VIBRATION ANALYSIS OF COMPOSITE BEAM WITH CRACK

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ABSTRACT

Composite beams and beam like elements are principal constituents of many structures and used widely in high speed machinery, aircraft and light weight structures. Crack is a damage that often occurs on members of structures and may cause serious failure of the structures. The influence of cracks on dynamic characteristics like natural frequencies, modes of vibration of structures has been the subject of many investigations. However, the parametric studies like effect of geometry, crack location and support conditions on natural frequencies of composite beam are scarce in literature. In the present work, a numerical study using finite element is performed to investigate the free vibration response of composite beams. The finite element software ANSYS is used to simulate the free vibrations. A variety of parametric studies are carried out to see the effects of various changes in the laminate parameters on the natural frequencies. The parameters investigated include the effects of fiber orientation, the location of cracks relative to the restricted end, depth of cracks, volume fraction of fibers, length of beam and support conditions. The study shows that the highest difference in frequencies occur when the value of the fiber orientation equal to zero degree. The increase of the beam length results in a decrease in the natural frequencies of the composite beam and also shows that an increase of the depth of the cracks leads to a decrease in the values of natural frequencies.

Keywords:- *High speed machinery, Fiber Orientation, Geometry.*

Introduction

In the recent decades, fiber reinforced composite materials are being used more frequently in many different engineering fields. The automobile, aerospace, naval, and civil industries all use composite materials in some way. Composite materials are gaining popularity because of high strength, low weight, resistance to corrosion, impact resistance, and high fatigue strength. Other advantages include ease of fabrication, flexibility in design, and variable material properties to meet almost any application.

Beams and beam like elements are principal constituents of many mechanical structures and used widely in high speed machinery, aircraft and light weight structures. Fiber-reinforced laminated beams constitute the major category of structural members, which are widely used as movable 3 elements, such as robot arms, rotating machine parts, and helicopter and turbine blades. Similar to other structural components, beams are subjected to dynamic excitations. Reducing the vibration of such structures is a basic requirement of engineers. One method to reduce the vibration of a structure is to move its natural frequencies away from frequency of excitation force. There are different methods to modify the natural frequencies of beam structures.

To avoid structural damages caused by undesirable vibrations, it is important to determine:

1 - Natural frequencies of the structure to avoid resonance;

2 - Mode shapes to reinforce the most flexible points or to determine the right positions to reduce weight or to increase damping;

3 - Damping factors.

Methodology

Modal analysis of ANSYS is used to determine the natural frequencies and mode shapes, which are important parameters in the design of a structure for dynamic loading conditions. They also required for spectrum analysis or for a mode superposition harmonic transient analysis. Modal analysis in ANSYS program is linear analysis. The mode extraction method includes Block Lanczos (default), sub space, Power Dynamics, reduced, unsymmetric, and damped and QR damped. The damped and QR damped methods allow to include damping in the structure.

Governing Equation

The differential equation of the bending of a beam with a mid-plane symmetry

($B_{ij} = 0$)

so that there is no bending-stretching coupling and no transverse shear deformation ($\varepsilon_{xz}=0$) is given by;

4 11 4 ( ) d IS q x d ω ω = (1)

It can easily be shown that under these conditions if the beam involves only a one layer, isotropic material,

then $IS_{11} = EI = Ebh^3/12$

and for a beam of rectangular cross-section Poisson's ratio effects are ignored in beam theory, which is in the line with Vinson & Sierakowski (1991)

Post Processing

The ANSYS post processor provides a powerful tool for viewing results. We can see the following results in Post processing: 1. Result summary 2. Failure criteria 3. Plot results 4. List results 5. Nodal calculation. The procedure for vibration analysis of composite beam with crack, i.e., V-notch is same as the above described steps, but a little bit modification in modelling process. Crack is created in the composite beam using key points and lines to define areas. Volumes can be made from extruding the areas and then using Boolean operation to achieve a crack in a composite beam. For proper meshing, we will divide the beam at location of crack into two volumes using working plane.

Results and Discussion

In order to check the accuracy of the present analysis, the case considered in Krawczuk & Ostachowicz (1995) is adopted here. The beam assumed to be made of unidirectional graphite fiber-reinforced polyamide. The geometrical characteristics and material properties of the beam are chosen as the same of those used in Krawczuk & Ostachowicz (1995). The material properties of the graphite fiber-reinforced polyamide composite, in terms of fibers and matrix, is identified by the indices f and m, respectively,

Modulus of Elasticity	E_m	2.756 GPa
	E_f	275.6 GPa
Modulus of Rigidity	G_m	1.036 GPa
	G_f	114.8GPa
Poisson's Ratio	ν_m	0.33
	ν_f	0.2
Mass density	ρ_m	1600 kg/m^3
	ρ_f	1900 kg/m^3

In this chapter, the results of vibration analysis of composite beam structure with or without crack are presented. Each of the cracked composite beam problems is presented separately for the following studies: I. Comparison with Previous Studies II.

