Crack Detection Techniques in Overhang Beam

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***Abstract*---**The methodology to detect crack is presented which takes advantage of wavelet finite element methods in the modal analysis for singularity problems like a crack beam. First, the beam is discretized into a set of wavelet finite elements, and then natural frequencies of beam with various cracks are accurately obtained .Thus the prominent effect is then correlated with crack location,depth etc. and then it is observed that non-uniform effect is maximized if any vertically stationary load is placed on the beam. The respective vibrational frequency and an analytical solution of dynamic response is being studied satisfactorily.

In this study, the finite element method, the component mode synthesis method, and the vibrational response functions are integrated for modeling of the cracked structures. Some results of bending vibrational beams are encountered and its excitational amplitude over curves are being presented. The frequency response functions, function of crack location and size ,are approximated by means of various vibrational transforms. Measured natural frequencies are used in a crack detection process and the crack location and size can be identified by finding the point of intersection of three frequency contour lines. And thus combining all the responses of the individual frequency functions based on the point displacements gives mode shapes.

Thus this combined study utilizes wavelet transform to identify natural frequencies and the corresponding mode shapes from the transient response functions of the system under ambient vibrating conditions. And it is applied to analyze flexural wave in a cracked beam. This fully demonstrates the effectiveness of the proposed methodology for system identification.

**Introduction**

The quantitative diagnosis of structural crack through non-destructive testing is an important part of predicting structural integrity and reliability of components for a wide range of civil, mechanical and aeronautical engineering applications. Due to the practical importance of an early detection of cracks, the crack identification problem in structures has been extensively investigated and has led to the development of various methods. The presence of a crack in a structural member reduces the stiffness and increases the damping of the structure. As a consequence, there is a decrease in naturalfrequencies and modification of the modes of vibration. Many researchers have used the above characteristics to detect and locate cracks and a phenomenon of vibration-based methods for crack detection has been developed.

Signals play a major role in our life. In general, a signal can be a function of time, distance, position,temperature, pressure, etc. and it represent some variable of interest associated with a system .for example, in an electrical system the associated signals are electrical current and voltage. Ina mechanical system, the associated signals may be force, speed, torque etc. in addition to these, some examples of signals that we encounters in our daily life are speech, music, picture and video signals.

A signal can be represented in a number of ways. Most of the signals that we come across are generated naturally. However, there are some signals that are generated synthetically. In general, a signal carries information, and the objective of signal processing is to extract this information.

Signal processing is method of extracting information from the signal which in turn depends on the type of signals and the nature of information it carries. Thus signal processing is concerned with representing signals in mathematical terms and extracting the information by carrying out the algorithmic operations on the signal. Mathematically, a signal can be represented in terms of basic functions in the domain of the original independent variable or it can be represented in terms of basic functions in transformed domain. Similarly, the information contained in the signal can be extracted either in the original domain or in the transformed domain.

**Objectives of the project are:**

* 1. Formation of Stiffness Matrix of Overhanged Beam.
  2. Mass Matrix of Overhanged Beam.
  3. Mathematical Model ( usingSingle degree of freedom, Multi degree of freedom system).
  4. Obtaining Response (By MATLAB Simulation).
  5. Verifying with ANSYS.
  6. Signal Processing using wavelet Transform.
  7. Detection of faults.

**Stated Objectives:**

* Vibrational analysis ofuncracked beam model.
* System modeling and crack localization in a beam.
* Natural frequency and mode shape response of any structural system.
* Finding response based on data programming using matlab.
* Experimental study based on wavelet transform.
* Interpreting results on graphical basis.

A beam is made more compliant by an open crack. The consequent reductions in the natural frequencies free vibrations and changes in mode shapes have motivated a number of researchers to identify cracks in structures. A crack on a structural member introduces a local flexibility which is a function of the depth of crack. This flexibility changes the dynamic behavior of the structure and from this criterion change in the crack position and magnitude can be well identified. The identification of the location and the depth of a crack in beam type structures is aimportant example of structural health monitoring and has received considerable attention. The estimation of crack size and location generally requires a mathematical model (usually a FEM model) along with modal parameters of the structure. The estimating methods are based on the change in natural frequencies, change in mode shapes or measured dynamic flexibility of a structural system.

Another class of crack detection methods based on the change in modal parameters uses a different identification approach based on the modification of structural modal matrices such as mass, stiffness and damping matrices using model updating methods. There are number of approaches to the modeling of cracks in beam structures .There are three main categories falls under this literature :-

* Local stiffness reduction models.
* Discrete spring models, and
* Complex models in two or three dimensions.

In recent years, vibration investigation of a damaged structure has become an approach for fault diagnosis. The main result obtained through experimental studies is that the observed decrease in the natural frequencies of the beam due to the presence of the crack is not sufficient to be described by a model of crack which is always open. Therefore it must be concluded that the crack alternatively opens and closes thus gives to the natural frequencies falls corresponding to the always open and always closed phenomenon.

**The effect of the cracks upon the dynamic behavior of cracked beams has been studied by many authors-**

* Dimarogonas, Chondros and Chondros&Dimarogonas modeled the crack as a local flexibility computed with fractured mechanics methods and measured experimentally, and they developed a spectral method to identify cracks in various structures relating the crack depth to the change in natural frequencies of the structure known as crack position.
* Cawley and Adams have developed an experimental techniques to estimate the location and depth of the crack from changes in the natural frequencies.
* Kirshmer, Thomsons and Petroskiillustrated the effects of cracks on structural response through simple reduced section models of cracked beams using energy methods and discussed the effect of the size and location of the crack to the natural frequencies and vibration mode of the damaged beam.
* Inagaki estimated the crack size and position by natural vibration analysis and by static deflection analysis in the case of transverse vibrations of cracked rotors.
* Infact, Warburton was pointed out the torsional vibration of rods, the local flexibility approach could be used for the estimation of the Christides& Barr exponent.

