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Flexural Behavior of Laminated Composites Plate under Uncertain Material Properties

Abhishek Kumar Shriwas[1], Narendra Patel[2]

[1] Dept. of Mechanical Engineering
Dr. CV Raman University Kota
Bilaspur (CG), India

[2] Dept. of Mechanical Engineering
Dr. CV Raman University Kota
Bilaspur (CG), India

Abstract

In many of the structural problem the mechanical responses are computed using well defined input parameter like geometry, material properties, boundary condition. In actual practice there may variation in all the above discussed parameter. In this work, variation in material properties like shear, young's modulus and poisons ratio is modelled using fuzzy finite element method. The uncertain material properties obtained from the fuzzy finite element method is used to compute the Flexural behavior of laminated composites plate. A simulation model is developed in ANSYS and discretized using SHELL 181 element. Convergence and comparison study is done and finally some new example have been solved and discussed in detail.

Keywords: *Composites, Flexural Analysis, Random Properties, ANSYS*

1. Introduction

A composites material is truly different from the conventional material. It is made by mixing of two or more that two different material in which one material is worked as the binder and bind the other one or more than one material. The most important things related to composites material is that its material property can be varied according to the requirements. The constituents of the composites material can be categorized as a fiber and matrix. The matrix are the material which works as the binder and bind the fiber. Fiber is a long or short thin wire like material which is used to provide the strength to the composites material. The material property what we measured by some test like tensile test is single valued that may vary when exposed to service condition. The change in property effect the performance of the structure. But it is difficult to say that which property change has greater effect on performance. To investigate the same the present work is planned.

2. Literature Survey

The analysis with uncertainty in material property, geometrical properties with the help of FFEM has been started around 1990s. In the early 1990 [1]. Elishakoff [2] proposed that the optimization approaches like hybrid optimization gives the better prediction with uncertain input. Rao and Chen [3] reported the novel approaches and algorithms for the optimizing the various parameter with adequate speed and accuracy. Muhanna and Mullen [4] are also suggested the novel fuzzy procedure for analyzing the problem with uncertainty like uncertainty in material property, uncertainty in loading and uncertainty in geometrical parameter. Lallemand et al. [5] suggested the fuzzy procedure for vibration analysis of the system having uncertain parameter. Akpan et al. [6] developed the fuzzy finite element procedure to evaluate the bending behavior of the structure. Rama Rao and Ramesh Reddy [7] also proposed the FFEM model to find out the bending responses of cable-stayed bridge with uncertain parameter. Franck and Lallemand [8] proposed the efficient procedure to advances the prediction and analyze the bending problems associated with design procedure. Balu and Rao [9] analyze the bending and vibration responses of the laminated structure using the FFEM model. In current past the bending problem have been solved and discussed with the help of the FFEM.

From the literature survey it is fond that various work have been done to evaluate mechanical performance with uncertain material property. But few work have been reported using ANSYS software. So the objective of this paper is to investigate the bending behavior of laminated composite plate with uncertain material property using ANSYS.

3. Results and Discussion

In this particular section the consistency test and the comparison of the new generated result with the currently proposed ANSYS model is discussed. Firstly, the bending responses of the laminated composite plate is obtained for the various mesh density. Then the responses are generated for comparison purpose by taking the material property and the geometrical parameter as discussed in the referred published literature. Finally, some of the new examples have been solved to evaluate the effects of different parameters like the type of lamination and the thickness ratios on the bending characteristics of the composite plate discussed in detailed. The input parameter like the material properties utilized in the present work is shown in table 1.

