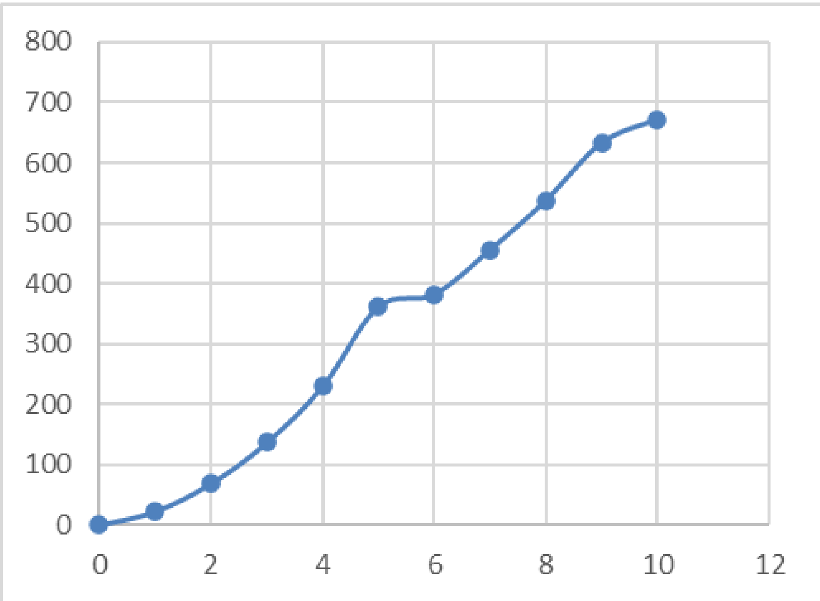

Fig. 19. Plot of frequencies Bamboo fiber with 8 layers

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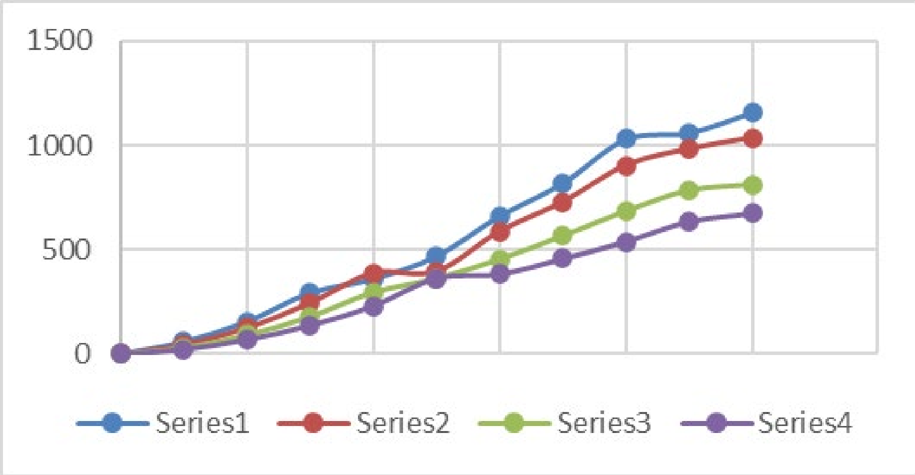

Fig. 20. Plot of cumulative frequencies of Bamboo fibers

- Natural frequencies of fiber with 6 wt% of rice husk with 3 layers:

0	0
1	82.323
2	155.01
3	168.18
4	347.27
5	503.58
6	512.17
7	608.11
8	736.89
9	864.72