In summary, the main problem with crack detection methods based on linear vibration analysis to the presence of small cracks seems to be lack of sensitivity. This paper is concerned with the possibility of crack detection by exploiting one or more characteristicfeatures and the presence of responses at natural frequencies using vibrational analysis method.

**Crack Identification in Beams:**

The most popular parameter applied in identification methods is change in natural frequencies and structure caused by the crack. It is due to the fact that estimates of the natural frequencies can be obtained from measurement of the vibrations at only one point on the structure. Its drawback makes attention to the most of investigators is that change in the natural frequencies due to the crack is proportional to the square or double of the relative crack depth for structural significant beam elements as shown by Dimarogonas. The identification problem was discussed by Chang &Petroski. It was developed the automization in the structural phenomenal features for the calculation of depth of crack for different beams and locations of the crack confined to the variant and invariant signals being processed and further improvement is carried out in it.

**Elastic behavior of a cracked beam:**

The cracked system depends on the crack orientation and magnitude with respect to the main dimensions of the cracked member and on the applied loadings and the mode of deformation.

For general loading conditions, a local flexibility matrix relates displacements to forces. In this analysis only bending vibrations are considered, rotational crack compliance is assumed to be dominant in the local flexibility matrix.

**Detection Of Crack Location:**

A crack in a structure introduces a local flexibility which is a function of the crack depth. This flexibility changes the stiffness and the dynamic behavior of structure. In the finite element model of the damaged structure, the effect of the crack on behavior of the structure can be simulated through the introduction of a simple reduced stiffness mode.

According to the principle of Saint Venant’s, the stress field is affected only in the region adjacent to the crack. Unsatisfactory condition being considered in a little existence and assumed that except for the cracked element, the stiffnesses of the elements remains unchanged. The parameters related to the stiffnesses of the cracked and uncracked elements will be identified using measured vibrational frequencies and mode shapes of the cracked structures via a system identification techniques.

**Wavelet Transform**:

The wavelet Transform has been used by researchers for several applications such as transient response analysis, time-frequency analysis, non stationary analysis, discontinuity detection, system identification, and damage detection among many others. The capability of the wavelet for carrying out time-frequency analysis has been exploited in this study for identification of modal parameters of a multi degree of freedom dynamical system. Wavelet transform is more advantageous than fourier transform, as in fourier transform the time-frequency analysis graph shows excitational behavior of the system in uniform or non-uniform state but wavelet transform shows in addition to it, at what time interval the phenomenon of the various stages of the structural system being well defined and calculated as shown graphically. Moreover, the wavelet transform has played an important role in processing wave propagation problems because of the local time-frequency analytical properties.

**References**

1. S.Christides and A,Barr 1984 International Journal of Mechanical Sciences 26(11), 639-648.One dimensional theory of cracked Bernoulli-Euler beams.
2. G.Gounaris and A.D.Dimarogonas 1988 Computers and Structures 28, 309-313. A Finite element of a cracked prismatic beam for structural analysis.
3. N.Anifantis, P.F.Rizos and A.D.Dimarogonas American Society of Mechanical Engineers Design Division Publication DE 7, 189-197. Identification of cracks on beams by vibration analysis.
4. M.D.Rajab and A.Al-Sabeeh 1991 Journal of Sound and Vibration 147, 465-473. Vibrational characteristics of cracked shafts.
5. W.M.Ostachowicz and M.Krawczuk 1991 Journal of Sound and Vibration 150, 191-201. Analysis of the effects of cracks on the natural frequencies of a beam.
6. P.F.Rizos and A.D.Dimarogonas 1989 Journal of Sound and Vibration 138, 381-388. Identification of crack location and magnitude in a characterized beam element from the vibration modes.
7. F.D.Ju and M.E.Mimovich 1988 ASME Journal of vibration, Acoustics, Stress and Reliability in Design 110, 456-463. Experimental diagnosis of fracture damage in structures by the modal frequency method.
8. A.K.Pandey, M.Biswas and M.M.Samman 1991 Journal of Sound and Vibration 145, 321-332. Damage detection from changes in curvature mode shapes.
9. M.A.Akgun and F.D.Ju 1990 Journal of Mechanical Structures and Machinery 18, 175-196. Damage diagnosis in frame structures with a dynamic response methods.
10. R.L.Carlson 1974 Experimental Mechanics 14, 452-458. An Experimental Study of the Parametric excitation of a tensioned sheet with a crack like opening.
11. P.Gudmundson 1983 Journal of Mechanics Physics Solids 31, 329-345. The dynamic behavior of the slender structures with cross-sectional cracks.
12. A.Ibrahim, F.Ismail and H.R.Martin 1987 Journal of Analytical, Experimental Modal Analysis 2, 76-82. Modelling of the dynamics of continuous beam including nonlinear fatigue crack.
13. G.L.Qian and J.S.Jiang 1990 Journal of Sound and Vibration 138, 233-243. The dynamic behavior and crack detection of a beam with a crack.
14. Kishimoto K, Inoue H, Hamada M, Shibuya T. Time-frequency analysis of disperse waves by means of wavelet transform. J ApplMech 1995;62;841.
15. Inoue H, Kishimoto K, Shibuya T. Experimental wavelet analysis of flexural waves in beams. ExpMech 1996;36;212.
16. Prasad L, Iyengar SS. Wavelet analysis with applications to image processing. Boca Raton, FL:CRC Press;1997.