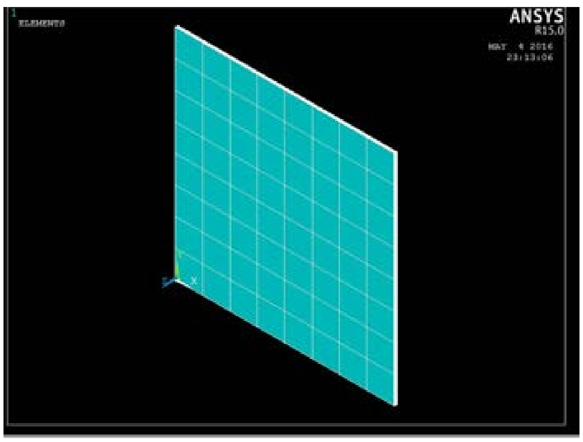

Fig.1. Shell pannel

3.1 Convergence and Validation

The consistency and the efficiency of the presently developed model have been checked by generating the bending responses of the laminated composites plate with different mesh sizes. For the computational purpose, a four layer clamped symmetric cross-ply square plate is considered under uniformly distributed load (UDL) and the material and geometric property are taken same as discussed in Material-1. The bending responses with different mesh sizes are shown in figure 2. From the figure it can be seen that the result are consistent after the mesh size (8x8). So the mesh size (8x8) is used for the further study.

TABLE I. Material and geometrical property.

Parameter	***Material-1***	***Material-2***
a	12 inch	0.25meter
h	12 inch	0.25meter
h	0.096 inch	0.003125meter
E_1	1.8282 x 106 Psi	141.9 GPa
E_2	1.8315 x 106 Psi	9.78 GPa
E_3	1.8315 x 106 Psi	9.78 GPa
G_{12}	3.125 x 106 Psi	6.13 GPa
G_{13}	3.125 x 106 Psi	6.13 GPa
G_{23}	3.125 x 106 Psi	6.13 GPa
V_{12}	0.023949	0.42
V_{13}	0.023949	0.42
V_{23}	0.023949	0.42

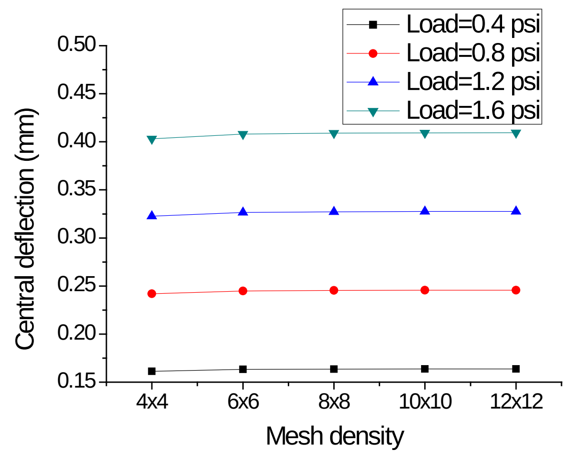

Fig.2. convergence study

The comparison of the newly genrated results with that of the referece [10] and shown in the table 2 .The material property (triangular membership function) and geometric property are taken same as discussed in the referred literature. From discussed table, it can be viewed that the results obtained through fuzzy finite element formulation are showing adequate closeness with the results of the published literatuer. It addition to that it is good to mension here that for α=1 i.e., the differece is acceptable.

TABLE II. Central deflection

Alpha	***Liu and Rao [11]***	***Present (ANSYS)***
0	0.000145628	0.00016459
0.2	0.000145628	0.00016523
0.4	0.000145628	0.00016624
0.6	0.000145628	0.0001670
0.8	0.000150875	0.00016769
1	0.000153799	0.00016798

To know effect of change in material property on the bending analysis, some of the numerical example have been solved by varying stacking arrangement, loading and boundary condition of the laminated composite flat plate. Geometric and material properties are taken as discussed in material-2. The variation in the material properties is taken in the range of [±20%] around their deterministic figure. A Triangular membership function is used for varying the material property as shown in figure 3-6.

