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A review on vibration analysis of cracked cantilever beam with rectangular cross-section

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Abstract
In this paper we study evaluate of various vibration based crack detection technique by various researches. For detection of crack in a composite and non composite structure, we compare finite element analysis and experimental modal analysis. Crack present in structure affect on its static as well as dynamic response characteristics. Crack in a beam modify the natural frequency, mode shape & stiffness. To note down all results it's possible to crack depth and crack position.

Keywords: crack detection, finite element analysis, natural frequency, mode shape, crack depth, crack position

Introduction

Structural health monitoring and analysis of structures like cantilever beam with cracks is of great importance from safety as well as system performance point of view, when a structure suffers from damages like cracks, its dynamic properties can change. Crack damage leads to reduction in stiffness, also with an inherent reduction in natural frequency. It is required structure must safely work during its service life. Crack in a structure due to static and dynamic loading, so the crack detection plays an important role in structural health monitoring application. Many of researchers develop various non-destructive techniques for early detection of crack location, crack depth and crack size. There are many techniques to evaluate the problem of a cracked beam such as numerical, analytical, and experimental. Finite Element Method is a common technique to obtain the stiffness matrix of the cracked beam element. During last few decades, deep research on the detection of crack using the vibration based techniques has been done. In this paper number of literatures published so far have been surveyed, reviewed and analysed. This paper focus on various cost effective reliable, numerical and experimental techniques developed by various researchers for vibration analysis of cracked beams.

Literature Review

Murat Kisa [1] explained that, in which the finite element analysis and component mode synthesis methods are used, the beam is separated into parts from the crack section. Numerous techniques, such as non-destructive monitoring tests, can be used to veil the condition of a structure. Novel techniques to identify structural defects should be explored. A crack in a structural element modifies its stiffness, dynamical performance and damping properties. The mode shapes and natural frequencies of the specimen hold information relating to the location and dimension of the crack.

Saidi abdelkri [2] explained that, dynamic characteristics of damaged and undamaged materials are very different. The dynamic properties of a structure can be found by modal-simulations or by experimental modal analysis. Crack formation due to cycling loads leads to fatigue of the structure and discontinuities in the interior configuration. Cracks in vibrating parts can initiate catastrophic failures. The aim of this study is to analyze the vibration characteristics of concrete beams both experimentally and using ANSYS subjected to the crack under free vibration cases. When the location of the crack increases from the clamped end of the beam, natural frequencies of the beam and the amplitude of high frequency also increase, but the amplitude of low frequency vibration decreases. It show that as the depth of the crack increases, the magnitude of amplitude of vibration increases at high frequencies but the natural frequencies decrease because of the stiffness reducing is inversely proportional to the depth of a crack.

D. R. K. Parhi [3] explained that, the identification of Multi cracked slender Euler Bernoulli beams through the knowledge of change in the natural frequencies and their measurements. The method is based on the modelling a crack by rotational spring. The model of crack is applied to establish the frequency equation on the dynamic stiffness of multiple damaged beams. Theoretical expressions for natural frequencies have been developed to find out the effect of crack depths on mode shapes and natural frequencies. The equation is the basic instrument in solving the multiple crack detection of beam. The significant changes in mode shapes are observed at the local area of crack location. The locations of the cracks in relation to each other affect changes in the frequencies of the natural vibrations in the case of an equal corresponding depth of the cracks. In the case of two cracks of different depth, the big crack has the most significant effect on the natural vibration frequencies. For other modes of vibration this is not so clear, because the effect of a crack location at a node is negligible. These changes in natural frequencies and mode shapes will be helpful in forecasting of crack location and its intensity.

