Damage Detection in Laminated Composite Beams

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Abstract

Delamination is a mode of failure that occurs in laminated composite materials. In laminates repeated cyclic stresses and impact causes layers to separate, forming a mica like structures of separate layers and significant loss in toughness. Delamination mainly occurs due to weak adhesive bonding between fibre and polymer matrix. Laminates are used in aircraft and space shuttles and thus delamination in such case leads to catastrophe. When a delamination occurs there will be a change in natural frequency of the material. The change in natural frequency is used to locate the position of delamination. Natural frequencies of normal and delaminated composites are experimentally obtained by an accelerometer. It is then determined numerically by using ABAQUS 6.14 software.

Keywords: Natural frequency, delamination, laminates

I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual. Delamination is a mode of failure for composite materials. In laminated materials, repeated cyclic stresses and impact can cause layers to separate, forming a mica-like structure of separate layers, with significant loss of mechanical toughness. Fiber pull-out (another form of failure mechanism) and delamination can occur, in part, due to weak adhesive bonding between the fibers and the polymer matrix. The material used for the analysis is Glass fibre epoxy. It is a combination of 14 plies. In vibration analysis the natural frequencies of the normal beams and that of the beams having delaminations are compared. Finite element analysis is done using ABAQUS 6.14.

II. MATERIAL USED

Glass fibre epoxy.
- Young’s Modulus, E_1=44.6GPa , E_2=17Gpa ,E_3=0.262Gpa
- Number of plies- 14
- Weight of each ply-250gsm
- Orientation-90 degree
- Dimension -25cm*3cm*0.8cm
- Density-1800kg/m^3
- Poisons ratio-0.264

III. EXPERIMENT AND RESULTS

A. Experimental Procedure and Results

1) Clamp the cantilever beam.
2) Mount the accelerometer on the beam.
3) Connect the accelerometer to lab view software using DAQ.
4) Open lab view software and draw the circuit to get the corresponding frequency domain graph.
5) Compare it with theoretical results.

