STUDY ON VIBRATION ANALYSIS OF INCLINED EDGE CRACKED BEAM WITH FIXED FREE BOUNDARY CONDITION USING ANSYS SOFTWARE

Hemant B. Wagh[1], Dr. R. B. Barjibhe[2]

1. P.G.Student, Department of Mechanical Engineering, S.S.G.B.C.O.E. & T., Bhusawal (India)

2.Dr. , Dean - Academics & Administration, Member - B.O.S., Mechanical, N.M.U. S.S.G.B.C.O.E.& T., Bhusawal (India)

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Abstract - *The presence of cracks causes changes in the physical properties of a structure and its dynamic response characteristics. This paper focuses on the vibration analysis of a beam with fixed free boundary condition and investigates the mode shape and its frequency. Finite element analysis using ANSYS software is adopted for the dynamic behavior of the beam. Variations of natural frequencies due to inclined crack with variable angles of inclination and with varying crack depths have been studied. A parametric study has been carried out. The analysis is performed using ANSYS software*

Key Words:* *ANSYS, Fixed-Free Beam, Inclined crack, Mode shape, Natural Frequency

1. INTRODUCTION

Structures like Beams are widely used as structural element in civil, mechanical, naval, and aeronautical engineering. Damage is one of the important aspects in structural analysis and engineering. Damage analysis is done to promise the safety as well as economic growth of the industries. During operation, all structures are subjected to degenerative effects that may cause initiation of structural defects such as cracks which, as time progresses, lead to the catastrophic failure or breakdown of the structure. To avoid the unexpected or sudden failure, earlier crack detection is essential. Taking this ideology into consideration crack detection is one of the most important domains for many researchers. Many researchers to develop various techniques for early detection of crack location, depth, size and pattern of damage in a structure. Many nondestructive methodologies for crack detection have been in use worldwide. However the vibration based method is fast and inexpensive for crack/damage identification. Kaustubha V. Bhinge et. al, tried to establish a systematic approach to study and analyze the crack in cantilever beam. This work addresses the inverse problem of assessing the crack location and crack size in various beam structures. The study is based on measurement of natural frequency, a global parameter that can be easily measured at any point conveniently on the structure.[1] D.Y. Zheng, N.J. Kessissoglou have studied on the natural frequencies and mode shapes of a cracked beam are obtained using the finite element method. An 'overall additional flexibility matrix', instead of the 'local additional flexibility matrix', is added to the flexibility matrix of the corresponding intact beam element to obtain the total flexibility matrix, and therefore the stiffness matrix.[3] Malay Quila et. al., have studied on cracks which causes changes in the physical properties of a structure which introduces flexibility, and thus reducing the stiffness of the structure with an inherent reduction in modal natural frequencies. Consequently it leads to the change in the dynamic response of the beam.[4] Ranjan K. Behera, Anish Pandey, Dayal R. Parhi in their research work has developed the theoretical expressions to find out the natural frequencies and mode shapes for the cantilever beam with two transverse cracks.[5] As discussed above the failure of machine component is loss of time, money and life. Most of the machine components failures are because of the crack. So there is necessity to predict such failures in advance so that losses because of failure are avoided or minimized. Condition based monitoring is one of the preventive maintenance method used in the plant maintenance. So there is requirement to develop the methodology which can be used easily to predict the crack in the machine component from the machine condition such as vibration data. The present work is aimed at finding the natural frequency of a fixed free beam with a single crack and un-cracked crack using finite element analysis ANSYS software

2. FINITE ELEMENT ANALYSIS

The finite element method (FEM) is a numerical method for analyzing structures. It is firmly established as a powerful popular analysis tool. It is most widely used in structural mechanics. The finite element procedure produces many simultaneous algebraic equations, which are generated and solved on a digital computer. The main rule that involved in finite element method is "DEVIDE and ANALYZE". The greatest unique feature which separates finite element method from other methods is "It divides the entire complex geometry into simple and small parts, called "finite elements". These finite elements are the building blocks of the finite element analysis. Based on the type of analysis going to be performed, these elements divided into several types. Division of the domain into elements is called "mesh". The forces and moments are transferred from one element to next element are represented by degrees of freedom (DOFs) at coordinate locations which are called as "nodes". Approximate solutions of these finite elements give rise to the solution of the given geometry which is also an approximate solution.

