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Dynamic Analysis of Delaminated Composite Plate with Finite Element Method

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Abstract

As we all know that composite material are widely used in industries because of their incredibly lightweight, high strength-to-weight and stiffness-to-weight ratios. The most common mode of damage in the composite structures is delamination. The specimens of Glass fiber and epoxy resin composite plates are manufactured by the hand-lay-up method with different position of delamination in composite laminated plate for 8 layers. The present study involves finite element analysis to investigate the free vibration of Glass/ Epoxy composite laminate plates with delamination in simply supported boundary conditions based on the comparison between natural frequencies of the healthy and delaminated composite laminate plates by using ANSYS 18.1.
Keywords: Composite, Delamination, Dynamic Analysis, FEA (ANSYS)

I. INTRODUCTION

Now days, the commonly used material in industries is composite material for their excellent mechanical properties. They are known for their incredible lightweight, stiffness to weight and strength to weight ratios. We can achieve difficult structures, complex shape or design with the help of composite material. But the common mode of damage is occurring in composite material called as delamination. Delamination is nothing but separation of two layers of composites. Delamination occur in composite plate is invisible because it occur inside of the material. Delamination also develops due to repeated cyclic stresses, manufacturing defects, low velocity impact, unlike environment condition. Due to delamination in composite plates may reduce mechanical properties such as loss in strength, toughness, stiffness, and material unbalance. Therefore detecting such type of damage the non-destructive test are used for composite and to solve such type of problem by using various approximate techniques in which finite element method can be used by using software ANSYS 18.1 for damage monitoring of laminated composite plates.

II. PROBLEM DEFINITION

Now- a -days, composite material are widely used in the industries but one of the type of damage occur in composite plate called as delamination. These plates fails during the service orthotropic-ally, sometimes cracks are observed and the structure becomes weak, also sometimes its fail due to vibrations. Detect the delamination in the composite plate in the time to take remedial action in advance and to reduce the effect of delamination

III. NEED OF COMPOSITE MATERIAL

Composite materials are the versatility in their properties which enables them to be applied in large number of fields. Other reasons are their light weight, corrosion resistance and durability. Nowadays, composite materials are used in large number of vast engineering fields such as aviation, automobile and robotics. The metals are equally strong in all directions, but the composites can be designed and engineered to be strong in a specific direction. Thermoset Composites give designers nearly unlimited flexibility in designing shapes and forms. Because thermoset composites can be precisely moulded, there is little waste and therefore significantly lower overall material costs than metals products. The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

IV. FINITE ELEMENT FORMULATION

A. *Formulation:*

In the present modal analysis we are using a finite element method (FEM) for free vibration analysis of delaminated composite plates. We consider a rectangular laminated plate with delamination.

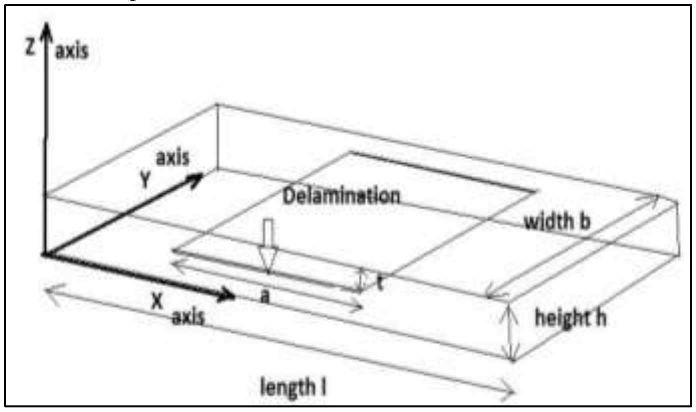


Fig. 1: Rectangular plate with through width delamination

Length = l,
Width =b,
Height=h
X and Y are the axis directions in the plane of the plate and
Z is perpendicular to this plane. *u* ,*v* are the displacements in X and Y-directions and
w is displacement in Z-direction