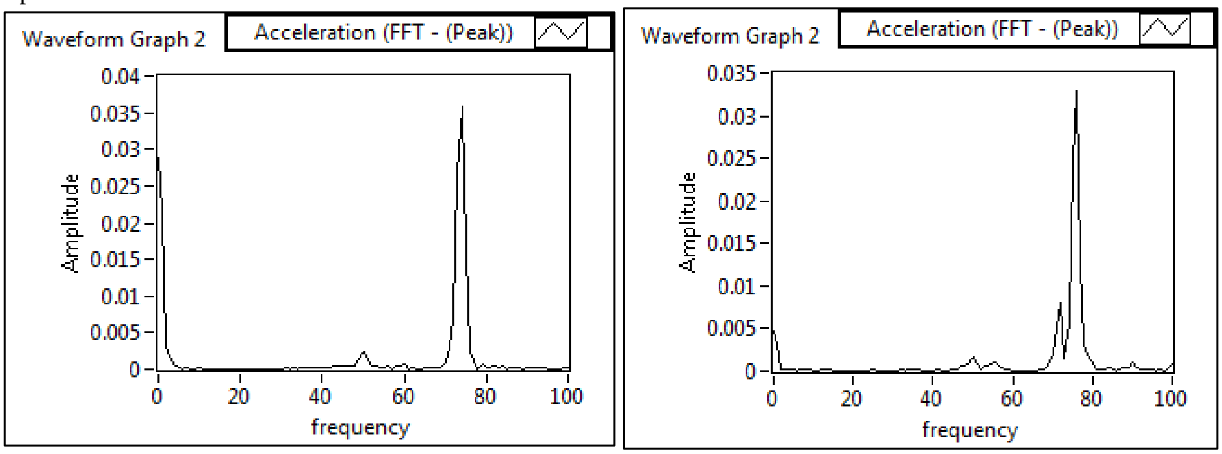

Fig. 1: Amplitude vs frequency graph of steel beam

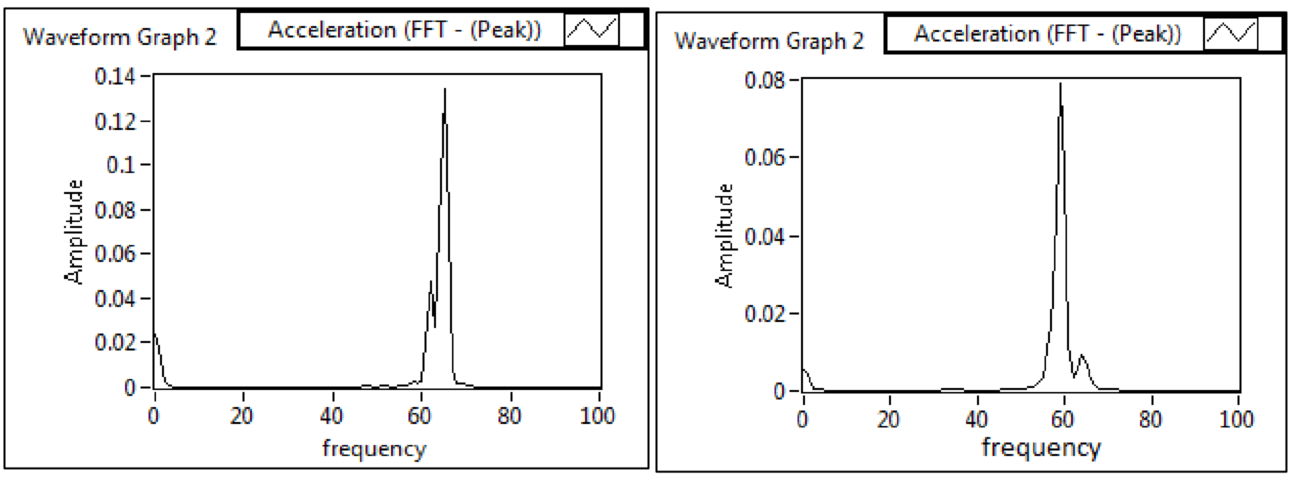

Fig. 2: Amplitude vs frequency graph of normal glass fibre beam

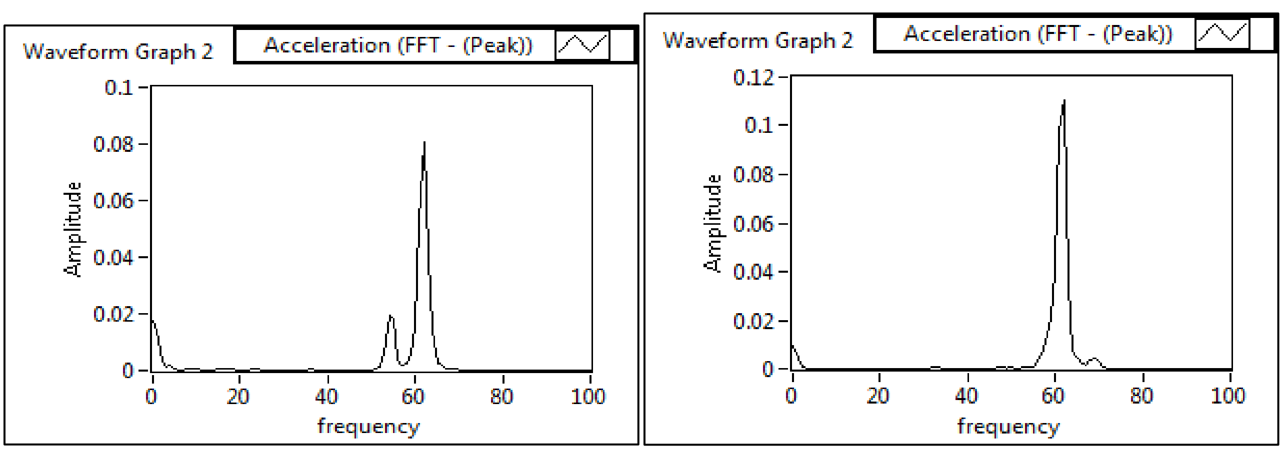

Fig. 3: Amplitude vs frequency graph of delaminated glass fibre beam at one third length