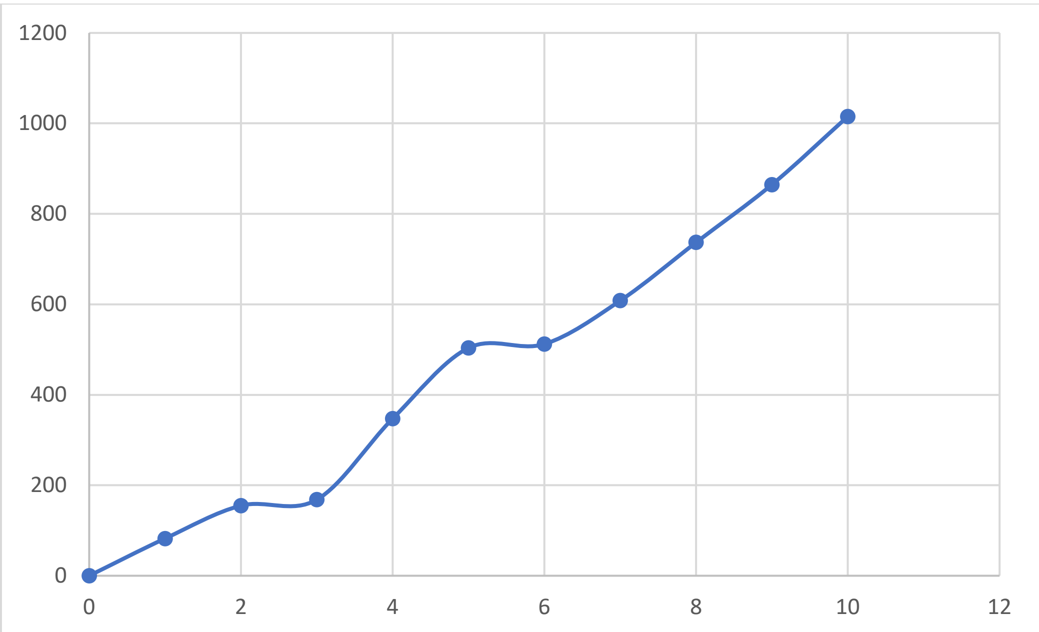

Fig. 21. Plot of frequencies of fiber with 6 wt% RH with 3 layers

- Natural frequencies of fiber with 6 wt% of rice husk with 4 layers:

0	0
1	112.43
2	162.56
3	201.02
4	416.12
5	542.66
6	598.31
7	626.67
8	856.42
9	1000.3
10	1081.7

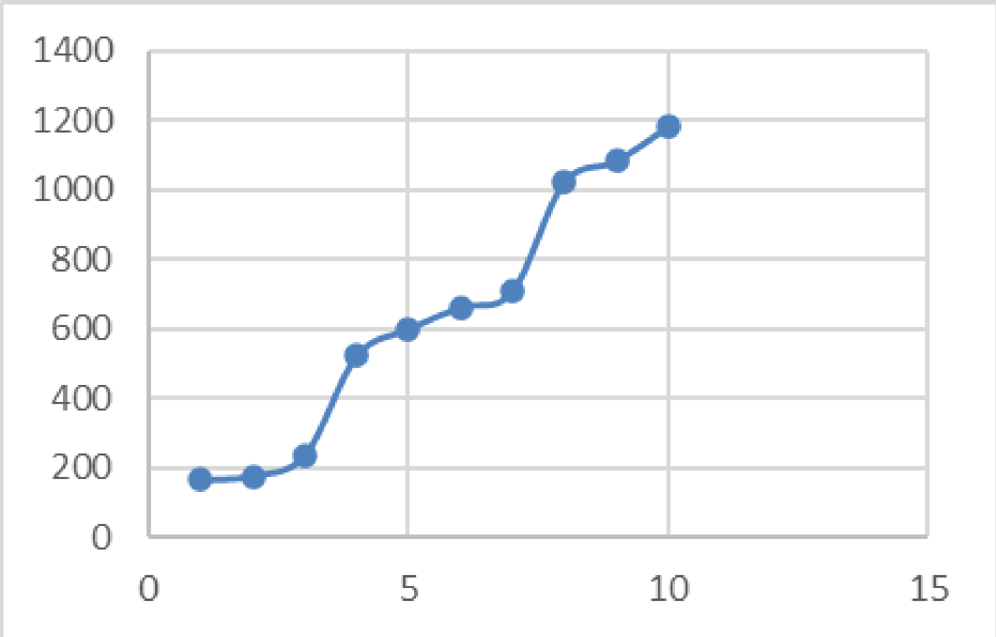

Fig. 22. Plot of frequencies of fiber with 6 wt% RH with 4 layers

- Natural frequencies of fiber with 6 wt% of rice husk with 6 layers:

0	0
1	164.16
2	176.26
3	235.41
4	522.25
5	598.88
6	662.1
7	706.48
8	1021.3
9	1082.9
10	1180.9

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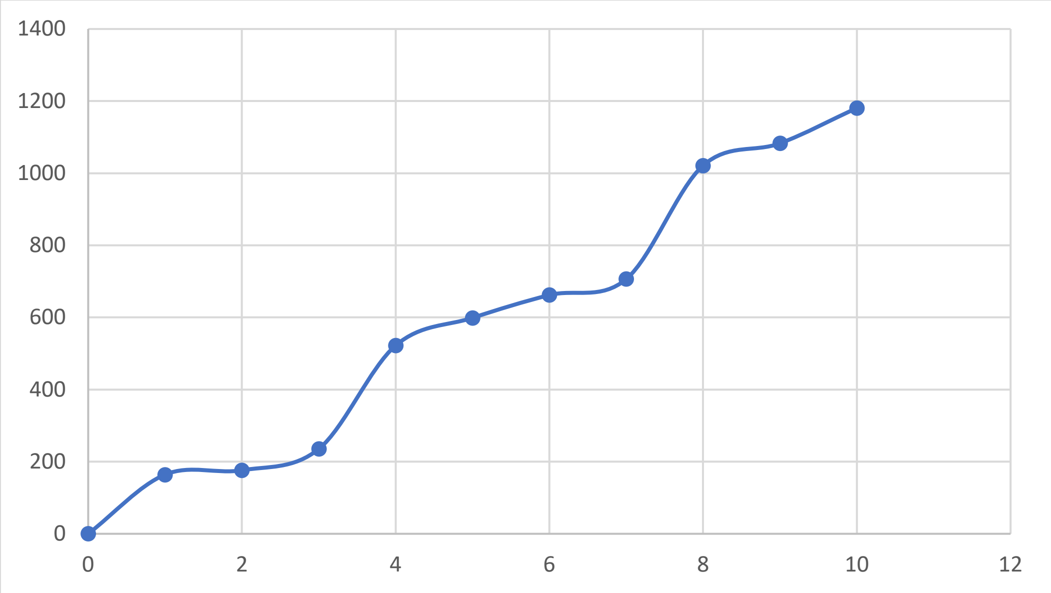

Fig. 23. Plot of frequencies of fiber with 6 wt% RH with 6 layers

- Natural frequencies of fiber with 6 wt% of rice husk with 8 layers:

0	0
1	188.8
2	207.58
3	247.47
4	595.84
5	651.1
6	695.62
7	727.04
8	1055.9
9	1082
10	1236.1