The approximate solution becomes exact when

1. The geometry is divided into numerous or infinite elements.
2. Each element of geometry must define with a complete set of polynomials (infinite terms).

The finite element method has become an important tool for the numerical solution of a wide range of engineering problems. It has developed simultaneously with the increasing use of high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum, is well-established numerical method applicable to any continuum problem, stated in terms of differential equations or as an extranet problem

Table. 1 Material Property and Dimensions of Aluminium Beam

Dimensions and Properties	Aluminum
Length	0.8 m
Width	0.03 m
Thickness	0.006 m
Density	2700 kg/m^3
Young modulus	70 Gpa
Poisson's ratio	0.3

3. MODELING OF BEAM USING ANSYS

The Beam is modeled in ANSYS Software. Element SOLID45 is used for the 3-D modeling of solid structures. Material properties are provided which is briefly listed in Table 1. After that 12 models are prepared with various inclination angles for crack with the location of crack as center of beam. After that the beam is meshed. The natural frequency of the cracked beam is found by the well known Finite Element (FEM) Software ANSYS. Modal analysis is carried out using the Block Lanczos method for finding the natural frequencies. The fixed free boundary condition was applied by constraining the nodal displacement in both x and y direction. The results are tabulated in Table 1 and Table 2. The five mode shapes of beam with and without crakes are shown in Fig.

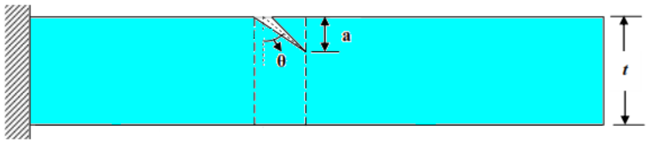


Fig. 1 Cracked Beam Modeled in ANSYS

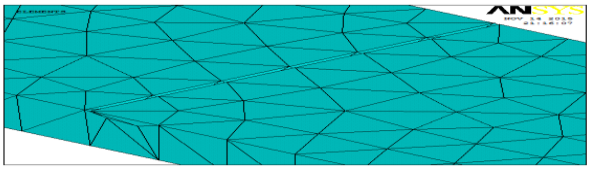
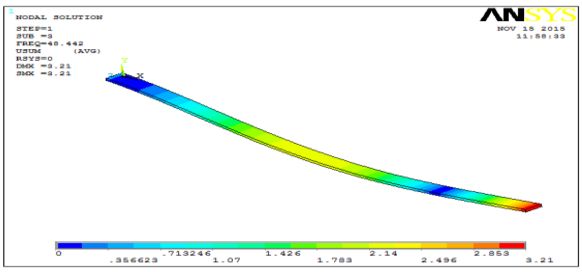


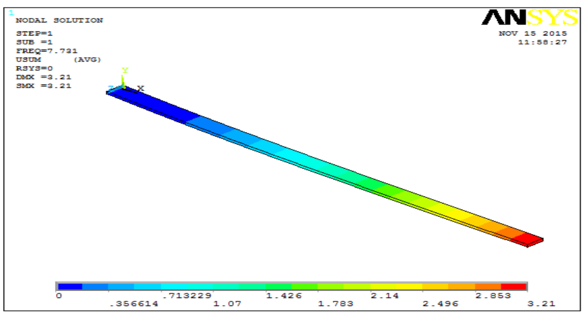
Fig. 2 Mesh Model

Table 2 : Natural Frequencies of Un- cracked beam (ANSYS)

	Natural Frequency in Hz				
Beam	**Ist Mode**	**IInd Mode**	**IIIrd Mode**	**IVth Mode**	**Vth Mode**
Uncracked Beam	7.731	48.442	135.628	265.767	656.319