Dr. R.K. Behera, S.Y.Pawar [4] explained that, vibration analysis conducted on a cantilever beam with two open cracks

to determine the response characteristics. In first phase matrices of different degree of freedom have been used model transverse crack in beam on available expression of strain energy release rate and stress intensity factor. The results obtained numerically are validated with results obtained from simulation (FEM). The simulations have been done with the help of ANSYS software. It is verified from both computational and simulation analysis that the presence of crack decrease the natural frequency of vibration. The mode shapes changes due to presence of crack. The presence of crack in structure member introduces local flexibilities which can be computed and used in structural analysis. The problem involves calculation of natural frequencies and mode shapes for cantilever beam without a crack and with two cracks of different crack depths. The results calculated analytically are validated with the results obtained by simulation analysis. The frequency of cracked cantilever beam decreases with increase crack depth for the all mode of vibration.

Dayal R. Parhi, Goutam Pohit [5] explained that, to identify location and the depth of crack in a beam containing single transverse crack is done through conceptual and experimental analysis respectively. It noticed that a crack in a beam has great effect on dynamic characteristics of beam. The strain energy density function also applied to examine the few more flexibility produced because of the presence of crack. The difference of mode shapes of cantilever beam, simply supported beam and Clamped – Clamped beam in between the first three mode shapes of cracked and un-cracked respectively beam with its amplified view at the location of the crack are studied. The theoretical analyses are carried out of the crack structure. It is found that the future work on the problem of fault recognition of a cracked beam can be carried by using more advanced hybrid techniques with the help of finite element method and artificial intelligence technique.

D. S. Sharma [6] explained that, detection of the crack presence on the surface of beam type structural element using natural frequency is discovered. First two natural frequencies of the cracked beam have been obtained experimentally and used for detection of crack location and size. Obtained crack locations and size are compared with the actual results and found to be in good agreement. Crack present in the specimen may grow during service and may result in the component failure they develop beyond a critical limit. Vibration Based Inspection can be a effective method for crack detection, it is essential to develop an effective and economically appropriate approach. The natural frequency is highly affected by crack depth and crack location. Using this approach, to detect crack location and size can be done fast using natural frequency. Crack with larger crack depth ratio (a/h) imparts higher reductions in natural frequency than that of the smaller crack depth ratio. Hence, the accuracy of results enhance as crack depth increases. Crack present near to fixed end affect greater reductions in natural frequency than away from the fixed end.

Vinod B. Tungikar [7] explained that, the method of multiple cracks detection in moving parts or beams by monitoring the natural frequency and forecasting of crack location and depth using Artificial Neural Networks. Detection of crack properties like depth and location is vital in the fault diagnosis of rotating machine components. For the theoretical analysis, Finite Element Method (FEM) is used wherein the natural frequency of beam is calculated whereas the experimentation is done by using Fast Fourier Transform (FFT) analyzer. In simply supported beam with one crack and cantilever beam with two cracks are considered. The experimental results are validated with the results of FEM (ANSYS) software. To investigate the validity of the proposed method, some predictions by ANN are compared with the results given by FEM. It is found that the method is capable of predicting the crack location and depth for single as well as two cracks.

B. Kumar and SA Khan [8] explained that, to develop suitable methods that can serve as the basis to detection of crack location and crack size from measured axial vibration data. Cracks develop gradually through time that lead finally to catastrophic failure. Vibration technique can be suitably used as a non-destructive test for crack detection of component to be tested. This method for detection of crack from measurement of natural frequencies of cracked free–free beam for axial vibration is developed. The error in prediction of crack location and crack size by theoretical and experimental analysis is less than 16%. The proposed method is confirmed by comparing it with results of Ansys FEM results. The proposed method is found to be both simple and accurate.

D.R. Parhi [9] explained that, the effect of an open crack on the modal parameters of the cantilever beam subjected to free vibration is analyzed and the results obtained from the numerical method i.e. finite element method (FEM) and the experimental method are compared. Mode shapes and natural frequencies of the vibrating structures are susceptible to change under the affect of crack depth & crack location. Mode shapes in magnifying views allow the researchers to get an idea of the major changes at the crack location. Therefore position and severity of crack can be determined by analyzing these changes. The experimental results can be confirmed conveniently by comparing the results obtained from cracked beam numerically.