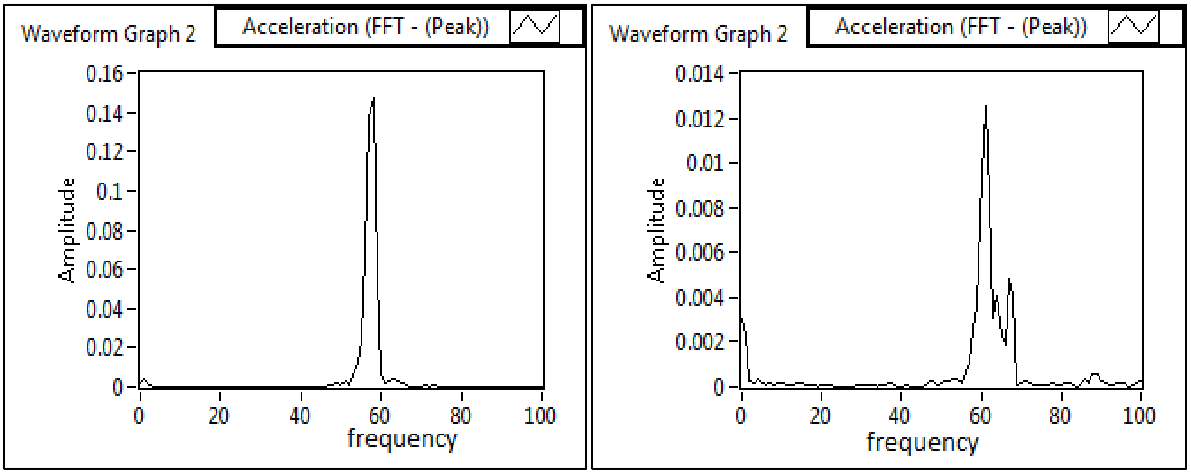

Fig. 4: Amplitude vs frequency graph of delaminated glass fibre beam at half length

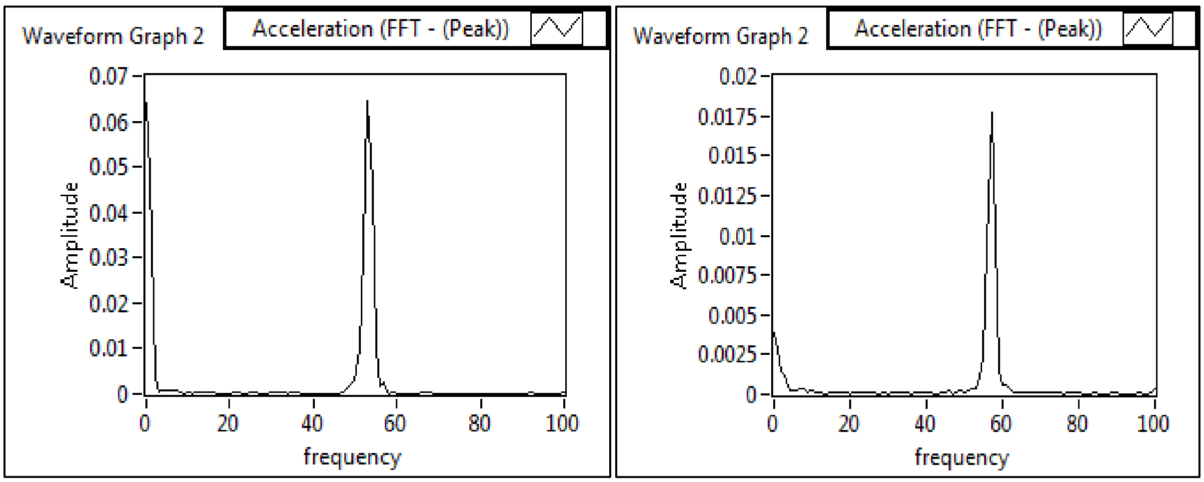

Fig. 5: Amplitude vs frequency graph of delaminated glass fibre beam at two third length