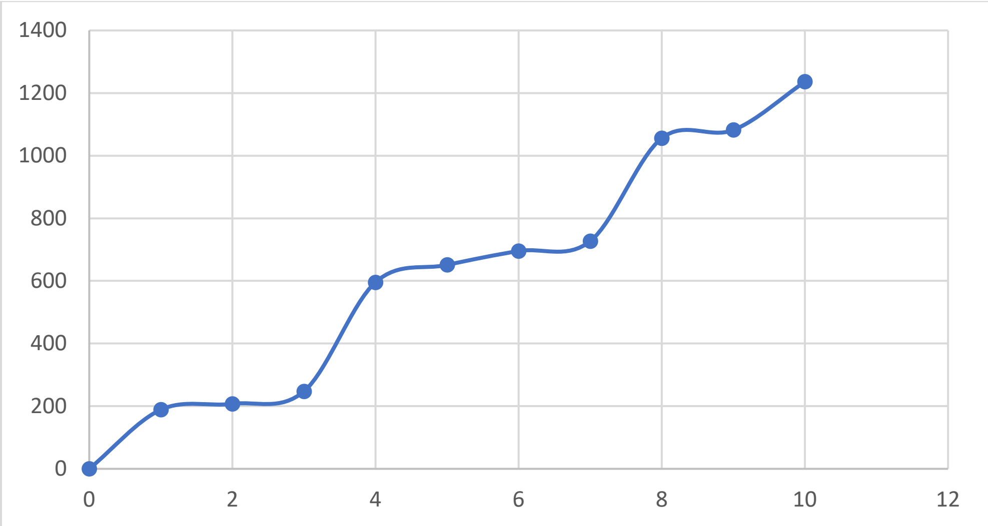

Fig. 24. Plot of frequencies of fiber with 6 wt% RH with 8 layers

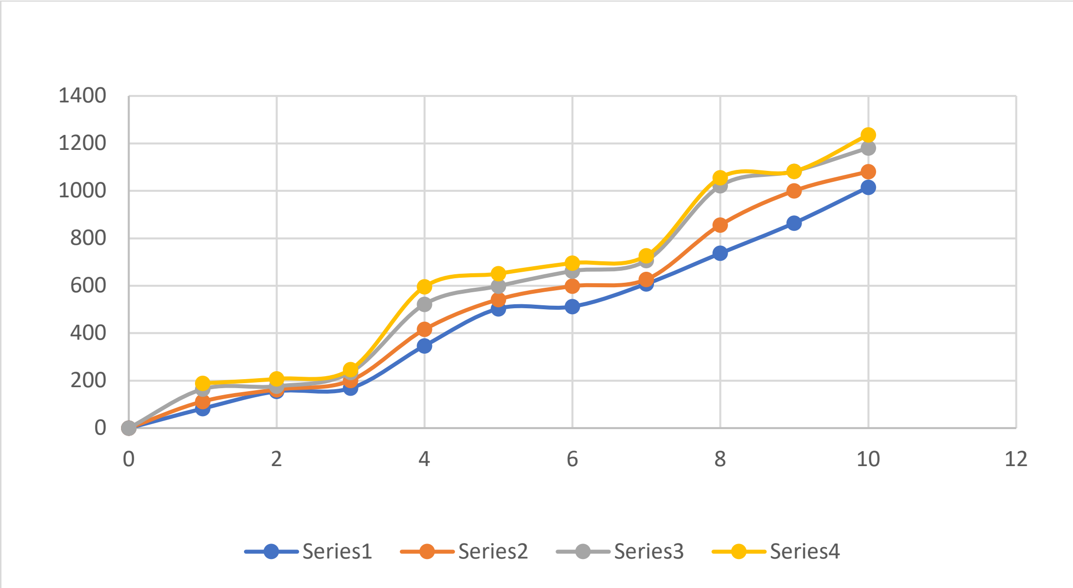

Fig. 25. Plot of cumulative frequencies of 6 wt% RH to fiber

- Natural frequencies of fiber with 10 wt% of rice husk with 3 layers:

0	0
1	58.296
2	117.81
3	152.68
4	274.3
5	418.96
6	420.56
7	453.93
8	604.93
9	764.15
10	846.24

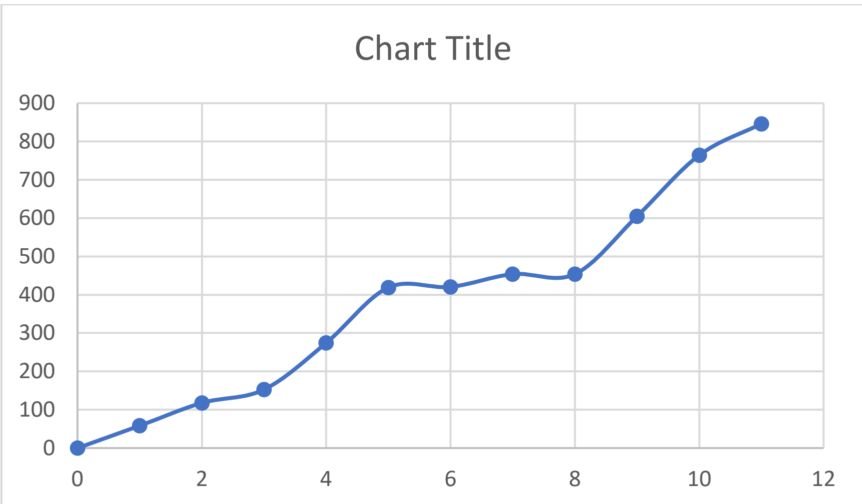

Fig. 26. Plot of frequencies of fiber with 10 wt% RH with 3 layers

- Natural frequencies of fiber with 10 wt% of rice husk with 4 layers:

0	0
1	76.114
2	115.53
3	174.91
4	315.69
5	409.74
6	413.82
7	515.41
8	669.32
9	843.1
10	850.91

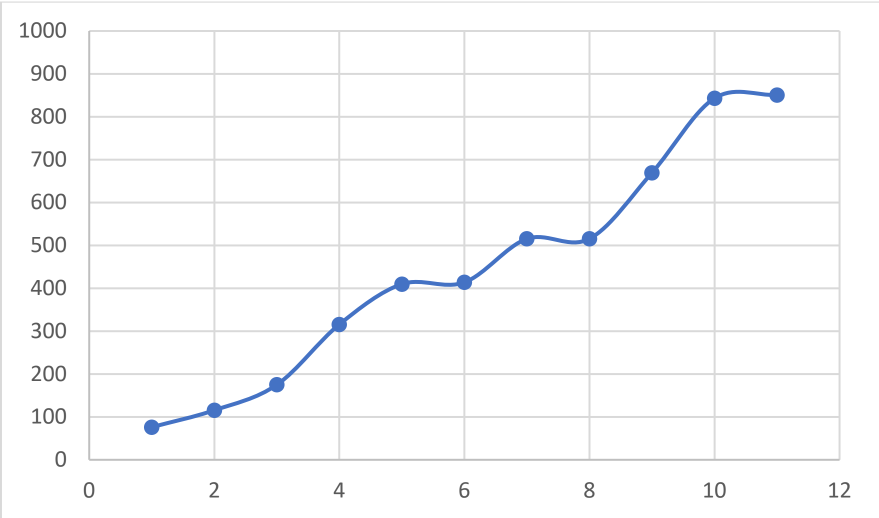

Fig. 27. Plot of frequencies of fiber with 10 wt% RH with 4 layers

- Natural frequencies of fiber with 10 wt% of rice husk with 6 layers:

0	0
1	103.16
2	112.61
3	193.77
4	363.53
5	394.78
6	409.52
7	578.71
8	743.62
9	845.5
10	893.39

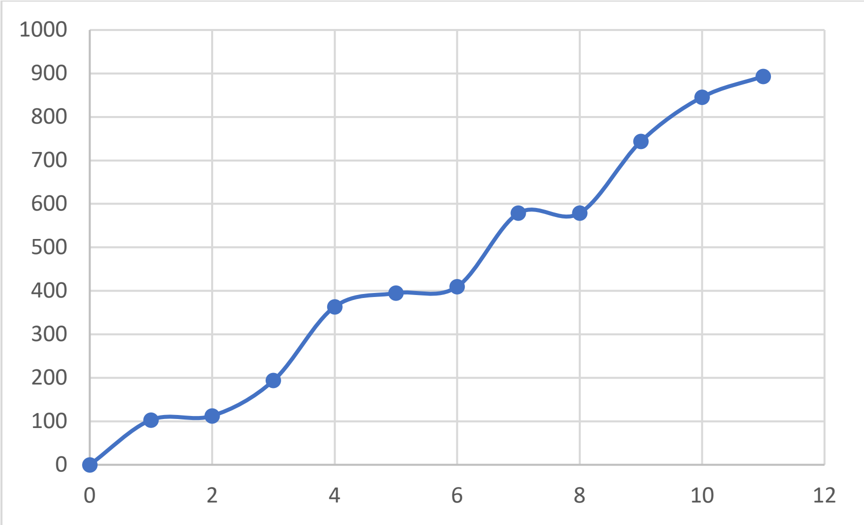

Fig. 28. Plot of frequencies of fiber with 10 wt% RH with 6 layers

- Natural frequencies of fiber with 10 wt% of rice husk with 8 layers:

0	0
1	110.87
2	122.42
3	196.03
4	384.87
5	388.15
6	407.73
7	585.01
8	757.11
9	815.97
10	844.78