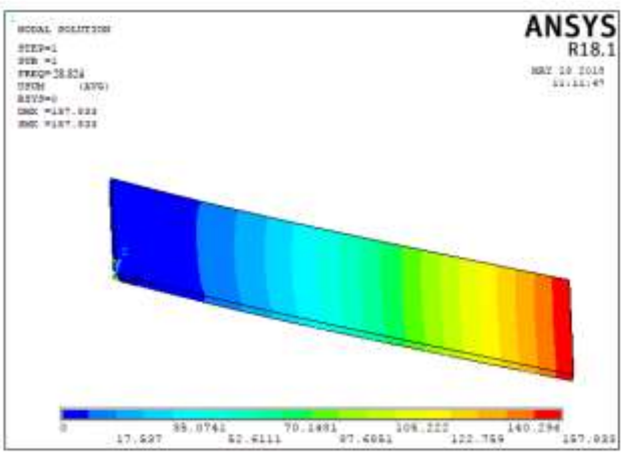


Fig. 2: 8 layer healthy Mode 1

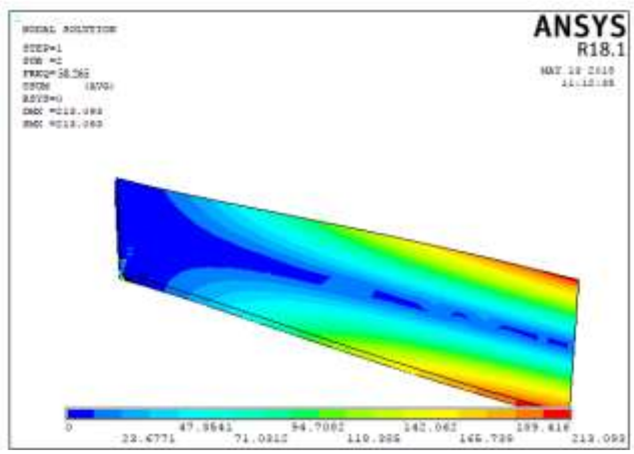


Fig. 3: 8 layer healthy Mode 2

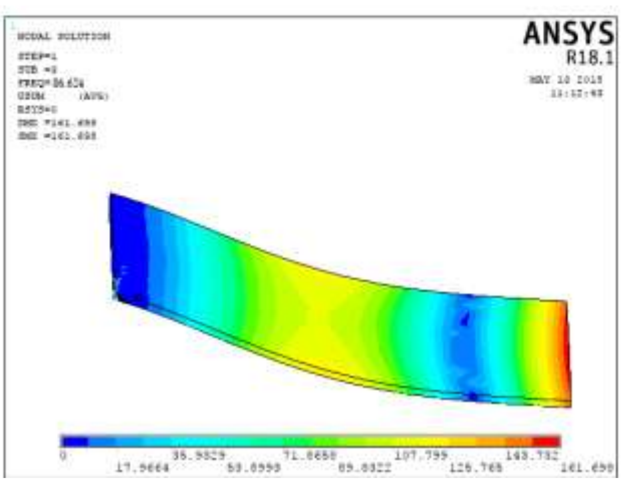


Fig. 4: 8 layer healthy Mode 3

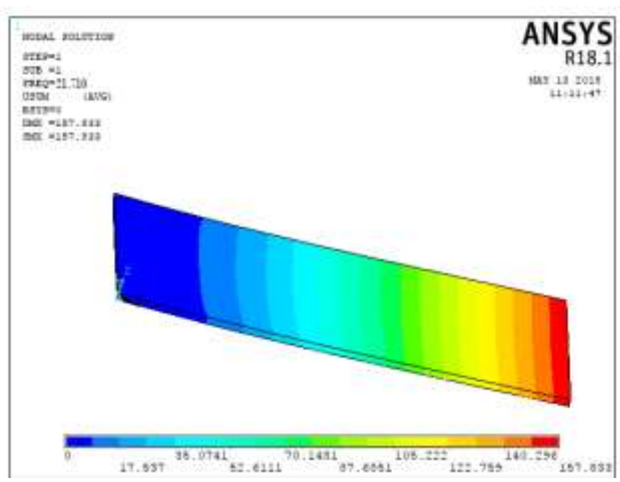


Fig. 5: 8 layer 1 delamination Mode 1