Anish Pandey [10] explained that, a crack in the vibrant structures can lead to premature failure if it is not detected in early stages. The failure rate increases as the crack growth increases due to the structure becomes weaker. Therefore, crack detection and type of crack is a key issue. The existence of cracks which affect the performance of structure as well as the vibration characteristics such as; natural frequencies, mode shapes, stiffness and modal damping. This paper presented model an inclined open edge crack in a cantilever beam and analyzes the model using a finite element analysis, as well as experimental approach, when the natural frequency increases, the crack location also increases. The crack position in the cantilever beam can be projected for crack size of more than 10% of depth. It has also been seen from examples that the determination of the crack location is more precise than the determination of the crack size.

Materials and Methods

Vibration analysis of various materials like Aluminium, Mild steel, Composite is followed by authors by their methods such as experimental, finite element analysis, MATLAB. Study of Epoxy resin, polyester and fibre glass is done by using model analysis, and experimental methods.

Discussion

Many researchers used different non-destructive techniques for detection of crack in vibrating structure. According to the researcher, presence of crack modifies the dynamic characteristics of structure. This change in dynamic source used as an information source. Researchers done lot of work on effect of crack depth, crack location and crack inclination on natural frequency and mode shape. Researcher used transfer matrix method as an input data. Physical properties, boundary condition, crack depth, crack inclination, orientation and number of cracks greatly influence the dynamic response of the structure. Some have used wavelet analysis for detection in vibrating structure. Many researchers worked on the genetic algorithm, Artificial Neural Network and Fuzzy logic techniques for identification of crack in beam structure. Researchers used concept like strain energy, stress intensity factor and fracture mechanics for detection of crack in cantilever beam.

Conclusion

It is found that detection of crack size, crack location in cantilever beam depends on natural frequencies and mode shapes. Many researchers studied dynamic behaviour of structure by varying crack location, crack inclination and crack depth. Researchers develop more technique for analysing vibration system. Now-a-days many researchers using artificial neural network, genetic algorithm and fuzzy logic techniques for damage detection in structure. Researchers developed various theories and concept like transverse crack, longitudinal crack, slant crack, surface crack, open crack etc for identify dynamic characteristics of structure.

References

1. Murat Kisa, Arif Gurel M. Free vibration analysis of uniform and stepped cracked beams with circular cross sections, International Journal of Engineering Science. 2007; pp. 364-380.
2. Saidi Abdelkri, Hamouine Abdelmadjid, Chabani abdelmadjid. Crack detection in concrete beams using experimental modal data, International Conference on Structural Dynamics, EURODYN. 2011; pp.2123-2126.
3. Jena PK, Parhi DRK. Effect of damage parameters on vibration signatures of a cantilever beam, International Conference on Modelling, Optimization and Computing. 2012; pp.3318-3330.
4. Mogal SP, Dr. Behera RK, Pawar SY. Vibration analysis of cracked beam, International Journal of Advanced Engineering Technology. 2012; 3:371-377.
5. Dayal R, Parhi, Goutam Pohit. Faults detection of a single cracked beam by theoretical and experimental analysis using vibration signatures, IOSR Journal of Mechanical and Civil Engineering. 2012; 4(3):01-18.
6. Sharma DS, Vishal Vyas. Crack detection in cantilever beam by frequency based method, Nirma University International Conference on Engineering. 2013; pp.770-775.
7. Vinod B Tungikar. Multiple Cracks Assessment using Natural Frequency Measurement and Prediction of Crack Properties by Artificial Neural Network. International Journal of Advanced Science and Technology. 2013; pp.23-38.
8. Kumar B, Khan SA. Approximate analytical method for damage detection in free-free beam by measurement of axial vibrations, International Journal of Damage Mechanics. 2013; pp.133-142.
9. Dr. Parhi. Effect of Crack on Modal Parameters of a Cantilever Beam Subjected to Vibration, Procedia Engineering. 2013; 51:665-669.
10. Anish Pandey, Dayal R Parhi. Numerical and Experimental Verification of a Method for Prognosis of Inclined Edge Crack in Cantilever Beam Based on Synthesis of Mode Shapes, International Conference on Innovations in Automation and Mechatronics Engineering, ICIAME. 2014; pp.67-74.