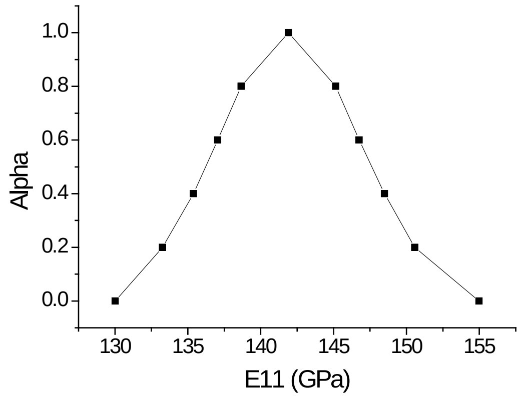

Fig.3. Variation of E1

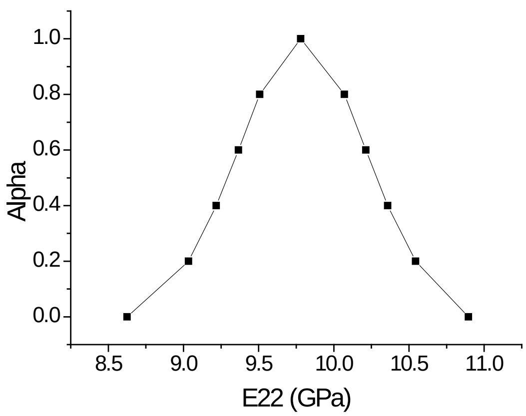

Fig.4. Variation of E2

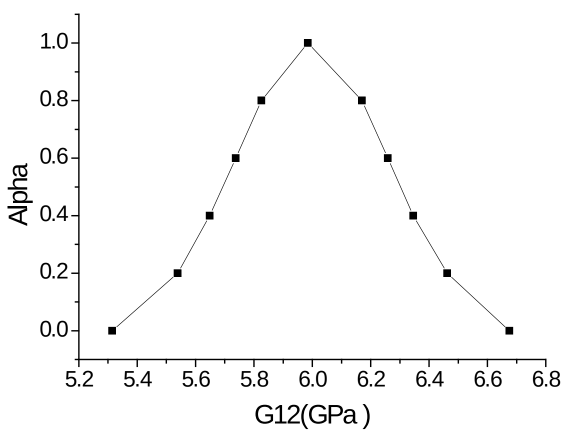

Fig.5. Variation of G12

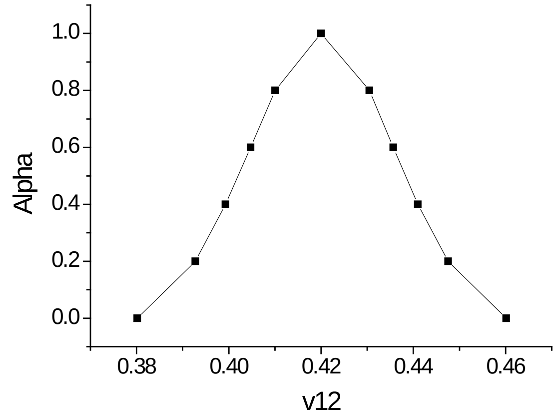

Fig.6. Variation of v12

Bending responses of symmetric and antisymmetric square laminated composites plate with uncertain material property are shown in figure 17-20. Figure 7 and 8 shows the Bending responses of symmetric and antisymmetric laminated composite plate respectively with all side clamped boundary condition, uniformly distributed load of 500 N/m2 and material property as discussed in earlier figure. Whereas the figure 9 and 10 are plotted for cantilever boundary condition. The lamination scheme plays a vital role in the performance of structures. This can be seen from the figures because only by changing the lamination scheme there is a difference in central deflection. Another important fact comes out from the figures is that response are mostly affected when all the properties are considered to be fuzzified i.e. When all material properties E1, E2, G12 and v12 are varying, the largest possible distribution range for central deflection for the plate is obtained. In case of individual properties randomization E1 is more dominating than other and the change in Poisons ratio has least range of change in responses.