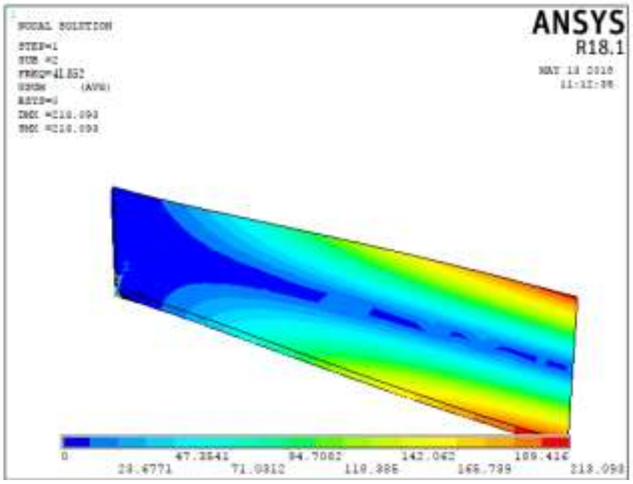


Fig. 6: 8 layer 1 delamination Mode 2

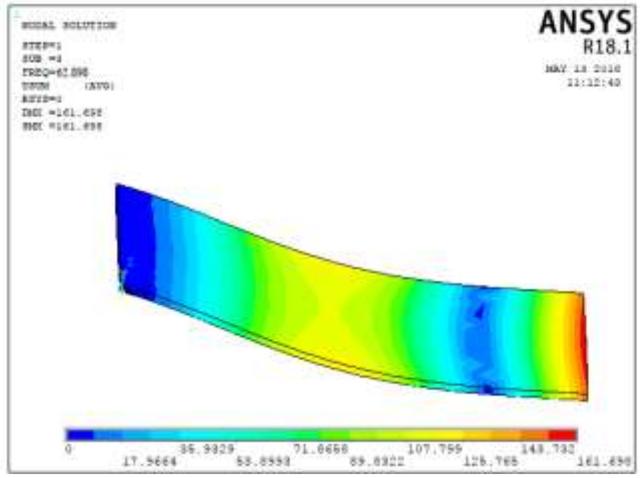


Fig. 7: 8 layer 1 delamination Mode 3

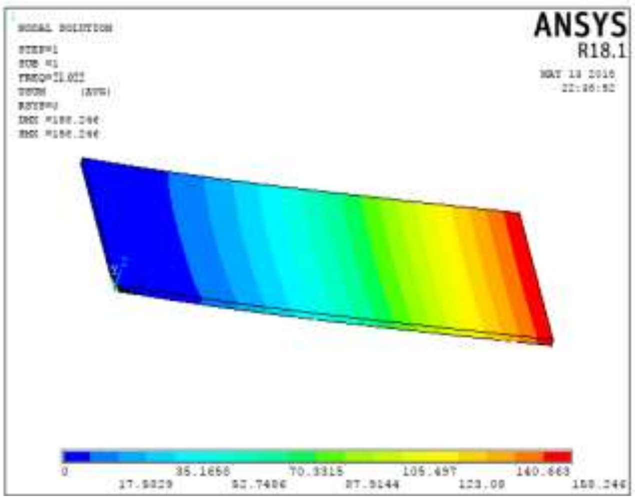


Fig. 8: 8 layer 2 delamination Mode 1

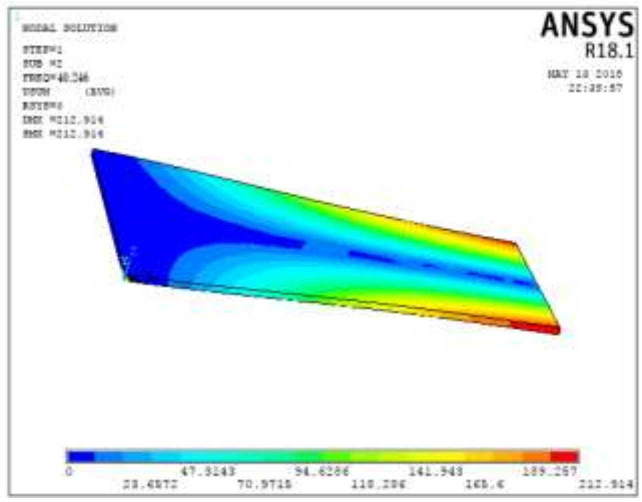


