A REVIEW PAPER ON DETECTION OF CRACK LOCATION AND CRACK DEPTH BY USING FUZZY LOGIC

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ABSTRACT
A crack in a structural member introduces local flexibility that would affect vibration response of the structure. The presence of damage leads to changes in some of the lower natural frequencies and mode shapes. Damage detection is one of the important aspects in structural engineering for safety reasons. Main problem is to detect existence of a crack together with its location and depth in the structural member. We propose a method based on some set of fuzzy rules obtained from the information supplemented by Numerical Analysis. Fuzzy controller use comprises of three input variables (first, second and third natural frequency) and two output variables (relative crack length and relative crack depth) are generated with Triangular MF
KEYWORDS – Free vibration; Crack; Natural frequency; Fuzzy Logic

INTRODUCTION
Crack is defined as any deviation introduced to a structure, either deliberately or unintentionally, which adversely affect the current or future performance of that system. It is clear from this definition that a comparison is needed between two states of a structure. Cracks are among the most encountered damage types in the structures due to fatigue or manufacturing defects. Crack will initiate in a structure when the stresses near the crack tip will exceed the permissible limit. Cracks found in structural elements may arise due to fatigue cracks that take place under service conditions as a result of the limited fatigue strength; they may also be due to mechanical defects, as in the case of turbine blades of turbine engines, compressor blades or may be because of defects due to manufacturing processes. Mechanical accidents, fatigue, erosion, corrosion, as well as environmental attacks, are issues that can lead to a crack in a mechanical structure. 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

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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 non-destructive methodologies for crack detection have been in use worldwide. However the vibration based method is fast and inexpensive for crack/damage identification.

In this paper efforts have been made to present various cost effective reliable analytical numerical and experimental techniques developed by various researchers for vibration analysis of cracked beams.

In this paper the effect of various parameters like crack size, crack location, of beam on modal parameters subjected to vibration of a damaged beam also have been reviewed.

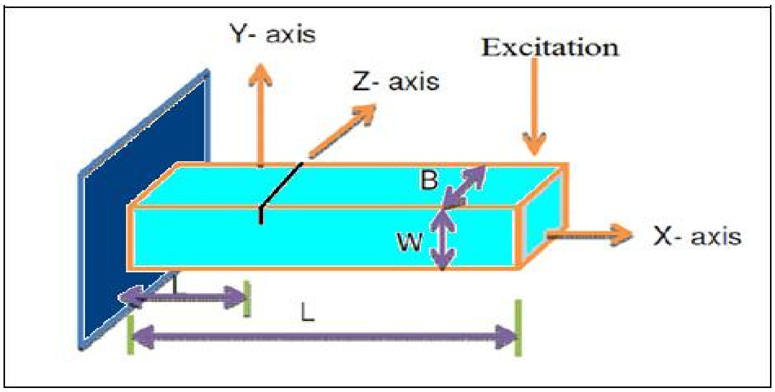

Fig.1 Uncracked cantilever beam model

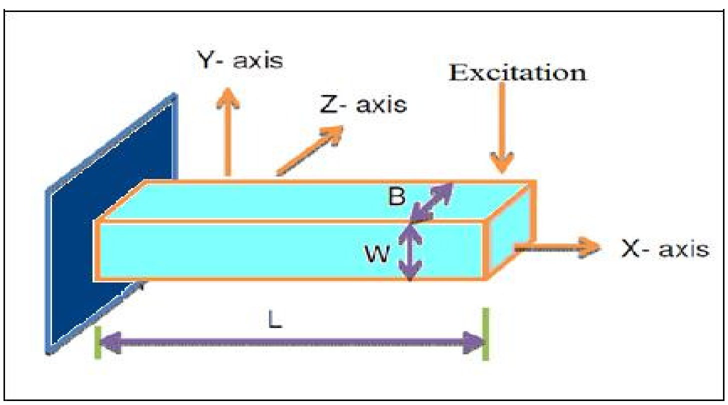

Fig.2 Cracked cantilever beam model

LITERATURE REVIEW

Ranjan K. Behera [1] has presented to model an inclined open edge crack in a cantilever beam and analyse the model using a finite element package, as well as experimental approach. The experiments are carried out using specimens having inclined edge cracks of different depths, positions and crack inclinations to validate the FEA results achieved.

Aniket S. Kamble [2] has presented crack is modeled as a rotational spring and equation for non-dimensional spring stiffness is developed. By evaluating first three natural frequencies using vibration measurements, curves of crack equivalent stiffness are plotted and the intersection of the three curves indicates the crack location and size. The time amplitude data obtained is further used in the wavelet analysis to obtain time-frequency data.

Marco A. Perez [3] has presented to investigate the feasibility of using vibration-based methods to identify damages sustained by composite laminates due to low-velocity impacts. Four damage indicators based on modal parameters were assessed by comparing pristine and damaged states. It's precision in determining the location of damage, its sensitivity regarding damage extent and pertinent correlations with residual bearing capacity.

