ALTERNATIVE SOLUTION TO THE DETECTION OF CRACK LOCATION AND CRACK DEPTH IN STRUCTURE BY USING SOFTWARE ANALYSIS METHOD

Dr. P.K. Sharma[1], Prof. Meghna Pathak[2], Mr. Patil Amit V[3]

[1] HOD & Co-Guide, [2] Prof. & Guide, [3] M.Tech Scholar,
Mechanical Department, NIIST, Bhopal. (India)

ABSTRACT

Early detection of damage is of special concern for engineering structures. The traditional methods of damage detection include visual inspection or instrumental evaluation. Here ANSYS software package is used for finite element analysis of both crack and un-crack cantilever beam taking input file as a CAD design developed in CATIA. Experiments is done for total 10 models of crack beam having different cross section, The presence of crack leads to changes in some of the lower natural frequencies.The proposed approach has been verified by comparing results obtained from theoretical method and finite element analysis.The concept of vibration can be applied to identify the crack location.The vibrations having certain amplitude and frequency may be reliable for human being. Modern non-destructive techniques to detect the cracks are time consuming. Software analysis technique is the alternative for non-destructive Testing techniques. This technique gives approximate solution for the crack detection in structure.

Keywords: Alternative Solution, Crack Location, Crack Depth.

I. INTRODUCTION

For crack detection of structure, vibration based methods make a good approach. Vibration based methods use the fact that due to the presence of the crack, there is a change in the flexibility which affects the natural frequency of the structural element. Vibration-based methods have been proved as a fast and inexpensive means for crack identification. A crack in a structure induces a local flexibility which affects the dynamic behaviour of the whole structure to a considerable degree. It results in reduction of natural frequencies and changes in mode shapes. An analysis of these changes makes it possible to determine the position and depth of cracks. Most of the researches used in their studies are open crack models, that is, they assume that a crack remains always open during vibration. The assumption of an open crack leads to a constant shift of natural frequencies of vibration.

A. Specifications:

E= Young’s modulus of the material,

I= Moment of inertia,
A= Area of cross section,
l=length of the beam,
m = mass of the beam per unit length
b= width of the cantilever beam section,
d= depth of the cantilever beam section.
ωi = natural frequency of the i^{th} mode
C= Constant depending mode of vibration,
C_1=0.56 for first mode,
C_2= 3.51 for second mode,
C_3= 9.82 for third mode.
I_1=Moment of inertia of a cracked beam,
I_c= Moment of inertia of cracked beam element.
q=displacement vector of the beam

II. LITERATURE REVIEW

Research of different researchers on crack detection in structure is as follows.

- D.K. Agarwalla concludes crack detection and localization is the main topic of discussion for various researchers across the globe. It is concluded that results obtained from experiment have a very good agreement with the results obtained from FEM and the structure vibrates with more frequency in the presence of a crack away from the fixed end.
- Amiya Kumar Dash represents the multi crack detection of structure using fuzzy Gaussian technique. He derived from thevibration parameters numerical methods of the cracked cantilever beam to set several fuzzy rules for designing the fuzzy controller used to predict thecrack location and depth.
- Dayal R. Parhi and Sasanka Choudhury a cantilever beam with a single crack has been taken into consideration. Finite element method is used to find out the natural frequencies of the faulty cantilever beam. A fuzzy controller has been designed using trapezoidal, Gaussian as well as triangular membership function to find out the crack depth and crack location.
- Meysam Siyah Mansoory attempt to evaluate the performance of the SUSAN edged Detector for noisy images based on fuzzy thresholding. Experimental results have demonstrated that the SUSAN edge Detector works quite well for digital images noisy with Gaussian noise Because the SUSAN algorithm uses no derivative too the proposed algorithm is less sensitive to noise than other edge detectors. Meanwhile this algorithm in comparison with other method had processing time less than other in this field.
- N. V. NarasimhaRao Rao proves the vibration analysis of crack cantilever beam with open transverse crack. A fuzzy logic interface system is used to analyze the crack in cantilever beam. A series of fuzzy rules are used finally for prediction of crack depth and crack location.