Fig. 9: 8 layer 2 delamination Mode 2

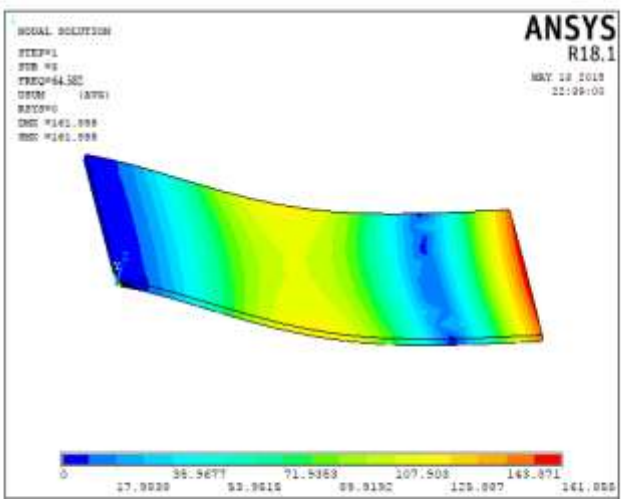


Fig. 10: 8 layer 2 delamination Mode 3

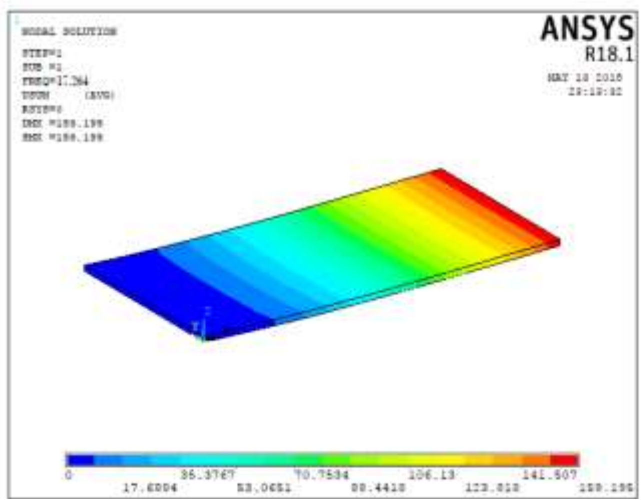


Fig. 11: 8 layer 3 delamination Mode 1

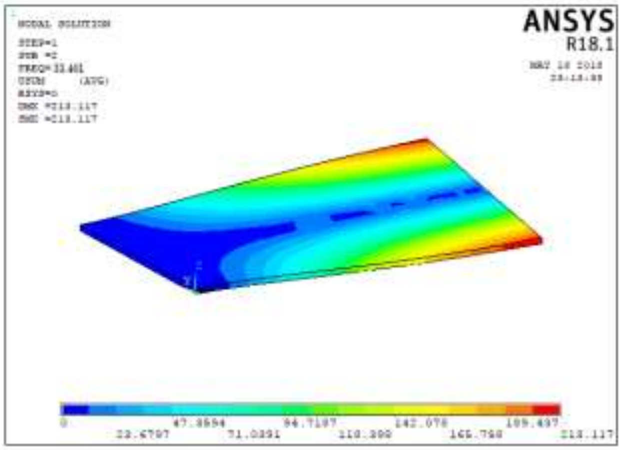


Fig. 12: 8 layer 3 delamination Mode 2

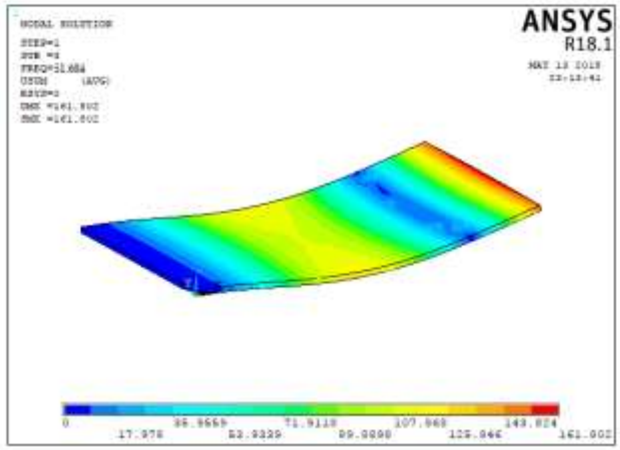