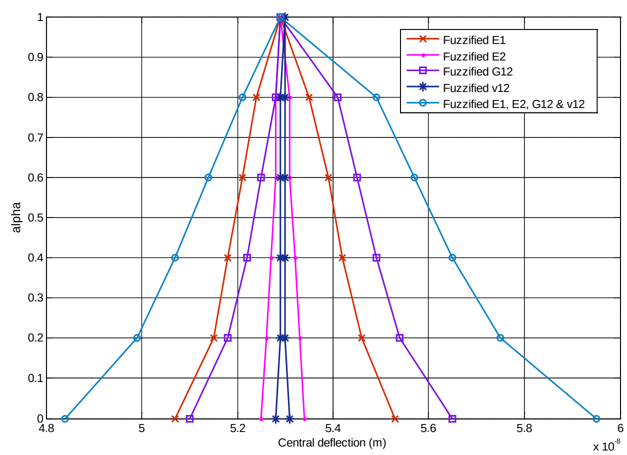

Fig.7. Central deflection of square eight layer [0/45/90/0/0/90/45/0] symmetric laminated plate

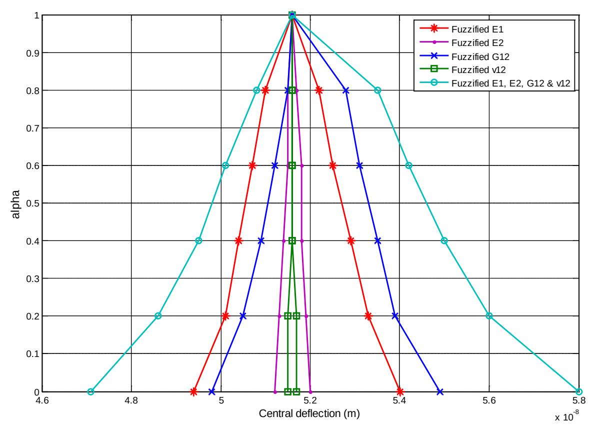

Fig.8. Central deflection of square eight layer [0/45/90/0/0/45/90/0] anti symmetric laminated plate

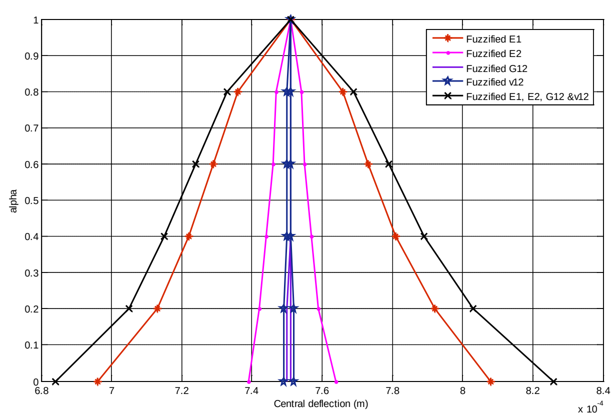

Fig.9. Central deflection of square eight layer [0/90/0/90/90/0/90/0] symmetric laminated plate

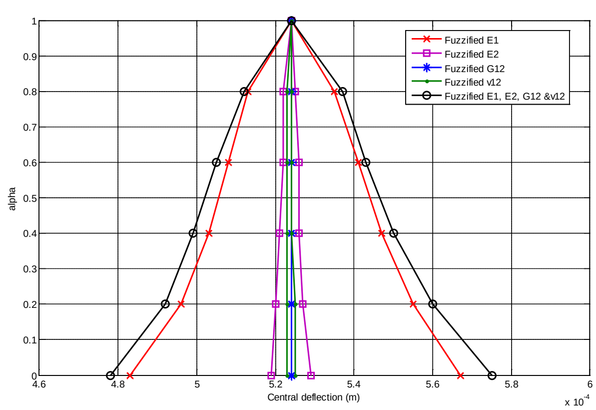

Fig.10. Central deflection of square eight layer [0/90/0/90/0/90/0/90] anti symmetric laminated plate

4. Conclusions

On the basis of the numerical example solved in the present work some conclusion have been found out:

- The FFEM is capable enough to predict the adequate accurate results for the problem with uncertain input parameter.
- The responses affected by variation in each of the material property but the greater effect can be seen with varying all the material property.
- The bending behavior i.e. central deflection distribution changes with changing the material property as well as types of lamination.
- The static responses are having greatest range when all the material property are fuzzified.
- In case when single material property is taken as a fuzzified (random), E1 has large range of responses.

The random property of v12 has least effect on bending responses.

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