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Effect of the Moisture on Dynamic Behavior of Fibre Reinforced Polymer Composites

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Abstract
The demand of the composites material are very high these days because it is not only the lighter material but also satisfy the strength criteria too. When these material are expose in different humidity condition their mechanical properties get degraded and due to these effect the mechanical response like vibration bending buckling they also changes. In the present work the vibration behaviour of composites material is computed using FE (finite element) method in ANSYS environment and the effect of humidity is analysed and discussed in detail.
Keywords: *Composites Material, Moisture, ANSYS, vibration analysis.*

1. Introduction

The introduction, improvement and increasing demand or application of the laminated composites material is creating history in the field of material technology. Composites material are having modifiable material property that can be changed according to application by changing the percentage of constituents or by changing the lamination scheme in case of laminated composites. The composites material having high strength and stiffness to weight ratio which increases its popularity. It has also a great wear resistance, high temperature corrosion resistance. The above discussed features are made the composite material very popular among the design engineers and gives the opportunity to design unique structure which is not possible with the conventional material. Most of time in service condition composite material structure has to exposed in the unlike environments that may be high moisture environments. With increasing the temperature and moisture concentration there might be change in geometrical parameter which induces some problem. So here the influence of the moisture absorption on fundamental frequency analysis of laminate composite plate is to be studied.

2. Literature Survey

To understand the change in vibration characteristic because of increase or decrease in the temperature and the moisture absorption some of previous work have been discussed. Dhotarad and Ganesan [1] studied the effect of the elevated temperature on vibration characteristic of the rectangular plate. Whitney and Ashton [2] investigated the elastic behaviour of laminated structure. Tauchert [3] studied the earlier work on the buckling, vibration and bending analysis of composite laminate subjected to hygrothermal loading done by various researcher in past. Gandhi et al. [4] found out the nonlinear fundamental frequency of the thick plate in unlike environments. Chen and Chen [5] analyse the fundamental frequency responses of rectangular composite plate in unlike environments. Chen and Lee [6] used the differential form of the mathematical equation to analyse the vibration of the composite laminate. Sai Ram and Sinha [7] analyse the temperature and the absorption of the moisture in unlike environments on the composites flat plate Constantinos and Dimitri [8] studied the moisture absorption and the increasing temperature effect on the dynamic behaviour of the composite.

3. Results and Discussion

This section represents the vibration characteristics of laminated composite plates subjected to moisture loading using the presently developed ANSYS procedure. In this work the isoparameric shell elements having eight node is

used to discretized the whole plate. The fundamental frequency is obtained for the plates under the moisture loading to consider the effect of different input parameters. The material property used t work is shown in Table 1-2 below.

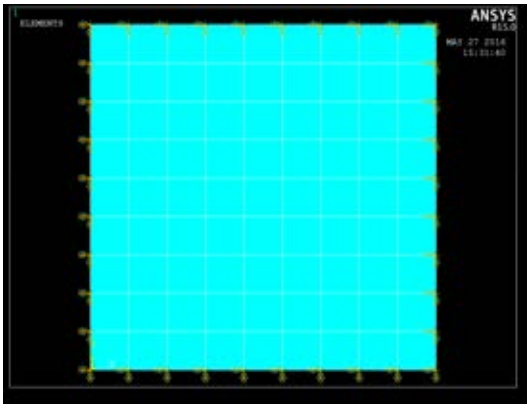

Fig.1. Flat Plate

TABLE I. Material property of graphite/epoxy composites lamina.

Elastic modulus (GPa)	***Moisture percentage***				
	0	0.25	0.5	0.75	1
E_1	130	130	130	130	130
E_2	9.5	9.25	9	8.75	8.5
G_{12}	6	6	6	6	6

G12= G13, G23= 0.5G12

3.1 Convergence study

To study the convergence behaviour one example have been solved here by taking the material property as elastic modulus E1/E2=40, E2=1 GPa, E3=E2, G12 = 0.6 E2, shear modulus G12= G13, G23= 0.6 E2, Poisons ratio v12= v13= v23=0.25 and the plate dimension a=b=1 meter. The results are sown in figure 2 where the results are almost same from the mesh size 8x8. So the mesh size (8x8) is used for further analysis.

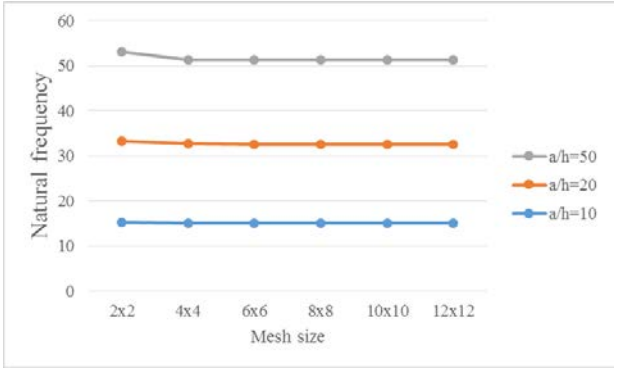

Fig.2. Convergence study

3.2 Comparison with previous studies

Now the next example of vibration analysis have been solved to comparison study and shown in table 2. The table shows that the current ANSYS outcomes is displaying good agreements with that of the reference.