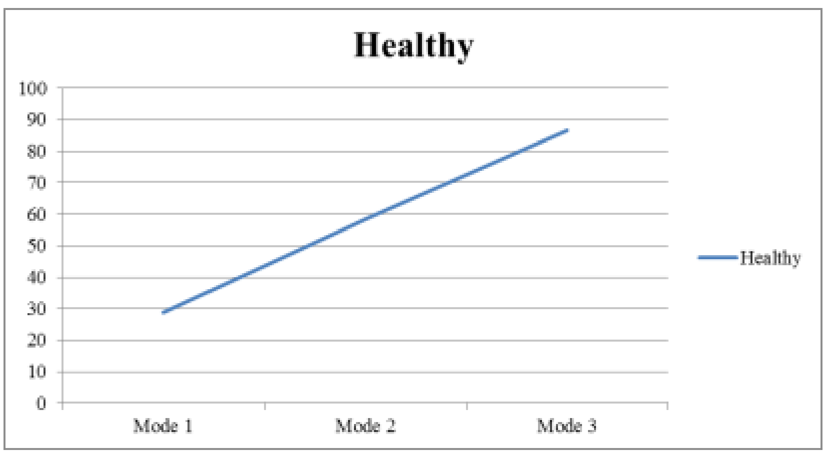
Fig. 13: 8 layer 3 delamination Mode 3

V. RESULTS

Results analysis for four layers laminated and delaminated composite plates:

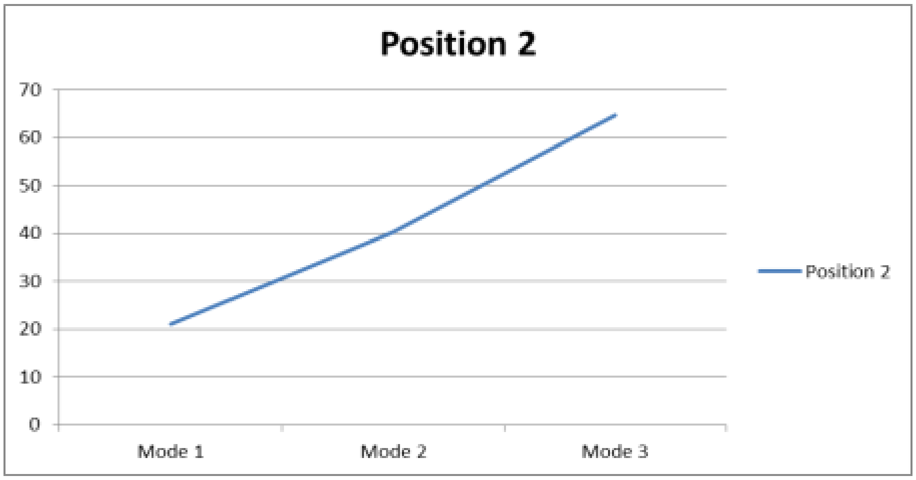
Table – 1
Natural frequencies for laminated composite plate with delamination.