First Mode



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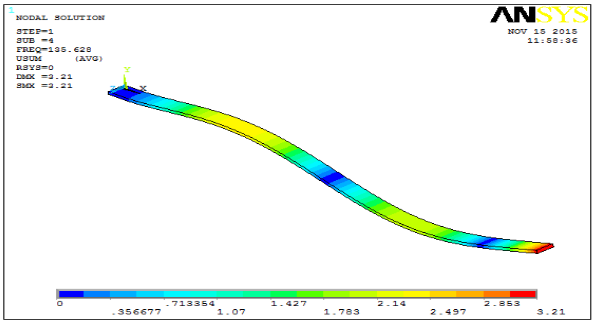
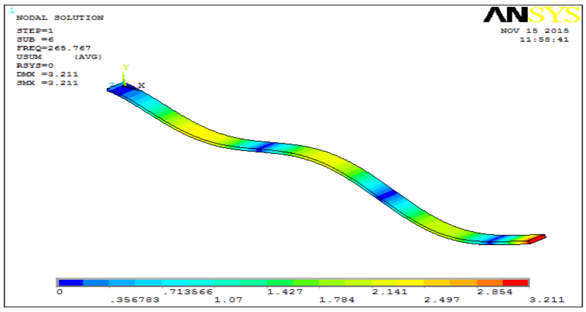


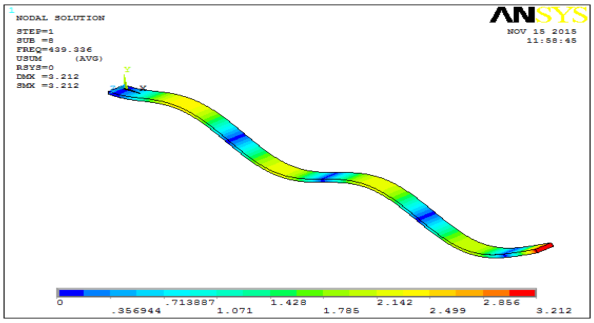
Third Mode



Fourth Mode

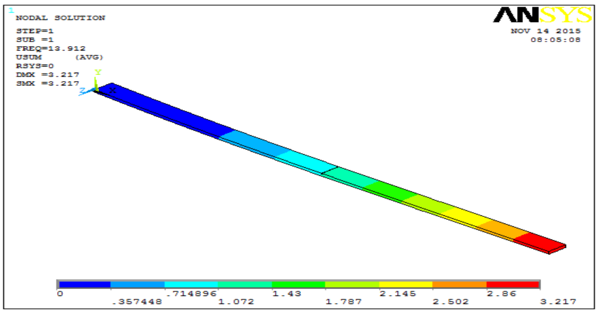
Table 3: Natural Frequencies of cracked beam with varies crack Inclination angle and depth of crack by Using ANSYS

Crack angle θ	Relative Crack Depth (α = a/t)	Natural Frequency in Hz				
		Ist Mode	IInd Mode	IIIrd Mode	IVth Mode	Vth Mode
0	0.1	13.98	86.89	241.24	472.35	778.64
0	0.2	13.84	85.85	239.21	467.33	771.68
0	0.3	13.76	85.43	238.39	464.75	769.21
15	0.1	13.91	87.14	244.81	478.74	788.62
15	0.2	13.84	86.61	242.52	474.76	780.67
15	0.3	13.50	84.48	237.69	464.05	766.14
30	0.1	13.86	86.98	244.02	477.59	785.13
30	0.2	13.81	86.75	242.99	476.14	782.11
30	0.3	13.76	85.94	241.47	469.28	775.66
45	0.1	13.96	87.19	243.82	477.55	782.52
45	0.2	13.81	86.46	241.72	474.9	777.23
45	0.3	13.75	85.98	241.45	471.66	778.18