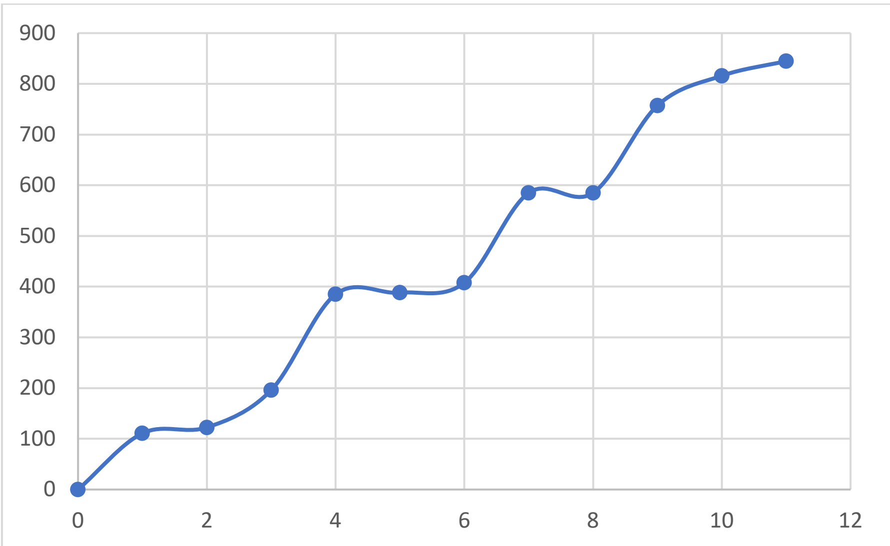

Fig. 29. Plot of frequencies of fiber with 10 wt% RH with 8 layers

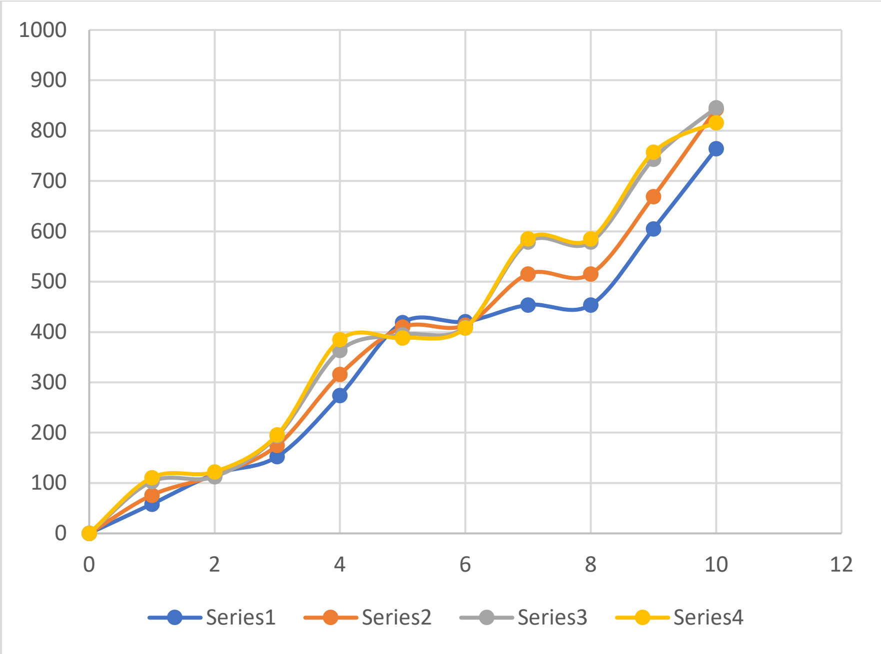

Fig. 30. Plot of cumulative frequencies of 10 wt% of RH added to fiber

VII. CONCLUSION

From this study, the validation of the buckling loads of glass fiber is performed, and mistakes are found as a result of slight variations in ANSYS's assumptions. According to the results of the modal research, fiber plates containing 6 weight percent rice husk vibrate the most, and fiber plates containing 10 weight percent rice risk vibrate the least. Additionally, it has been found that fiber plates made of 6-weight percent rice husk with 8 layers have higher natural frequencies than those made of 3 layers, whereas plates made of 10-weight percent rice husk with 3 layers have higher natural frequencies than those made of 8 layers.

VIII. REFERENCE

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