TABLE II. Comparison with previous studies

E1/E2	***ANSYS***	***Matsunaga [9]***
3	0.3066	0.2491
10	0.3563	0.3063
15	0.3734	0.3309
30	0.3951	0.3731
40	0.4001	0.3893

After the convergence and comparison stud, in this section the some new numerical example have been solved to evaluate the effect of the moisture concertation. Figure 3 shows the natural frequency of twenty layer all side clamped angle ply laminated composite plate with different angle. The material property is taken as shown in table 1. Plate size is taken as length and with a=b=0.5m and thickness h=0.005m. From the figure it viewed that vibration decreases with increasing the moisture absorption.

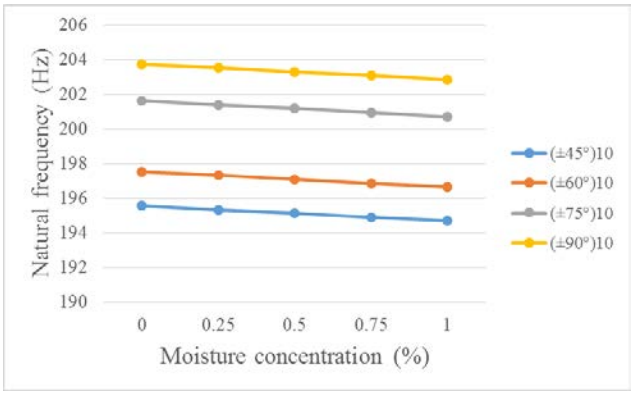

Fig.3. Moisture effect on vibration (a/h=100)

Further one more problem of thick plate is taken to analyse the effect of moisture concentration. For this the a plate of length 0.5m, width 0.5m and the thickness of 0.05 m is consider. The material property is taken as shown in table 1. The result obtained is shown in figure 4 and from the figure it viewed that thick plate decreasing with increasing the moisture percentage.

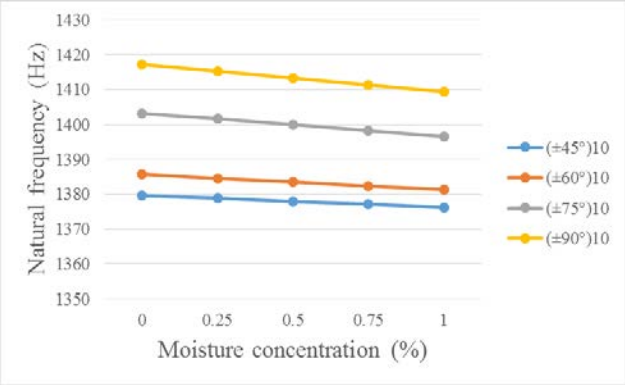

Fig.4. Moisture effect on vibration (a/h=10)

In the next example, the effect of boundary condition along with the effect of moisture concentration is analysed. The analysis is passed out by considering material property as shown in table 1. Three type of boundary condition is taken say all side clamped CCCC, two side clamped two side free CFCF and cantilever CFFF. The result is shown in figure 5 where it is viewed that with increasing moisture concentration frequency goes down and frequency is increasing from CFFF to CCCC.

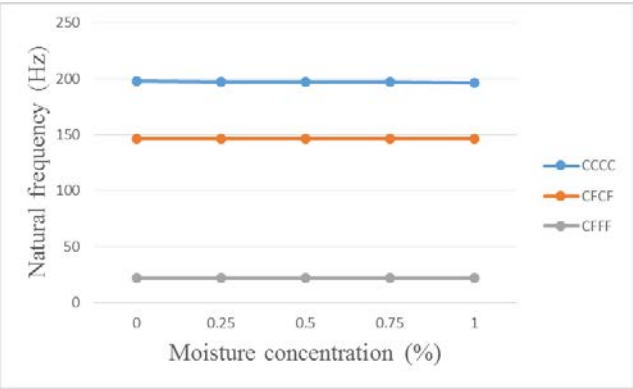

Fig.5. Effect of boundary condition on natural frequency (a/h=100)

4. Conclusions

Here the concept of FEM is engaged to obtain the vibration responses of the composites laminate plate subjected to the moisture absorption. ANSYS software is used in the present investigation and eight noded iso-paramertic SHELL 281 element is utilized for model discretization. The various numerical example have been solved and discussed. On the basis of solved numerical example some remarkable conclusion have been drawn and discussed in line below:

- The natural frequency is obtained for twenty layer angle-ply thin (thickness=0.05m) laminate with different angle. For each angle with increasing the moisture the natural frequency decrease.
- Again the analysis is extend for thick laminated composite plate (thickness=0.05m) and effect of moisture concentration is evaluated and found that fundamental frequency decrease with increasing moisture percentage.
- Finally, the conclusion is made that as the moisture absorption increases, natural frequency decrease.

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