B. Numerical Results

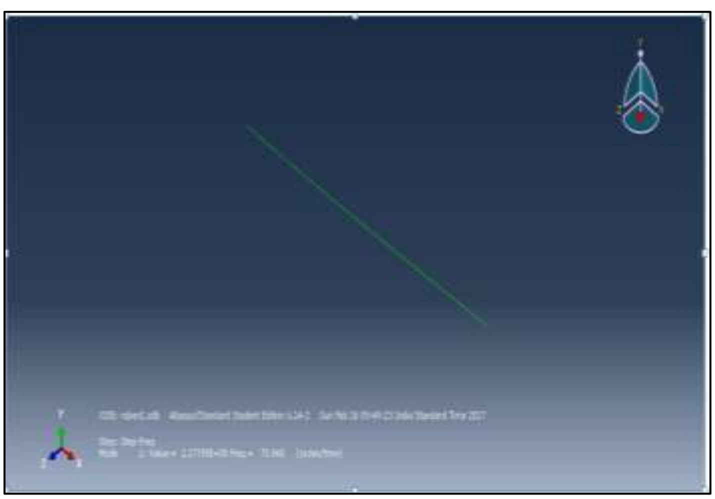
Fig. 6: Abaqus result for steel beam

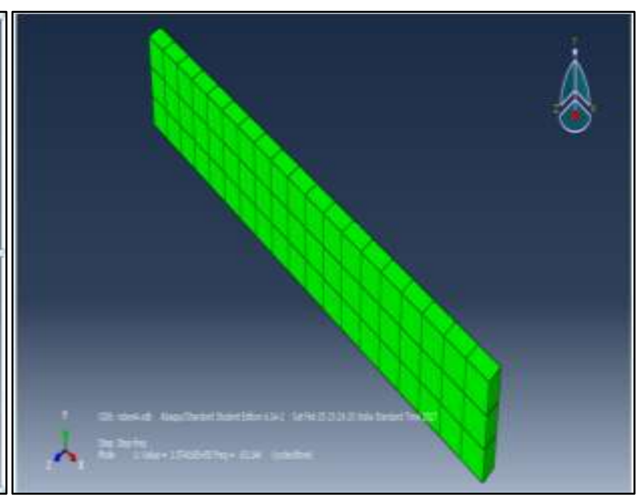
Fig. 7: Abaqus result for normal glass fibre