Numerical Results

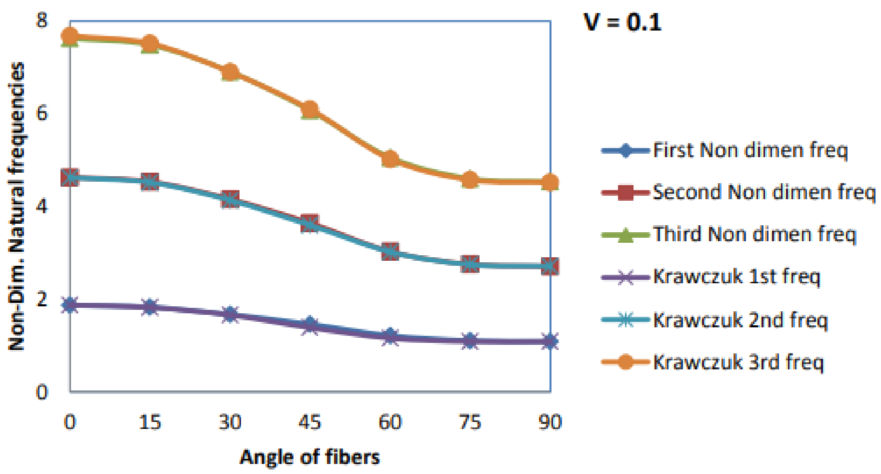
A. Vibration Analysis of composite beam with single crack

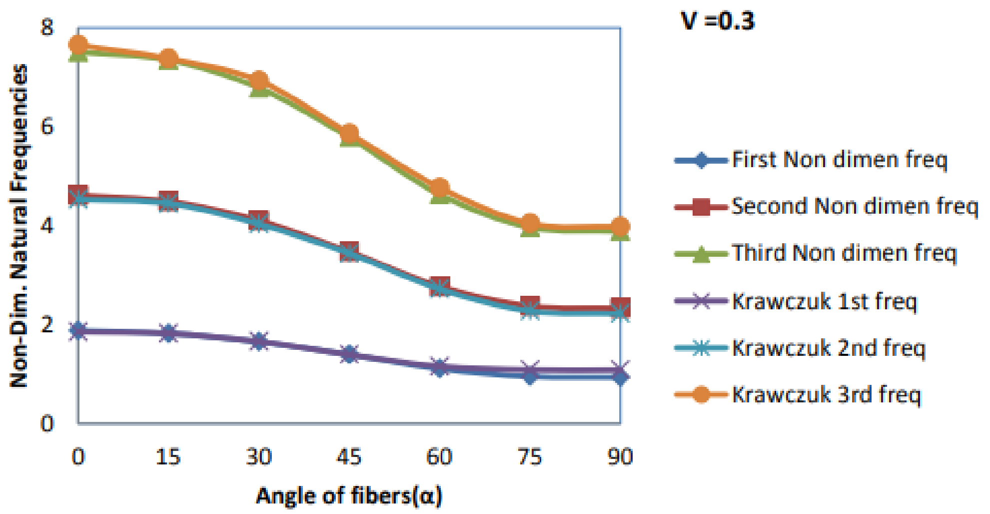
B. Vibration Analysis of composite beam with multiple cracks

Comparison with Previous Studies.

Quantitative results on the effects of various parameters on the vibration analysis of intact and cracked composite are presented.

The presented method has been applied for the free vibration analysis of an intact and cracked composite cantilever beam. Free vibration analysis of a cantilever cracked composite beam has been examined by Krawczuk & Ostachowicz (1995) using finite element method (FEM). In this study the results obtained with present element are compared with the results of Krawczuk & Ostachowicz.





Comparison of non-dimensional natural frequencies of the composite beam with crack as a function of the angle of fibers (α) for crack depth a/H =0.2, 0.4, 0.6 (volume fraction of fiber V = 10%, crack location L1/L = 0.1)

Conclusion

The following conclusions can be drawn from the present investigations of the composite beam finite element having transverse open crack i.e. v-notch.

This element is versatile and can be used for static and dynamic analysis of a composite beam.

- The in-plane bending frequencies decrease, in general, as the fiber angle increases; the maximum occur at α = 0°and decrease gradually with increasing the fiber angle up to a minimum value obtained for α =90°.
- In case of composite beam with crack, as the angle of fibers (α) increases the value of the natural frequencies also increases. The most difference in frequency occurs when angle of fibers is zero degree.
- The non-dimensional natural frequencies is also depends upon the volume fraction of the fibers. The flexibility due to crack is high when the volume fraction of the fiber is between 0.2 and 0.8 and maximum when the fiber fractions is nearly 0.45
- Decrease in the natural frequencies become more intensive with the growth of the depth of crack.
- The increase of the beam length results in a decrease in the natural frequencies of the composite beam
- Boundary conditions have a remarkable influence on the natural frequencies. The natural frequencies for the clamped-clamped support are higher compared to clampedfree support condition

Scope for future work

1. The vibration results obtained using ANSYS 13 can be verified by conducting experiments.
2. The dynamic stability of the composite beam with cracks
3. Static and dynamic stability of reinforced concrete beam with cracks.
4. The Vibration analysis of composite beam by introducing inclined cracks in place of transverse crack

Reference

1. Ali and Aswan (2009*). "Free vibration analysis and dynamic behavior for beams with cracks". International Journal of science engineering and Technology, Vol.2, No. 2.*

2. Broek D. *Elementary Engineering Fracture Mechanics. Martinus Nijhoff, 1986.*

3. Bao and Suo (1992*). "The role of material orthotropy in fracture specimens for composites". Journal of Applied Mechanics 29, 1105-1116.*

4. Dimarogonas (1996). "Vibration of Cracked Structures: A State of the Art Review". Engineering Fracture Mechanics, 55(5), 831-857.

5. Goda and Ganghoffer (2012). *"Parametric study on the free vibration response of laminated composites beams". Mechanics of Nano, Micro and Macro Composite Structures, 18-20*

6. Gaith (2011). *"Nondestructive health monitoring of cracked simply supported fiber reinforced composite structures. Journal of Intelligent Material System and Structures, 22(18).*

7. Ghoneam S. M. (1995*). "Dynamic analysis of open cracked laminated composite beams". Composite Structures, 32, 3-11.*

8. Hamada A. Abd El-Hamid (1998). *"An investigation into the Eigen-nature of cracked composite beams". Composite Structures Vol. 38, No. l - 4, pp. 45-55*