- R. Tiwari and M. Karthikey developed identification procedure for the detection, localization, and size of a crack in a beam based on forced response measurements. They used circular beam supported by rolling bearings at both ends for this experiment.
- S Lalonde J Lanteigne, F Leonard, and Y Turcotte studied cracks that occurred in metal beams obtained under controlled fatigue-crack propagation.
- An analytical and experimental approach by H. Nahvi and M. Jabbari et al. to the crack detection in cantilever beams by vibration analysis. Sensibility analysis of the inverse problem of the crack parameters (location and depth) determined by M. B. Rosales, C P Filipich and F S Buezas et al. An efficient numerical technique is necessary to obtain significant results.

III. THEROTICAL FORMULATIONS

For crack depth and location, the terms RCD and RCL are considered and calculated by the formula,

$$RCL = \frac{\text{distance of crack grom fixed end}}{\text{length of the beam}} \quad (1)$$

$$RCD = \frac{\text{depth of the crack}}{\text{depth of the beam}} \quad (2)$$

It is assumed that the natural frequency changes due to the change in moment of inertia only. The beam made up of structural steel material by extrusion process. The Young's modulus for the beam material is 210×10^9 N/m^2.The beam models no. 1 to 5 is of rectangular cross section while beam model from 6 to 10 are of square cross section.

IV. FINITE ELEMENT ANALYSIS

Finite element analysis has been carried out by ANSYS12 software. ANSYS is a general-purpose finite-element modeling package for numerically solving a wide variety of mechanical problems. These problems include static/dynamic, structural analysis (both linear and nonlinear), heat transfer, and fluid problems, as well as acoustic and electromagnetic problems.

The solution is obtained by using ANSYS Work Bench modeler. First 10 modes of natural frequencies are set down and from the resulted data, first three modes of transverse vibration are taken for comparison of 10 beam models. The results are tabulated in Table 1and 2.

Table 1 Finite Element Analysis Result of Rectangular Cross-Section Beam

Beam Model No.	Relative Crack Depth	Relative Crack Location	First Natural Frequency	Second Natural Frequency	Third Natural Frequency
6	0	0	16.65	104.25	291.46
7	0.2	0.25	16.62	104.25	291.38
8	0.4	0.25	16.55	104.25	291.13
9	0.2	0.5	16.64	104.20	291.40
10	0.4	0.5	16.62	104.06	291.46

Table2 Finite Element Analysis Result Of Square Cross-Section Beams

Beam Model No.	Relative Crack Depth	Relative Crack Location	First Natural Frequenc y	Second Natural Frequency	Third Natural Frequency
1	0	0	8.34	53.20	146.32
2	0.2	0.25	8.31	53.11	145.90
3	0.4	0.25	8.23	52.88	144.97
4	0.2	0.5	8.33	52.09	146.34
5	0.4	0.5	8.31	51.43	146.30

Following steps show the guidelines for carrying out Modal analysis.

Define Materials

1. Set preferences. (Structural steel)
2. Define constant material properties. (Density, Young's modulus, Poisson's ratio)

Model the Geometry

3. Follow bottom up modelling and create/import the geometry.

Generate Mesh

4. Define element type. (Default mesh of element size 2 mm)

5. Mesh the area.

Apply Boundary Conditions

6. Apply constraints to the model. (Fixed support at the end of beam)

Obtain Solution

7. Specify analysis types and options. (Modal analysis up to 10 modes)
8. Solve

The ANSYS 12 finite element program was used for free vibration of the cracked beams. For this purpose, the total 10 models are created at various crack positions in CAD software (CATIA) and imported in ANSYS (.stp file).

V. CONCLUSION

We can draw following conclusions When the crack depth increases and the crack location is constant the natural frequency of the beam decreases. Natural frequency changes at the area of crack location. When the crack depth is constant and crack location increases from the cantilever end natural frequency decreases. Crack depth and crack location of a beam can be predicted by measuring natural frequency by Finite Element Analysis. As square cross section beam have same transverse and longitudinal frequency, it is better to use rectangular cross section beams since they have larger transverse frequency than longitudinal. Hence it saves considerable amount of computation time.

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