P. K. Jena [4] has presented the fault detection of Multi cracked slender Euler Bernoulli beams through the knowledge of changes in the natural frequencies and their measurements. The spring model of crack is applied to establish the frequency equation based on the dynamic stiffness of multiple cracked beams. Theoretical expressions for beams by natural frequencies have been formulated to find out the effect of crack depths on natural frequencies and mode shapes. Cantilever beam with two cracks analysis show an efficient state of the research on multiple cracks effects and their identification. **Kaushar H. Barad [5]** has presented detection of the crack presence on the surface of beam-type structural element using natural frequency. First two natural frequencies of the cracked beam have been obtained experimentally and used for finding of crack location and size.

Amit Banerjee [6] has presented to obtain information about the location and depth of transverse open multiple cracks in a rotating cantilever beams. Mode shape of damaged rotating beam is obtained using finite element simulation. Using fractal dimension of mode shape profile, damage is detected.

A. Dixit [7] has presented damage measure which relates the strain energy, to the damage location and magnitude. The method is applicable to beams, with notch like non-propagating cracks, with arbitrary boundary conditions. The analytical expressions derived for mode shapes, curvature shapes, natural frequencies and improved strain energy based damage measure, are verified using experiments. The damage measure was shown to be extremely sensitive to the damage as both the discontinuity in stiffness and also the curvature are contained in the damage measure.

Mousa Rezaee [8] has presented the energy balance method is proposed for free vibration analysis of a cracked cantilever beam by taking into account both the structural damping and the damping due to the crack. The stiffness changes at the crack location are considered to be a nonlinear amplitude-dependent function which causes the frequencies and mode shapes of the beam to vary continuously with time.

MATERIAL & METHODOLOGY

ASSUMPTIONS

For the purposes of crack identification the following assumptions are made:

1) The beam is a long beam.
2) The crack is open. This assumption is expected to be realistic because the crack is usually found in areas which are exposed to heavy weights, which naturally leads to an open crack.
3) The crack is regular over the surface of the specimen, uniform in propagation.
4) The crack is a transverse crack.
5) The vibrations are flexural in nature. The axial vibrations are not present.

MATERIAL SELECTION

Structural steels are used in load bearing frames in buildings and as members in trusses, bridges, space frames, towers, water tanks, silos, bunkers, beams, domes, folded plates, offshore platforms, chimneys, and cooling towers. Therefore Structural steel beams have been considered for making specimens.

The specimens are cut to size from ready-made square bars. Total 05 specimens are cut to the size as length 700 mm and cross section area is 10mmX10mm. The modulus of elasticity and densities of beams have been measured to be 210GPa and 7850 Kg/m3. and analysis on material is followed by methods such as theoretical analysis, experimental analysis.

Theoretical analysis is done by Euler's beam theory.

Experimentation will be conduct on FFT analyser.

The steps adopted to carry out research methodology are as follows:

1. To measure the natural frequencies of various beam models by using Euler's Beam model theory. The theory used in this report is Euler's Beam theory. The natural frequencies are finding out by this theory for beams of different crack sizes and cross section.
2. To measure the natural frequencies of various beam models by using Experimentation (FFT analyzer). The FFT Analyzer is used to carry out experimentation on beam models for validation of proposed theory.
3. To compare the natural frequencies of models by above two methods. A comparison is made to find the errors in the above methodologies.
4. To identify the crack by using curve fitting toolbox in MATLAB. The curve is generated in MATLAB to identify the cracks present in model.
5. To introduce Fuzzy logic toolbox in MATLAB. The toolbox Fuzzy logic in MATLAB software is one of the better methods to identify crack.
6. To identify the crack by using Fuzzy logic toolbox in MATLAB. A fuzzy model is developed for proposed theory and finds the numerical solution of the problem.

SOFTWARE

1. Matlab: MATLAB is used to plot three dimensional surfaces from the data generated by theoretical data.
2. Minitab: MINITAB is used to plot contour lines.
3. Microsoft Excel: Microsoft Excel is used to plot three contour lines on the same axis to get their common intersection point. For this the data is collected from MINITAB software.

TEST RIG

1. FFT analyzer is used to measure natural frequencies of cracked and uncracked beam.
2. Experimental setup is used to carry out experimental modal analysis. Experimental set up consists of a fixture to clamp the test beams so that clamped-free boundary conditions will get simulated and beam is considered as cantilever beam. The fixture consists of two plates, four nuts, bolts and washers.

CONCLUSION

It has been observed that the changes in natural frequencies are the important parameter that determine crack size and crack location respectively. Researchers are presently focusing on using the concept of fuzzy Logic as an effective tool for crack analysis of structures.

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