No. of Layers	*Mode Number*	*NATURAL FREQUENCY*			
		Healthy	*P1*	*P2*	*P3*
		ANSYS	*ANSYS*	*ANSYS*	*ANSYS*
8	1^{st}	*28.824*	*21.710*	*21.022*	*17.264*
	2^{nd}	*58.265*	*41.852*	*40.246*	*33.401*
	3^{rd}	*86.624*	*62.898*	*64.582*	*51.684*

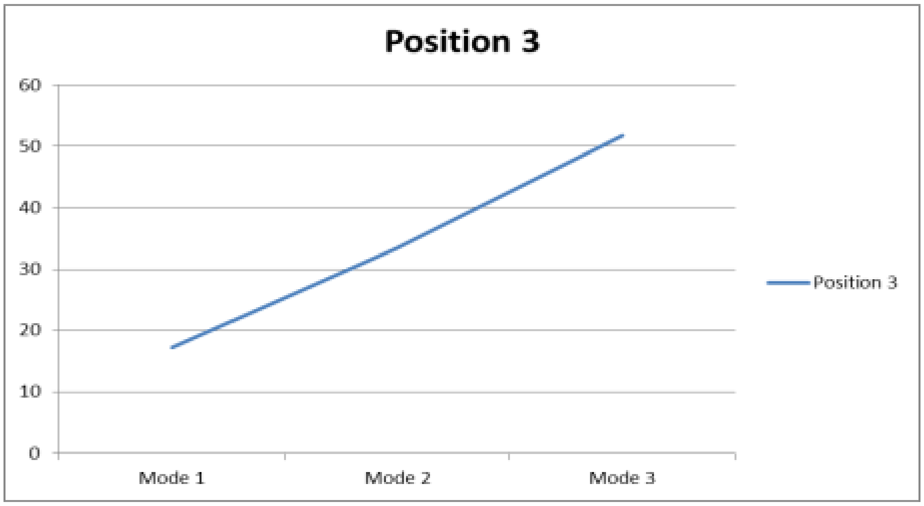


Graph - 1: Frequency Vs Mode for Healthy composite plate.

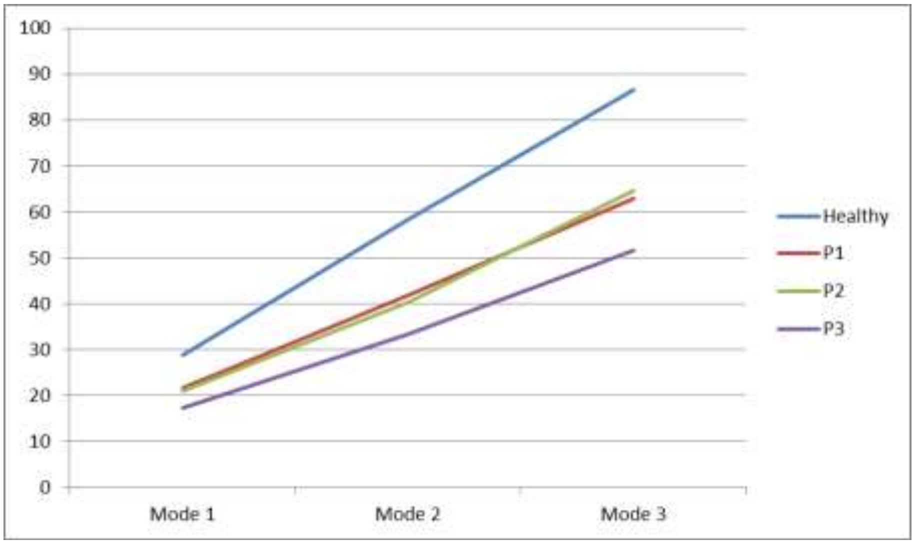
Graph - 2: Frequency Vs Mode for delaminated composite plate with Position 1



Graph - 3: Frequency Vs Mode for delaminated composite plate with Position 2



Graph - 4: Frequency Vs Mode for delaminated composite plate with Position 3



Graph - 5: Frequency Vs Mode between healthy and delaminated plates.

VI. CONCLUSION

- It is clearly exhibited that the dynamic response of the delaminated composite plates is greatly affected by size and location of delamination and also by the geometrical and material parameters and the support conditions of the plate.

- Free vibration behavior of the laminated composite plates greatly depends on the geometrical and material parameters and the support conditions.
- The presence of delamination at the mid-plane of the laminated structure affects the free vibration responses of the delaminated plate significantly than the other.
- Frequency of a delaminated simply supported homogeneous plate decreases with increase in delamination length.
- Frequency increases with increase in mode of vibration. For higher mode of vibration, the frequency will be higher.

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