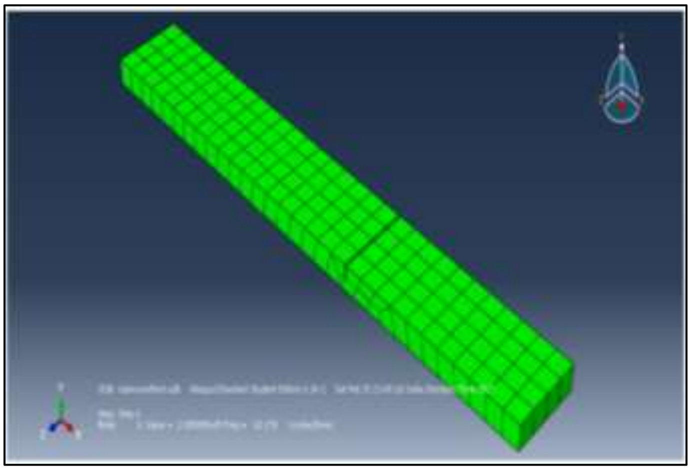

Fig. 8: Abaqus result for delaminated beam at one third length

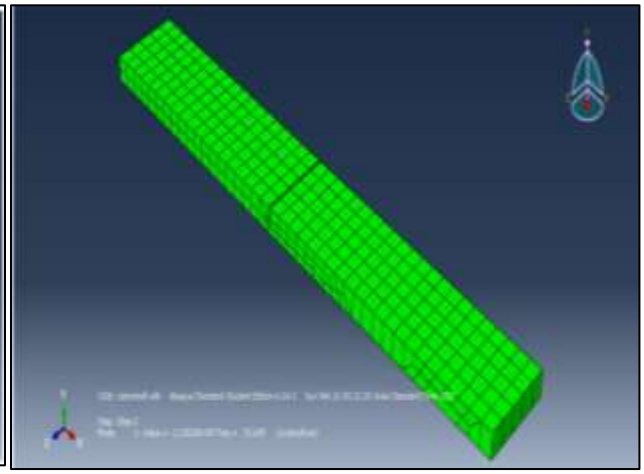

Fig. 9: Abaqus result for delaminated beam at half length

C. *P-H Diagram*

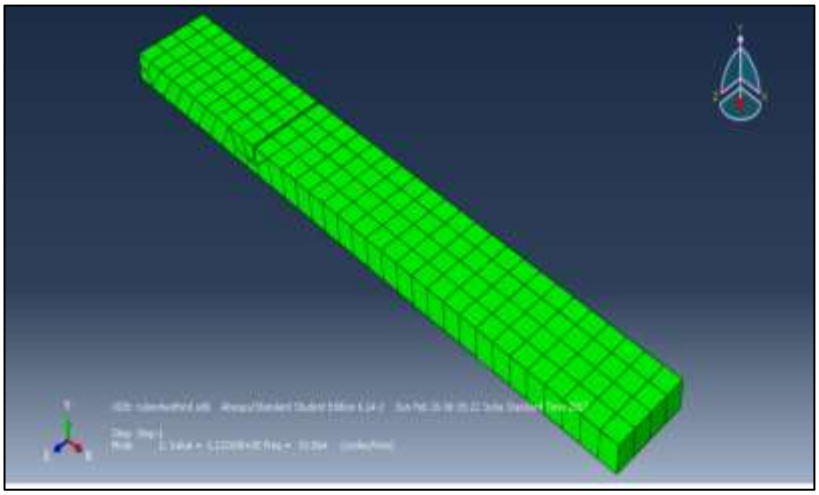

Fig. 10: Abaqus result for delaminated beam at two third length

IV. CONCLUSION

Delamination results in the reduction in strength of the composite material and thus finally leading to the failure of the structure. This was detected by using the difference in natural frequency of the normal beam and delaminated beam. Experimental results were compared with numerical values obtained through finite element analysis. There was slight changes in the experimental and numerical values due to the effect of external condition and instrumental errors. Natural frequency was found to change with the position of delamination. Natural frequency was found to increase with the position of delamination from the fixed end.

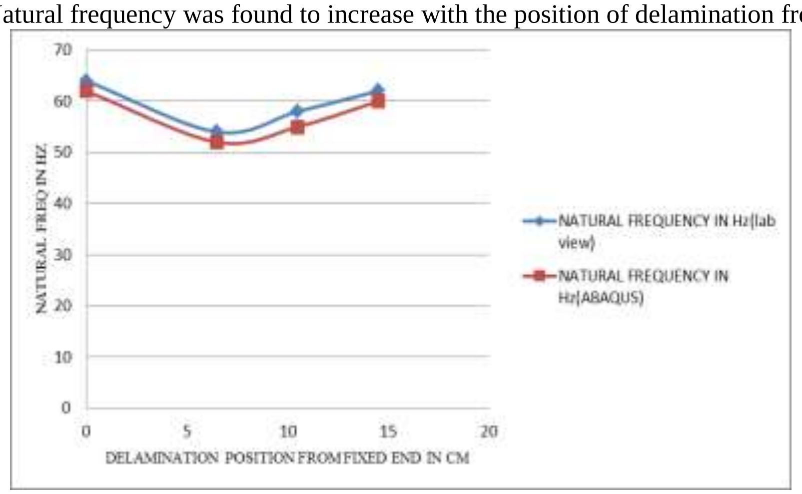

Fig. 11: Natural frequency vs delamination position

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