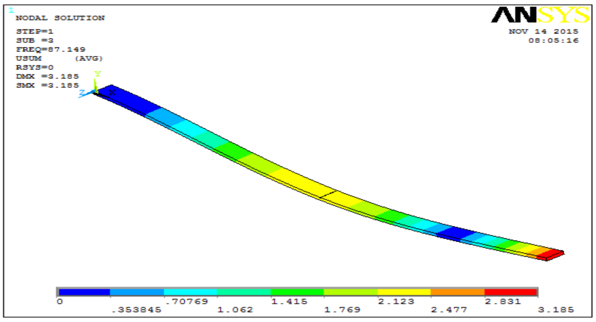


Fifth Mode

Fig.3 Mode Shape of Fixed Free Un-cracked Beam



First Mode



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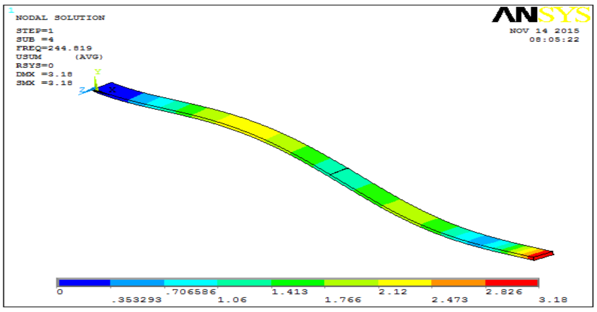

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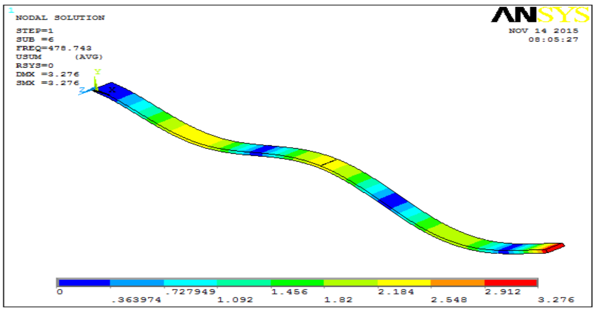
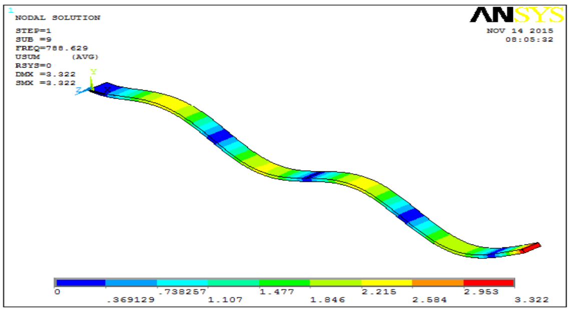


Fourth Mode



Fifth Mode

- **Fig. 4 Mode Shape of Fixed Free Cracked Beam ($\theta=15^0$ and $\alpha= 0.1$)**

4. RESULTS AND DISCUSSION

Figures 3 and 4 shows that natural frequencies of the beam with out and with a inclined edge crack at various crack inclination and crack depths for first, second, third, fourth and fifth modes of vibration respectively. Results show that there is an appreciable variation between natural frequency of cracked and un-cracked fixed and cantilever beam. It is observed that natural frequency of the cracked beam decreases both with increase in crack inclination and crack depth due to reduction in stiffness. It appears therefore that the change in frequencies is not only a function of crack depth and crack inclination but also of the mode number

5. CONCLUSION

It has been observed that the natural frequency changes substantially due to the presence of cracks depending upon inclination and depth of cracks. The results of the crack parameters have been obtained from the comparison of the results of the un-cracked and cracked cantilever beam during the Modal analysis using ANSYS software. When the crack location and crack inclination are constant, but the crack depth increases. The natural frequency of the cracked beam decreases with increase the crack depth. It has been observed that the change in frequencies is not only a function of crack depth, and crack inclination, but also of the mode number. As largest effects are observed at the crack inclination 15^0 and depth ratio is 0.3 on cantilever beam we can say, decrease in frequencies is more for a crack located where the bending moment is higher.

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